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GUEST EDITORIAL

Snapshots of the Govindjee lab from the late 1960s to the late 1990s, and beyond…

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Introduction

This volume of *Photosynthesis Research* is the second part of a two volume Special Issue to celebrate the contributions of Govindjee to photosynthesis and to the photosynthesis community—spanning over 50 years of research, teaching and service. Govindjee obtained an MSc in Botany from Allahabad University, India, in 1954, and then went to the University of Illinois at Urbana-Champaign in 1956 where he did his doctoral studies under Professors Robert Emerson and Eugene Rabinowitch (Fig. 1). After receiving his PhD in Biophysics from the University of Illinois at Urbana-Champaign (UIUC) in 1960, he joined the faculty as an Assistant Professor in 1961 and maintained a thriving research laboratory until his retirement in 1999 (Eaton-Rye 2007). Below is a collection of recollections from some of the many students and collaborators who passed through Govindjee's lab.

Govindjee returned to Urbana in 1961, after a short visit to India, following a US Public Health Service Postdoctoral Traineeship. The first PhD student supervised by Govindjee was **Carl N. Cederstrand** (PhD in Biophysics, 1965); this, he did jointly with Eugene Rabinowitch. Carl had in fact known Govindjee from his arrival at UIUC and provided the following memory of that time:

> "When Govindjee first came to the U.S., in 1956, he was so thin that when he stood sideways to the sun, he couldn't cast a shadow. That's a little exaggeration, but not much. Govindjee needed a car when he came to this country. I undertook to teach him how to drive. We started out in my Chrysler. He drove too damn fast (my fault for letting him go that fast) and bent up the front end; when he tried to go around his first corner, he hit the curb. After that I took him out in my 850 Mini and he demolished its gear box. Mini parts were very inexpensive at that time so I rebuilt the gearbox over the next weekend. Teaching Govindjee to drive was quite painful for me. I recommended that Govindjee buy a beetle VW as he could handle that. He did."

Both Carl and Govindjee had studied with Robert Emerson and inspired by Emerson's 1957 paper in the Proceedings of the National Academy of Sciences, USA, with Carl N. Cederstrand and Ruth V. Chalmers, on the discovery of the Emerson Enhancement Effect, Govindjee encouraged Carl to go for a PhD. Indeed, he involved him early on in two of his papers (the discovery of the two-light effect in fluorescence, Archives of Biochemistry and Biophysics **89**:322–323, 1960; and of a 750 nm absorbing pigment in *Anacystis nidulans*, Science **134**:391–392, 1961). Later in 1966, four papers from Carl Cederstrand's PhD thesis were published in Biochimica et Biophysica Acta with Govindjee and Eugene Rabinowitch.

From Papageorgiou, Munday, Bazzaz and Mohanty

Many of those who worked in Govindjee's lab during this period are shown in Fig. 2. **George C. Papageorgiou** (PhD in Biophysics, 1968) was the first PhD student of Govindjee. He recalls his time in Govindjee's laboratory, as well as a couple of incidents later in life.

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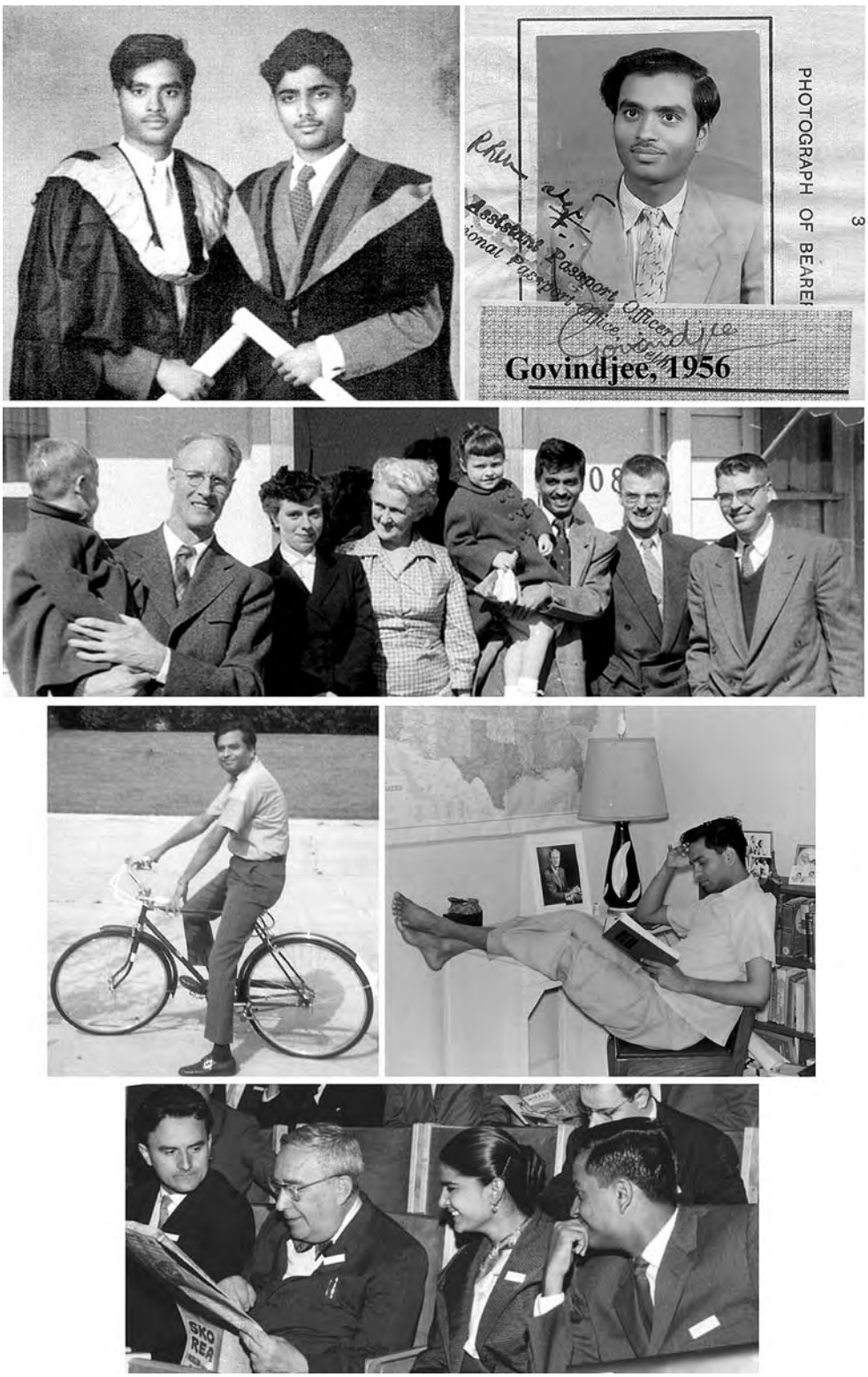

Fig. 1 *Top row*: (Left) Govindjee (left) and his contemporary Manmohan Laloraya, holding their M.Sc. (Botany) degrees in their hands, Allahabad University, 1954. (Right) Govindjee's photograph in his Indian passport, 1956. *Second row*: A 1956 group photograph at Urbana, Illinois. Left to right: Govindjee's first professor, Robert Emerson (holding one of Lavorels' children), Mary-Jo Lavorel, Ruth V. Chalmers (Emerson's assistant), Govindjee (holding another child of the Lavorels), Jean Lavorel and Paul Latimer. *Third row*: (Left) Govindjee on his new bicycle, 1965. (Right) Govindjee studying in his apartment at 201 North Goodwin Avenue, Urbana, Illinois, 1959. *Bottom row*: A 1961 photograph taken in Stockholm, Sweden, at the International Biophysics Congress. Eugene I. Rabinowitch (2nd from left; Govindjee's professor) reading a Swedish newspaper, Rajni Govindjee and Govindjee

"The first lecture on the 'Introduction to Photosynthesis', that I attended, during the 1963/1964 academic year, at the University of Illinois at Urbana-Champaign, began by Govindjee's remarks: Everything that is important in photosynthesis has been already discussed between James Franck (the Nobel laureate) and Eugene Rabinowitch. I was sure that Govindjee's statement was biased, but I still remember it.

Fig. 2 Govindjee's graduate students from 1962–1972. *Top row*: (Left) Anne Krey[1] (Anne (left) was in the lab in the early 1960s; photo taken in 2005) and Govindjee. (Middle) Govindjee, left, and Louisa Yang[2] Ni (in the lab in the early 1960s; photo taken in 2005). (Right) Left to right: George C. Papageorgiou[3] (PhD, 1968), Govindjee, and Prasanna Mohanty (PhD, 1972), photo taken at a conference, ~1987. *Second row*: (Left) John C. Munday[4], Jr. (PhD, 1968), photo taken in 283 Morrill Hall, in 1968. (Right) Left to right: Govindjee and Frederick Y.-T. Cho[5] (PhD, 1969), photo taken in 1990 in Tempe, Arizona. *Third row*: (Left) Left to right: Ted Mar[6] (PhD, 1971), Alan J. Stemler (PhD, 1974), Eugene Rabinowitch, Patrick Breen (then Govindjee's post-doctoral associate) and Govindjee; sitting in white shirt is Prasanna Mohanty, photo taken in 283 Morrill Hall, in ~1969. (Right) Maarib D.L. Bakri (Bazzaz[7]) (left, PhD, 1972) and Govindjee, photo taken at 1101 McHenry Avenue, Urbana, IL, in ~1967. *Bottom row*: (Left) A group photograph at a conference on photosynthesis research ~1981. Left to right: Standing: Govindjee and Prasanna Mohanty[8] (PhD, 1972); sitting: Paul A. Jursinic (PhD, 1977), Alan Stemler (PhD, 1974), Barbara A. Zilinskas (PhD, 1975) and George Papageorgiou (PhD, 1968). (Right) Glenn Bedell[9] (PhD, 1972), with a plaque honoring Robert Emerson and Eugene Rabinowitch, and Govindjee (photo taken in 2006). [Missing from these photographs are Carl N. Cederstrand[10] (PhD, 1965; jointly under Rabinowitch) and Raymond Chollet (PhD, 1972) who worked jointly with William Ogren.]
Notes are given in a separate section before Appendix I

I vividly remember the great evening seminars, once a week, in the Govindjees' living room (1101 McHenry Street, Urbana). They were attended by Anne Krey, Louisa Yang (Ni); John Clingman Munday, Jr., Frederick (Fred) Yi-Tung Cho, Ted Mar, Glenn Wesley Bedell II, Prasanna Kumar Mohanty, Maarib Darwish Lufti Bakri (Bazzaz), Rajni Govindjee, and I (George Christos Papageorgiou). Later, Alan James Stemler joined the group; possibly, there were more who I do not recall at this moment. There were no slides, no power-points, just a blackboard (Govindjee still has it) put on the wall across from a sofa and some armchairs, with the chalk dust freely precipitating on Rajni's carpet. The spirit was great, presentations also, discussions were heated but friendly, with arguments, counter arguments and counter-counter arguments flowing freely; and, there was noise, and all the while the Govindjee children (Anita and Sanjay) were sleeping peacefully in their rooms. Rajni was a great hostess serving us tea and snacks.

I also remember the 'Photosynthesis Group' seminars at the University, held weekly on one of the late afternoons, starting at 3:30 pm, and lasting often till 5:30 pm. First, these seminars were held in the Natural History Building, then in Burrill Hall, and finally in Morrill Hall, where the lab had later moved from the 155–157 Natural History Building to the entire North side of the 2nd floor of Morrill Hall. These exciting seminars were jointly attended by Eugene Rabinowitch and his postdocs (Neti R. Murty, Ashish Ghosh, Patrick Williams, Danuta Franckowiak, Mrinmoyee Das, Gauri Singhal, Laszlo Szalay, Elizabeth Tombacz and Janos Hevesi) and Govindjee's graduate students (as mentioned above) (also see Ghosh 2004).

A hot topic at that time (1963 and early 1964) was clearly the Two-Light Reactions and the Two Pigment Systems; we asked: how many chlorophyll *a* (Chl *a*) subforms in vivo could be detected spectroscopically, and which ones belonged to which system. I recall Gauri Singhal arguing about several Chl *a* "spices" and another non-American colleague confronting him with a different number of Chl *a* "spessies." Whereupon Eugene intervened to set the discussion on its right track saying that actually it is about species (or spectral forms) of Chl *a*.

I felt fortunate in meeting famous scientists while in Urbana (in the Department of Botany, in the Photosynthesis Laboratory, or at Govindjees' home): Pierre Joliot, Lester Packer, Sir George Porter (a Nobel laureate), Academician A.A. Krasnovsky, Warren Butler, A.T. Jagendorf, Shmuel Malkin, Wim Vredenberg, and many others. Butler lectured on phytochrome, Jagendorf on his discovery of inducing chloroplasts to phosphorylate ADP to ATP by a pH jump in the dark, Packer on light-induced light scattering changes in chloroplasts, Joliot on his "period four" experiments on photosynthetic oxygen evolution, Malkin on physicochemical significance of the complementary area above the fast rise trace of Chl *a* fluorescence and Vredenberg on photosynthetic bacteria.

A particular piece of equipment has remained in my memory: it was Carl Cederstrand's dodecahedron integrating device for absorption spectroscopy. I have often wondered why Carl did not construct an eicosahedron as it is the highest order regular polyhedron (a platonic solid) that may exist; it has 20 equal and equilateral triangular faces, but Carl's equipment had only 12 pentagonal faces. Carl constructed the dodecahedron as an improvement to the Ulbricht integrating sphere which was used then for measuring absorption spectra of scattering samples (for example *Chlorella* suspensions). The disadvantage of the integrating sphere was the uncertainty about light path lengths because of multiple reflections on the MgO-coated inner surface. Carl put a photodiode on each of the 12 faces (save perhaps one) so that light reaching it (transmitted or scattered) could be detected directly. Carl's intention was to directly measure the absorption of the spectral forms of Chl *a* in vivo (see Cederstrand et al. 1966). Probably Carl's 'dodecahedron' has ended up in a garbage dump when Govindjee gave away all the equipment of the famous Photosynthesis Laboratory of Urbana, Illinois (Emerson → Rabinowitch → Govindjee) after his own retirement in 1999.

The most exciting local social events in the 1960s were Govindjees' great house parties. Govindjee would meet each guest at the door. Then, just as soon as the guests reached the living room, he would immediately offer a highball drink which was 4/5th Scotch (whiskey) and 1/5th soda instead of the usual 1/5th Scotch and 4/5th soda. And at one time, our great electronics technician Jobie D. Spencer–without him, perhaps, there would be no home-built unique fluorometer (that measured not only emission and excitation spectra, but also chlorophyll fluorescence transients) in Govindjee's lab–brought a squeeze bottle with 95% alcohol but labeled as "distilled water" and offered to dilute our drinks. I do not remember how long it took us to discover Jobie's switch. Govindjee became a tea-totaller almost 20 years ago.

I was privileged to be invited, at regular intervals, by Govindjee as one of his 2 senior grads in his office to discuss laboratory matters. The committee of three (Govindjee, George Papageorgiou and John Munday) soon would become a committee of two because John couldn't tolerate the dense smoke in Govindjee's office (cigar smoke from Govindjee and cigarette smoke from me). Govindjee and I can now sympathize with John's reaction, having quit smoking many many years ago.

Then, there was the Okazaki bus incident, in 1996/1997, I believe. Govindjee, Rajni Govindjee and I were at that time in Norio Murata's famous laboratory in Okazaki, Japan. One Sunday, we went to Mikimoto Island (of pearl fame) by train, on the other side of the Nagoya Bay and returned by ferry to Toyohashi to take the bus to Okazaki. The Japanese pay the exact fare on the way out from the door next to the driver. Govindjee, unaware of that, put a 500-yen coin in the machine and told the driver to keep the change. This brought the whole system to a standstill. The driver didn't know what to do and people waiting behind for their turn became impatient. I do not remember how we got out of that situation.

Another recollection is about a dinner at a Nagoya restaurant, in 1996/1997. A waitress brought the menu, which in Japan contains pictures of trays with various combinations of dishes. Patrons are required to select a tray, but Govindjee wanted to make his own selection by picking dishes here and there. The waitress was confused, called another waitress whose English was better but still to no avail. Then, the manager was called in who settled the issue by just one word: "*setto*", which in Japanese means a "set."

Finally, Govindjee, Rajni Govindjee, my wife Sophie and I recently enjoyed great times together, on a joint holiday in August, 2007, on the beautiful island of Spetses, Greece. We reminisced 44 years of our friendship, and discussed new future joint projects. The last one was the 2004 Springer book "Chlorophyll *a* Fluorescence: A Signature of Photosynthesis" (Advances in Photosynthesis and Respiration, Volume 19) that we had great fun editing."

Also from this period in Govindjee's laboratory, **John C. Munday Jr** (PhD in Biophysics, 1968) recently wrote (see C.A. Rebeiz, C. Benning, H. Bohnert, J.K. Hoober and A.R. Portis (2007) Photosynthesis Research **94**:147–151) at the time Govindjee received the *Lifetime Achievement Award for Basic Biology* from the Rebeiz Foundation, in June, 2007:

"[Govindjee,] You continue to be an inspiration by your ongoing activity in pursuit of scientific truth. May you enjoy many more years of fruitful endeavor. I hope there will be additional opportunities to offer congratulations to you for being a scientist of high calling, a professor, a mentor, and a good friend. I have often wished to be able to come back to the laboratory to do some additional experiments and to enjoy your fellowship."

Interestingly, John's hope came true rather soon, within a month, as Govindjee received the prestigious "Communication Award" of the ISPR (International Society of Photosynthesis Research) in July, 2007, at the 14th International Congress of Photosynthesis Research, held in Glasgow, UK. It was signed by Eva-Mari Aro, President of ISPR. It reads: " *The ISPR Communication Award is presented to Govindjee to acknowledge his outstanding contributions to public understanding of photosynthesis*." In a related article, The Society for Experimental Biology (UK), in its October, 2007 Bulletin (pp 10−17) displays several pictures of Govindjee and describes Govindjee's teaching methods (see http://www.sebiology.org/publications/Bulletin/October07/PS07.html).

Time and again those who passed through Govindjee's lab recall his commitment to photosynthesis and the excellent training and inspiration they received during their time in Urbana. **Maarib Bazzaz** (PhD in Plant Physiology, 1972) writes:

"The following is my recollection of my early days of becoming a student of Govindjee. I remember with great fondness the days of me joining the *Photosynthesis lab* as a graduate student of Govindjee in 1961. Govindjee and Rajni Govindjee taught me a great deal about the photophysics and photochemistry of photosynthesis that has helped me throughout my career as a research scientist. I always followed Govindjee as an example in citing honestly and faithfully in my own publications. I always admired Govindjee's dedication to science in general and photosynthesis in particular. Govindjee was always so generous with his time to discuss and give explanation to experimental results obtained by his graduate students."

Almost all who work with Govindjee encounter his knack of getting you to go that extra distance. However, sometimes one could feel that, momentarily, he or she had not lived up to expectations. Here is a short reminiscence from **Prasanna Mohanty** (PhD in Plant Physiology, 1972):

"The story of the Lab Report. Prof G. had returned from his sabbatical in France and soon, thereafter, asked us one afternoon to report to him on what

progress we have made during his absence. Usually, progress reports were given in the evenings at his residence in a home setting, but this request was unusual. I do not fully recall who all were then there but we were quite a few. Paul Jursinic spoke first as he had worked hard during his absence, Alan (Al) Stemler talked about the functioning of his newly set up Joliot–electrode, but most of us, the others, had not much to say. For a long time, almost 2 to 3 hours in Morrill Hall, Govindjee sat on his chair and said nothing. ...At the end of deliberations, he took us to *Thunderbird* restaurant for drinks. Throughout that night I wondered why did he not explode at some of us, particularly at me, as I imagined that he must have been upset with us (i.e., I thought he had *gussa*—loosely translated from Hindi and Urdu as anger) at the lack of progress of some of us, if not all of us. His statue-like position in the chair at the meeting in his office has stayed with me for many years."

Of course, Prasanna has always held Govindjee in high esteem and is in fact an author on three contributions to this Special Issue (one in Part A and two in Part B!). In his email to me Prasanna also stressed:

"During my stay in Govindjee's laboratory, the Photosynthesis Laboratory was full of fun, frolic and festivities..."

Govindjee's ability to challenge his students has always been balanced by very generous gifts of his time along with encouragement and an ongoing commitment to help his students do better in their research.

From Stemler, Zilinskas, Jursinic, Wydrzynski, Khanna, Rajan and van Rensen

Alan J. Stemler (PhD in Plant Physiology, 1974) writes:

"Through Govindjee's inspiration, photosynthesis in his lab was a grand obsession for everyone. I was privileged to be a part of that headlong quest to understand its secrets and will always remain indebted for that limitless source of inspiration."

Many faces from this period in Govindjee's research group are captured in Figs. 2 and 3. **Barbara A. Zilinskas** (PhD in Plant Physiology, 1974) added the following:

"There is nothing more important in the emergence of a fledgling scientist than the role played by the research mentor. The rare talent of how to spark the interest in discovery, calm the qualms of the ill-confident, encourage the frustrated to persevere, serve as confidant in times of personal challenge, insist on rigor and thoroughness, recognize and promote creativity, and provide the apron strings when needed and then the wings to fly when the student is ready is exemplified no better than by my mentor, Professor Govindjee. He was my first true role model. From our daily interactions during my tenure as his graduate student (1969–1974) to this very day, Govindjee taught me not only how to do science, but equally importantly how to be a great teacher and mentor. I learned much about photosynthesis (his passion of life). However, in my professional career, what I have valued most from Govindjee has been my lessons from him on how to inspire students to love learning and the pursuit of new knowledge, both in the classroom and in the research laboratory, and how each and every student can and must be encouraged to do their very best. For this I will be forever grateful."

Also from this period **Paul A. Jursinic** (PhD in Biophysics, 1977) writes:

"I remember my first meeting with Govindjee as I wandered over from the Physics Department with the desire to do physics in biological systems. I met an enthusiastic professor who showed me interesting equipment and a growth chamber filled with bubbling algae in growth vials. He explained quickly the essential problems to be investigated in photosynthetic research and helped me identify a possible route for graduate study. I was hooked.

Govindjee was a generous professor with his time and help. He made me become a writer by pushing me to publish my experimental findings and of course present these ideas at scientific meetings. I recall the returned drafts from Govindjee being mostly red ink. However, all criticisms were to improve one's work and never to belittle or to be cruel. He made everyone do better work than they originally imagined possible. About the middle of my perusal of a Ph.D., I was drafted into military service. After three years in the U.S. Navy, Govindjee welcomed me back to Urbana to resume my research and education. I had other options but Govindjee made me feel that my earlier work was important and so much more could be accomplished. He assisted me in obtaining a Robert Emerson Fellowship, which made my transition much easier.

The most fun I ever had was doing Ph.D. research! The sheer joy of thinking and being encouraged to do it without concern for the financial outcome but only for intellectual outcome was a unique time in my life. I also remember Govindjee's and Rajni's kindness

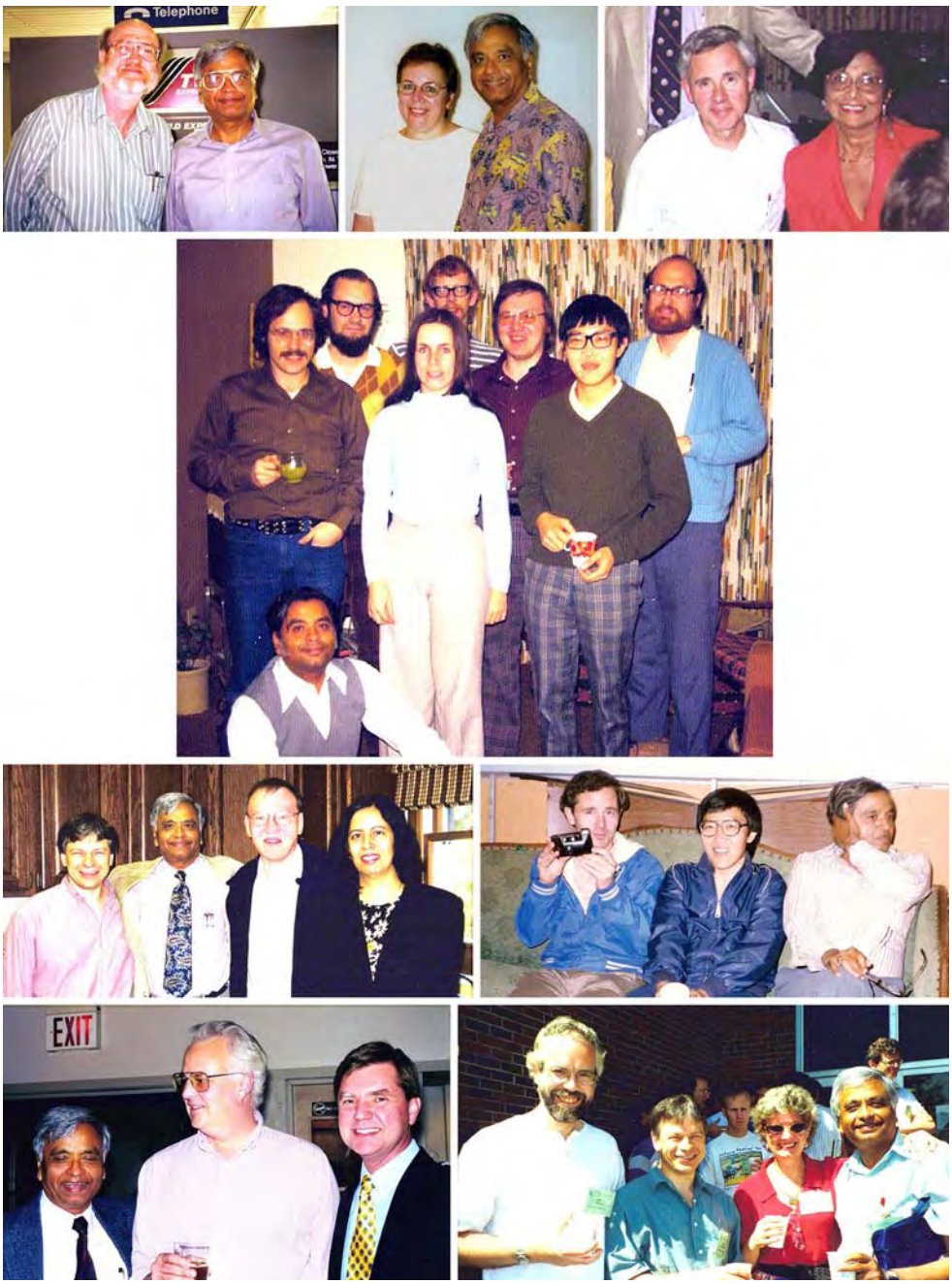

Fig. 3 Govindjee's graduate students in the mid 1970- early 1980s. *Top row*: (Left) Alan Stemler[11] (PhD, 1974, left; photo taken ~2004) and Govindjee. (Middle) Barbara Zilinskas[12] (PhD, 1975, left), and Govindjee (photo taken in 2004). (Right) Paul Jursinic[13] (PhD, 1977) and Maarib Bazzaz (see also Fig. 2; photo taken in 1999). *Second row*: A ~1976 group photograph. Left to Right: R. Slovacek (with moustache), Ralph Schooley[14] (with beard), Barbara Zilinskas (behind her is David VanderMeulen[15] (with glasses; PhD, 1977), Thomas J. Wydrzynski[16] (in red shirt; PhD, 1977), Daniel Wong[17] (PhD, 1979), and Alan Stemler; sitting on the floor is Govindjee; photo taken at 1101 McHenry avenue, Urbana. *Third row*: (Left) Left to right: Julian J. Eaton-Rye (also see Fig. 4), Govindjee, Thomas Wydrzynski and Rita Khanna[18] (PhD, 1980). (Right) Paul Jursinic, Daniel Wong and Govindjee (photo taken ~1977). *Bottom row*: (Left) Govindjee, James M. Fenton[19], and Professor Michael Wasielewski (from Northwestern University, Chicago; photo taken in 1999). (Right) Willem J. Vermaas[20], Julian Eaton-Rye, Christa Critchley and Govindjee (photo taken around 2000)

and generosity. They opened their house to all of the graduate students for weekly lab meetings and parties, which were referred to as seminars with drinks. Govindjee helped me enter a career in scientific discovery and now medical physics clinical work. The thorough education I received at the University of Illinois and in Govindjee's laboratory has allowed me to pursue a satisfying and varied career in science and now medicine."

Paul ended his remarks by sending his 'warmest regards'.

Here follows a recollection from **Thomas J. Wydrzynski** (PhD in Plant Physiology, 1977):

"There is no doubt that Govindjee has an intense passion for photosynthesis, especially the fluorescence properties (and the bicarbonate effect!!). He was not only a great inspiration to me when I was a student in his lab but I believe also to all of those who have had the good fortune to know him personally. One recollection I have of Gov is when I was writing up my thesis. I had a tight schedule since I needed to finish my PhD requirements before July, 1977, when

I planned to embark on my first trip to Europe to work with Jean-Marie Briantais at the CNRS (Centre National de la Recherche Scientifique) Laboratoire de Photosynthèse. As I was working on the thesis, Gov asked to see a manuscript on the work we planned to publish in Biochemistry, which he wanted to submit before I left. When I told him that I felt I didn't have the time, he said that he wouldn't read my thesis until he had a draft in hand. Since we both have a stubborn streak, nothing happened for about a week. And then he gave in and started to read my thesis. I completed my PhD requirements just a few days before I was scheduled to leave the country and of course the Biochemistry paper didn't come out until the following year. We all know that if the work is not written up before one moves on to another job, then often it is delayed and loses its impact. With Govindjee, who has an encyclopedic knowledge of photosynthesis, each new piece of information is important in achieving the ultimate goal to understand one of Nature's most beautiful of biological processes."

Rita Khanna (PhD in Plant Physiology, 1980) was also a member of Govindjee's research group at this time and writes:

"I joined Professor Govindjee's laboratory in 1974, and was a part of it until 1979. I was welcomed into the world of photosynthesis and into the home and family of Govindjee and Rajni from the moment they received me at the airport.

Right from the day I joined Govindjee's laboratory, it felt that I was at the center of research on photosynthesis. It was inspiring being in a laboratory so rich in tradition dating back to Robert Emerson and Eugene Rabinowitch. I was also fortunate to overlap with an exceptional cohort of fellow students and researchers including Alan Stemler, Barbara Zilinskas, David VanderMeulen, Ralph Schooley, Paul Jursinic, Tom Wydrzynski, Daniel Wong and others. But it was Govindjee who was the force, guiding light and glue of the lab. It was he who kept alive the tradition of the lab, it was he who tracked and connected the people and knowledge in the field with the network that spanned the world, it was he who motivated and painstakingly guided each of our research, and it was he and his wife Rajni who welcomed all of us into his home and made us their extended family. I still remember the weekly meetings at their home-where we shared the latest developments in the field and our own research, and the delicious food that Rajni was sure to serve us.

Although I left the field many years ago, I remain impressed with Govindjee's passion and dedication to the field. Anyone who was around him could not fail to imbibe that enthusiasm. Many years later (October, 1999), I was attending his retirement ceremony, the invited speaker Jerry Babcock had started speaking and Anita (Govindjee's daughter) was a little late in arriving. She asked if she had missed anything, and her five-year-old daughter (Sunita) piped up, "Yes, he has already spoken about Photosystem II."

I was fortunate to have been a part of Govindjee's research group. Those years have helped shape my professional life. I am also fortunate that he and Rajni are still like family to me."

During this period **Srinivasan Rajan** (Novartis Institutes for BioMedical Research, Cambridge, MA) was also in the lab and worked with Rita Khanna on NMR (see Note 44). Rajan (his given name) writes:

"Dear Professor Govindjee: ... Once in a while I do browse your web site!! Often times, I admire your love for the subject, your vigor and enthusiasm. You are a unique professor. The fact that I had the opportunity to be associated with you was a wonderful thing in my life. It is quite sometime ago but the feelings are real and alive ...
With my warmest regards,
"Rajan" Rajan
(Srinivasan Rajan)"

Govindjee is of course well known for his work on the bicarbonate effect in Photosystem II. A long-standing collaborator in this area has been **Jack J.S. van Rensen** from the University of Wageningen, The Netherlands. Below are excerpts from Jack's recollections:

".....I decided after a few years of my PhD to look for a sabbatical year abroad. In 1975, Govindjee's group (Tom Wydrzynski) had published about bicarbonate acting at the electron acceptor side of PS II, and I got the idea that there could be some resemblance between the actions of PS II herbicides (I had studied) and bicarbonate. Thus, I decided to try to go to Govindjee's laboratory in Urbana. ... In April 1977, I traveled with my wife Mary-Ann and three children to Urbana, Illinois. Govindjee and Rajni Govindjee were very helpful; they had rented a house for us in Champaign, and assisted us by buying a car and getting us to feel at home. In the summer of 1977 we moved to another home in Champaign. Mary-Ann and the children had a good time. Our children went to school and made friends. We lived close to the home of Bill Ogren, and our son became friends with

their son Jason, and our youngest daughter became friends with their daughter Susan.

I had a great time in Govindjee's lab in (then) the Botany Department at 277–283 Morrill Hall, 500 S. Goodwin Avenue. At that time there were several PhD students: Tom Wydrzynski, Rita Khanna, Daniel Wong and Jim Fenton. Rita introduced me into the secrets of the bicarbonate experiments, and Daniel taught me about fluorescence polarization. In that year there were two papers published (see Note 36 and van Rensen et al. (1978)). ... In 1981 it appeared that there is indeed a relationship between effects of those herbicides and bicarbonate; see van Rensen and Vermaas (1981) and Khanna et al. (1981).

After my stay with Govindjee we kept contact till the present day. I have been back in Urbana several times and Govindjee came several times to my laboratory in Wageningen. There are now 15 papers, with both of us as (co)authors."

From Vermaas, Baianu, Critchley, Padhye, Coleman, Eaton-Rye, Shim, and Xu

Many of those in the lab during this period are shown in Fig. 4. At this time, **Wim F.J. Vermaas** (Arizona State University), then a PhD student with Jack van Rensen, arrived in Urbana. Wim writes:

"My venture of going to the Govindjee lab as a visiting student in 1980 was my first research experience outside The Netherlands. Fresh off the plane and Greyhound bus, I not only joined a distinguished lab at the University of Illinois, but I also had the privilege to be on the receiving end of the famous "*Govindjee and Rajni hospitality*" at their house during my first few days in Urbana. That was really very important for someone "fresh off the boat"; also, having Gov or Rajni with me on those first trips to the housing office, the bank, Strawberry Fields, etc. was greatly appreciated. When I asked Gov whether I could do anything in return, the answer was simply "*do the same to others when they come to you when you have your own lab*". Wise words, and I'm still trying to follow them.

The Govindjee lab at the time was pretty much focused on the bicarbonate effect on photosystem II, and while at least in Gov's and my minds there was clear experimental evidence for formate-induced inhibition on the acceptor side that could be reversed by bicarbonate addition, there was also the possibility that there was a bicarbonate effect on the donor side. The possibility of two overlaying effects in the same photosystem made for great discussions and detailed experimental design, most experiments focusing on the creative use of chlorophyll fluorescence and oxygen evolution in the presence of inhibitors or artificial electron donors or acceptors to tease apart acceptor and donor side effects. This was also the time of the fabricated 60-odd kDa water-splitting enzyme of Mark Specter and Doug Winget, and I vividly remember discussions on how to detect whether ^{14}C-labeled bicarbonate might bind to this protein with very high affinity and specificity. Fortunately, we ended up not chasing this red herring, but in the process Gov taught me how to look at experimental evidence objectively and thoroughly (as a young student one is more interested in proving one's hypothesis than noticing that little blip in the fluorescence induction curves that you gloss over unless guided by the expert).

It was clear that the more I learned, the more I knew I had not learned enough. So when Gov asked me whether I was interested in writing a draft for a review for an Indian journal, and later also for Photochemistry and Photobiology, I said yes and started compiling papers. My desk at the time did not look any better than it looks now... hard to find an open spot among the piles. Anyway, after Gov had looked at my first draft, he took me aside, and handed me an autographed copy of "The Elements of Style" by Strunk and White, with the fatherly admonition of "*great work and wonderful synthesis, but pretty awful writing; here's something that will help make your writing readable; for one thing, cut those long Germanic sentences and words into three or four pieces*".

The success of a lab does not just depend on a great mentor, but the interactions between grad students and others in the group also are an important part of the dynamics that lead to new ideas. At the time I was there, Jim Fenton was getting closer to finishing his elegant work on early photosystem I electron transfer reactions with picosecond time resolution, and Bill Coleman, Danny Blubaugh, and Julian Eaton-Rye were in the earlier stages of their work. Christa Critchley came for a shorter visit, looking at thylakoids from mangroves that at the time were thought to have an altered innate chloride requirement for the water-splitting system of photosystem II. Altogether a fun environment to think, bounce ideas off, and discuss. I'm not entirely sure, though, to which extent the others felt fully comfortable sharing their ideas with me, as Dutch bluntness tended to permeate my comments and answers; Gov led by example in showing how diversity of opinion and ideas is so valuable in coming up with creative new solutions.

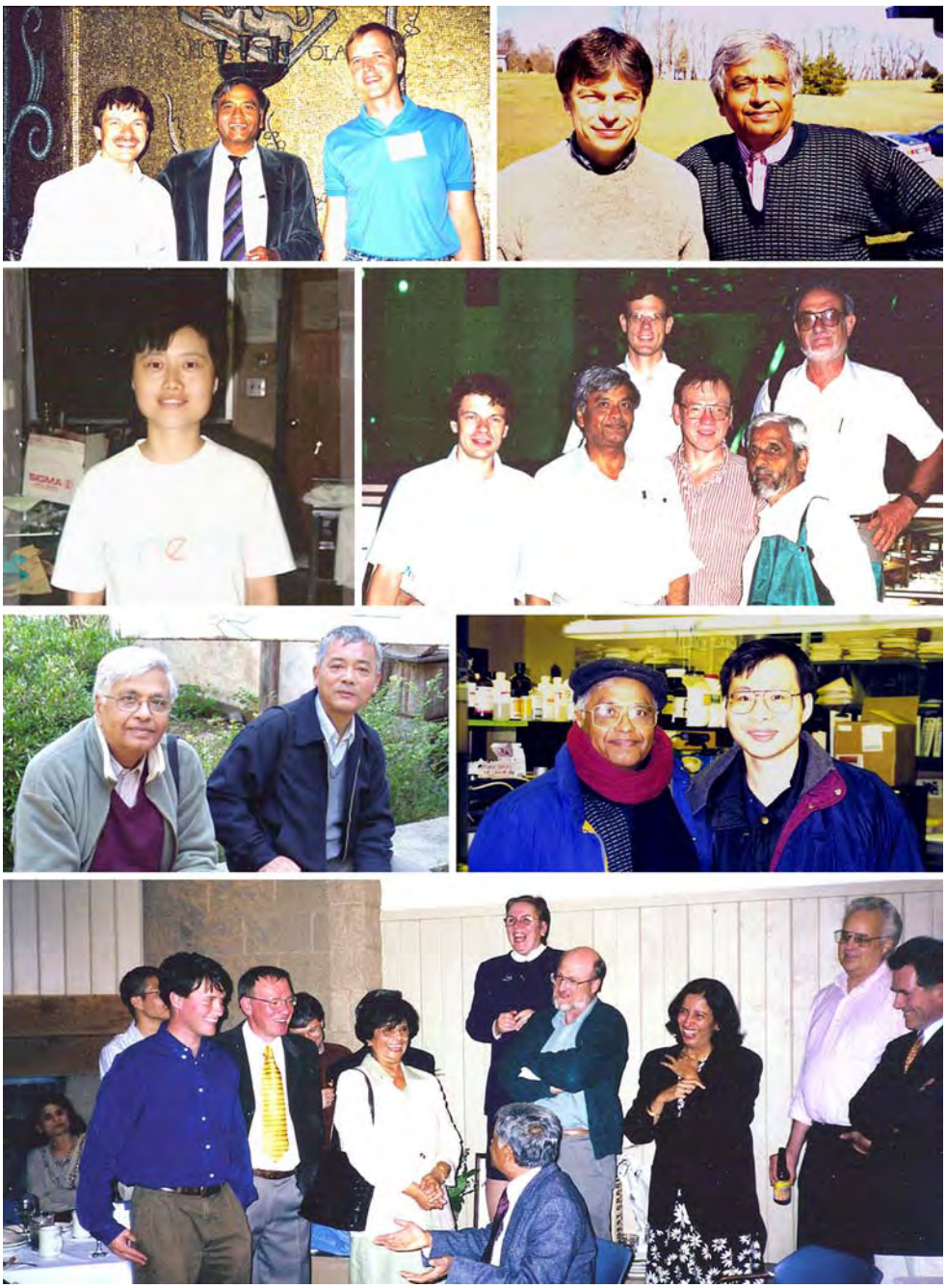

Fig. 4 Govindjee's graduate students in the late 1980–1990s. *Top row*: (Left) Julian Eaton-Rye, Govindjee and William J. Coleman[21] (PhD, 1987, right), photo taken in ~1989. (Right) Julian Eaton-Rye[22] (PhD, 1987, left), and Govindjee, photo taken in ~1998. *Second row*: (Left) Hyunsuk Shim[23] (PhD, 1992, jointly under Professor Peter Debrunner), photo taken in 1992. (Right) A ~1995 group photograph. Left to Right: Julian Eaton-Rye, Govindjee, Danny J. Blubaugh[24] (PhD, 1987; behind Govindjee), Thomas Wydrzynski, Prasanna Mohanty (holding a Conference bag) and George Papageorgiou (his left hand is visible). *Third row*: (Left) Left to right: Govindjee and Chunhe Xu[25] (PhD, 1992), photo taken in ~2000. (Right) Govindjee and Jin Xiong[26] (PhD, 1998), photo taken ~2002. *Bottom row:* A 1999 group photograph, taken at Govindjee's retirement party. Left to right: Paul Spilotro[27], Thomas Wydrzynski (in yellow tie), Maarib Bazzaz (in white dress), Barbara Zilinskas (standing high), Alan Stemler, Rita Khanna, James Fenton and Jack J.S. van Rensen. Govindjee is sitting, defending himself! Missing in the photographs are Jiancheng Cao[28] (PhD, 1992), and Fatma El-Shintinawy[29]

The photosynthesis crew in Urbana at the time included quite a cast of talented faculty and scientists. For example, I remember doing cytochrome redox measurements on Don Ort's (or was it Colin Wraight's?) machine, being introduced to thermoluminescence by Don DeVault (cf. Note 46), working with Howie Robinson in the Crofts' lab on oxidation kinetics of Q_A^-, and discussing with Bill Rutherford, also in Crofts' lab at the time, about the ramifications of heterogeneity in photosystem II. The Govindjee lab was part of what I think was the world's largest concentration of excellent photosynthesis researchers at the time. (My publications from that visit included: Vermaas and Govindjee (1981a,b; 1982a,b) and Note 20)

Gov did not just teach me writing and how to do science, he also taught me the art of driving in his red Buick, which was way too new for my taste. The first few times we practiced way out there, in the Illinois boondocks, and I am still amazed that Gov's hair did

not turn grey overnight. The Buick survived, soon I graduated to Urbana driving, and I passed the driving test the first time around.

Hard to believe I spent less than a year in Gov's lab. There's so much I learned, both as a scientist and as a person. Thanks, Gov!"

Also appearing on the scene at this time was **Ion C. Baianu** (now Professor and AFC-NMR (Agricultural and Food Chemistry-Nuclear Magnetic Resonance) and NIR (Near Infra Red) Microspectroscopy Facility Coordinator, ACES (Agricultural, Consumer and Environmental Sciences) College, University of Illinois at Urbana-Champaign). Ion recalls his work with Govindjee, and his research associate Christa Critchley:

"I remember with pleasure our group's research kindly coordinated by Govindjee (Biophysics) and Herb Gutowsky (Chemistry) at our University in the early 1980s. It started a train of photosynthetic research studies that continued over two decades and continues to be of great interest today. When Christa Critchley joined our group in 1980 with her experience on salt-tolerant mangrove chloroplast photosynthesis, research took an exciting turn as it was now possible to observe 'directly' the chloride ion binding/exchange on such chloroplast preparations for a wide range of chloride and bromide ion concentrations. It was interesting to compare our high-field NMR results on algae and isolated chloroplasts obtained in collaboration with William Coleman who was working on his PhD thesis with Govindjee with those obtained on salt-tolerant mangrove chloroplasts prepared by Christa; the results were strikingly different which stimulated Govindjee and Christa to design additional, validity check, fluorescence experiments. We had quite a few either stormy or exciting discussions where all of us enjoyed Govindjee's supporting presence and his introduction to other discoverers of photosynthesis fundamentals; one of them—especially fond of Govindjee was the late Gerry Babcock—I still have in my cherished album a picture with both of them. (Unfortunately, both Gerry and Herb are no longer with us, but their memories, discoveries and creations live on.) The *Chloride*, *Manganese* and *Bicarbonate* Sagas in Photosystem II continued for twenty years afterwards, always with Govindjee encouragingly and helpfully smiling and providing his incisive analysis of the pertinent facts. The following is a 'dry' and very short summary of such facts as I see them now after the passage of time! These are a tribute to Govindjee' s intense but very pleasant creativity and his kind understanding of all his coworkers. Undoubtedly, he has a great deal more to find and create even after half a century of highly productive research.

Together with Govindjee, we were deeply involved in studies on "High-Field NMR of Photosystem II in Isolated Chloroplasts and Algae." We were the first ones to report the first high-field NMR studies of chloride-35 binding and exchange in relation to photosynthetic water oxidation in isolated chloroplasts from spinach and salt-tolerant mangrove plants. Our collaboration was a great deal of fun as we had constant extensive discussions and often late-night experiments including weekends. Our results were published in 2 major papers (Critchley et al. (1982) and Note 38, and several conference reports. The selectivity of chloride was attributed to a combination of steric and ionic field effects; and chloride was suggested to facilitate Photosystem II electron transport by 'reversible ionic binding' to the oxygen-evolving complex."

Christa C. Critchley (University of Queensland, Brisbane, Australia) also recalls:

"I first met Govindjee when I was a PhD student in Düsseldorf at the Heinrich Heine University. It would have been 1973 or 1974 (he'll probably remember, his memory is much better than mine). While I was already working on chloroplast membranes—about which we knew very little really—I had not focused on photosystems. Gov changed all that and I have been interested in their structure and function ever since. It was a great pleasure and an honor to work with him as a postdoc at the University of Illinois in Urbana-Champaign from 1980 to 1982 and our friendship has continued. His energy and enthusiasm remain a great inspiration."

Another visitor to Govindjee's lab in this period was **Subhash Padhye**, from the University of Pune, India. Subhash (given name) writes:

"*Master with Magnificent Obsession*. It was the role of manganese ions in water oxidation in the photosynthetic process that attracted me to get involved with synthesizing mimics of the water oxidase enzyme and join University of Illinois as a Fulbright Fellow with Professor David Hendrickson and half-time with Professor Govindjee. Since the x-ray structure of the water-oxidizing complex was not available at that point of time, we were building up a hypothesis about the most likely candidate for the donor ligand to manganese ions which would be redox active in order to accommodate the four-step Kok's cycle of charge delocalization process of water

oxidation that will match the spectroscopic, fluorescence and thermoluminescence data available through several research groups ahead of their actual publications. Histidine residues in the protein surrounding manganese ions seemed to be the most likely candidates and Dr. Takeshi Kambara and I floated a hypothetical model of the water oxidation complex during my stay at Urbana along with Professors Govindjee and Hendrickson (see Notes 39 and 48). It was during preparation of the draft of this manuscript that I worked very closely with Govindjee and learned my first lessons of how to write a meaningful and attractive manuscript with nearly flawless logic. The manuscript went through 7 drafts each crowded with several suggestions and comments about improving it in red ink by Govindjee so much so that one could hardly read the original text! During the discussions of those drafts I not only learned a great deal about the intricacies of the photosynthetic process but also about the history of discoveries in photosynthesis research, and that too from the historian of photosynthesis! In subsequent years, the course of my research has changed to Drug Discovery and Development and yet the friendship with Rajni and Govindjee remains unabated. I had the privilege of staying in their home while they were away and dropping the key in an envelope in their mailbox before leaving. Each of those meetings always turned out to be enriching for me with information and knowledge on the new ways of looking at life. It is no wonder that Govindjee's amazing enthusiasm for knowledge has rubbed off on each of us who have come into his contact; it has enriched our lives. Celebrating his 50 years with photosynthesis is indeed a celebration of his obsession with the Mystery of the Unknown 'a magnificent obsession!'"

William J. Coleman (PhD in Cell Biology, 1987) writes:

"What I remember most fondly about working in the Govindjee laboratory was the emphasis on discussion and debate of scientific ideas. Friendly criticism and analysis helped to foster a considerable amount of creative thinking among everyone in the group. The other key element was the encouragement that he gave to projects involving interdisciplinary research and collaboration. We take it for granted now, but 25 years ago, there was not as much productive interaction between laboratories in the biological, chemical and physical sciences. Govindjee certainly paved the way for this new broad-based approach to solving scientific problems. *And finally, he always impressed upon us the sheer beauty and elegance of the photosynthetic process*. I always felt privileged to be working in such an amazing field."

It was during this period that I was a student and I include a few of my own reminiscences of that time (**Julian J. Eaton-Rye** (PhD in Plant Physiolgy, 1987)):

"I arrived in Urbana in August 1981. At that time Wim Vermaas had just completed a 6 or so month stint in Govindjee's lab and then gone on to East Lansing to work with Charlie Arntzen at Michigan State University. Govindjee invited Wim down to Urbana for a weekend to show me how to use the instruments in the lab and to provide an introduction to the bicarbonate effect. Wim introduced me to Govindjee's magnificent Cary 14 spectrometer and Jobie Spencer's fluorometer. Wim in fact crammed a great deal of instruction into a couple of days—and it was very evident why his time in Govindjee's lab, working on the bicarbonate effect, was so productive. As time has passed I have come to appreciate more and more how Govindjee made time to help me get settled in. This included the practical help of driving me around while I was hunting for an apartment but he also made time available one afternoon a week for much, if not all, of my first semester to explain basic concepts in photosynthesis. Another impressive quality was how fast Govindjee turned drafts around. You would get something back within a day or so with extensive detailed suggestions, corrections and instructions, all done by hand with a deft use of colored pens designed to teach how to write science. The lab members during most of the time I was in Urbana consisted of Danny Blubaugh, Bill Coleman and Jim Fenton. Danny also worked on the bicarbonate effect and along the way interfaced Jobie Spencer's fluorometer to a computer, Bill worked on the chloride effect on oxygen evolution and Jim worked on primary photochemistry of photosystem I. Govindjee allowed us a great deal of independence in our projects. In my case I was given the space to build a "double flash" fluorescence instrument for following the effects of bicarbonate on electron transfer between the Q_A and Q_B plastoquinone electron acceptors of photosystem II. I used a design developed in Tony Crofts' lab with much help from his postdoc at the time Howard Robinson. This was a major undertaking that took over 12 months from start to finish but Govindjee just let me get on with it. Moreover, Govindjee was very understanding when in the first trial run of the S-100 board, interfacing the computer to the instrument, the computer burst into flames. I was simply allowed to order another computer.

I will mention one last recollection that impressed me. Govindjee loved his cigars but when in ~1984 he was diagnosed with heart disease the cigars vanished overnight."

Bill, Danny and I all graduated in 1987 but around this time several new students joined the lab, among them Fatma El-Shintanawy, Hyungsuk Shim, Jiancheng Cao and Chunhe Xu. **Chunhe Xu** (PhD in Biophysics, 1992) has also sent his recollections:

"I joined Govindjee's lab in 1986; this lab was a very united group. It was a group where the atmosphere was such that all of Govindjee's students helped each other and the atmosphere was that of friendship. At that time, Julian Eaton-Rye, Danny Blaubaugh, and Bill Coleman were about to finish their graduate (PhD) study. They still gave me great help to get familiar with their experiments. Julian showed me how to measure doubleflash fluorescence dynamics. Danny taught me how to measure chlorophyll *a* fluorescence transients. Bill showed me how to isolate oxygen-evolving photosystem II particles and how to do EPR measurements. All of those techniques were very successfully used not only in my PhD studies, but also in those of Fatma El-Shintanawy, Hyungsuk Shim as well as Jiancheng Cao.

In one afternoon in the early spring of 1987, Govindjee happened to be knocked down by a careless student going on a bicycle, and it affected his health. After being in the Carle hospital for a while, he had to go home for a recovery for several days. As soon as he felt a little better before his leaving the hospital, he still remembered to talk with me for more than half an hour about my research work.

Once, I took his course in Bioenergetics. Among all the students, I was the only graduate student. For being so familiar with the content of the course, I quickly finished the term (Exam) sheet. However, after the test, he told me that he was not satisfied with my answers and can only give me a B grade. But, if I would like to precisely re-answer every question (as a term paper), he would reconsider my grade. I accepted it, and finished it by using two-weeks of time (including Christmas Day and the winter break). He was still not satisfied, and he still gave me a B. But, this process helped me to understand many concepts in Photosynthesis. And, I remained thankful for his efforts to teach me until I graduated with a PhD.

There are two major Photosynthesis Research Labs in China, one in Shanghai and the other in Beijing; both keep a very pleasant friendship with Govindjee for his help. In 1974, the first Chinese delegation of photosynthesis research visited the United States, and Govindjee hosted a family dinner in his home. During his three visits in China, he also gave them very valuable presentations. He introduced their work in many cases, making them feel that he recognizes and appreciates the work done by his Chinese coworkers and former graduate students. In summary, it was a pleasure to work with Govindjee and I shall cherish the time I had with him in Urbana."

Hyunsuk Shim (PhD in Biophysics, 1992) added:

"I had a pleasure to have Dr. Govindjee (Biophysics) as a co-mentor for my PhD education; the other was Dr. Peter Debrunner (Physics). Govindjee is a living history of photosynthesis research. He is a great teacher who has taught me how to approach scientific problems as well as be a great mentor. Now, I am an independent investigator in the Radiology Department, Emory University, Atlanta, GA with my own trainees at various levels (undergraduate, graduate students, post-doctoral students, and medical residents.). I wish I can be an as inspiring a mentor as Dr. Govindjee was for me."

From Wasielewski, Xiong, Sayre, Clegg and Holub

Michael R. Wasielewski, Northwestern University, a longtime collaborator of Govindjee's writes:

"One of the distinct pleasures that results from a career in science is the pure joy and satisfaction that comes from investigating an important scientific problem with good friends. Govindjee and I along with Mike Seibert (National Renewable Energy Laboratory, NREL) had a great deal of fun pursuing the problem of how fast is primary charge separation in photosystem II (PS II) reactions centers. It is one of the most pleasant memories I have during my scientific career. This all started when Govindjee and I began working with Jim Fenton to use "more modern" laser technology to look at the primary charge separation rates in photosystem I (PS I) (See Note 19; Wasielewski et al. 1987). At that time accurate determination of the time-resolved absorption spectra of the intermediates involved in the primary charge separation within PS I was a difficult problem because the most stable protein complex still contained about 40 chlorophylls per P700. This made it

difficult to separate the relatively small absorption changes due to $P700^{+}$-A_0^{-} from the spectral changes due to formation of excited states within the antenna pigments.

Shortly thereafter, Govindjee and I began looking at PS II preparations that were carried out at the University of Illinois at Urbana-Champaign, but these preparations were photochemically unstable under laser illumination. We discovered that Mike Seibert was working in similar directions and had developed a simple, yet effective oxygen-scrubbing system to protect PS II from degradation. Govindjee proposed a three-way collaboration, and the rest, as they say, is history. Following a lot of preparation, we all first met at Argonne National Laboratory (where my lab resided until 1998) in the early summer of 1988. The Seibert lab isolated the PS II complex and employed the newly discovered procedures developed at NREL to improve the stability of the material; my lab had state-of-the-art laser equipment ready; and Govindjee brought his extensive experience, keen insights, knowledge of the literature, and passion for Japanese food. In looking back over the period, the outings to the Yokohama restaurant in neighboring Westmont, IL during these collaborative runs may have been the cement that kept this work going. Our work together over the better part of 15 years led to great improvements in the understanding of the early photophysical and photochemical events in PS II. (The first paper was: Wasielewski et al. 1989; also see Note 49.)

The best part of working with Govindjee was his enthusiasm for the project and his encyclopedic knowledge of the literature. I know that I learned a great deal from him during this time. His enthusiasm was infectious and helped drive the project over the many years that we worked together. I am both proud and grateful to have had the experience of working directly with Govindjee and to count him amongst my friends. And I wish him all the best for his next 50 years in photosynthesis research."

This next recollection is from **Jin Xiong** (PhD in Plant Physiology/Plant Molecular Biology, 1996) who was Govindjee's last PhD student.

"I was the last PhD student of Govindjee. At the very outset, I would like to say a few words about his passion in teaching. When I first attended his class I was literally transfixed by the way he taught. It was utterly refreshing; not only photosynthesis and electron transfer were clearly explained, his use of cartoons, animation and games really had made learning a great joy. The most contagious was his love and enthusiasm in science that emanated from his lectures, which I am sure had motivated scores of undergraduate students to pursue science as a career; I know many had become medical doctors as well. As his graduate student, I had the privilege to enjoy his personal tutelage. When, at one time, Govindjee sensed that I had gone a little overboard with molecular biology, but paid insufficient attention to the biophysical aspect of the work, he would spend entire afternoons (I sort of remember it was every Thursday afternoon in his office) to personally teach me the nuances of Photosystem II (PS II) light-harvesting, electron transfer and chlorophyll fluorescence. That not only helped me balance my priorities but also helped me to learn more up-close the way big scientists think and work. After many years, I still feel indebted for the tremendous investment he had made in me. Most importantly, I learned from him how to become an independent scientist and how to ask my own new questions, plan the experiments to test my hypotheses and interpret the results and compile them for publication.

Another important skill that I learned from Govindjee was how to write in English. I had my writing style shaped primarily while working under Govindjee. I remember the first day of my joining his lab when he bought me a copy of "*Strunk and White: Elements of Style*" as a welcoming gift and told me that it was a Bible and worth studying over and over. That says volumes of his strong emphasis on writing. He would spend a tremendous amount of time editing almost everything I wrote, papers, posters, meeting abstracts, and even fellowship applications. Through the markings he made on the pages, I learned spelling, grammar, style and proper word usage. I felt fortunate to have such quality advice from a prolific author and an outstanding editor of a major journal and books. To work with Govindjee was a privilege to be had indeed.

Looking back, I really think my graduate school years were some of the most rewarding and positive part of my life. It had a major impact in my career as I learned quite a bit from Govindjee's passion in research and teaching. The fact that I am still doing photosynthesis-related research was obviously due to the education I received from him and his laboratory. Govindjee has been an inspiration in my life.

I would like to add a bit about my research in Govindjee's lab. I joined his laboratory as a student in the Physiological and Molecular Plant Biology Program in the fall of 1991. I had expressed my interest in both molecular biology and photosynthesis to Govindjee who gladly gave me a project on

D1 site-directed mutagenesis. The goal was to use the newly created mutants to understand the structural basis of the bicarbonate effect on PS II electron transfer.

At the time when I started the project, Govindjee passed on to me some tips of cyanobacterial mutagenesis that he had learned from Wim Vermaas (who was his own graduate student at one time) at the Arizona State University. I initially planned to use the same system for my mutagenesis work. There were, however, several technical problems working with cyanobacteria such as slow growth rate and fluorescence quenching. To find a better system that would be devoid of these drawbacks, I later wanted to switch to a green alga, *Chlamydomonas reinhardtii*. Govindjee was very accommodating with my change of plan. To help me get started quickly with this new system, he arranged collaboration with Richard Sayre at Ohio State University, who had been working on this model system for years and had a gene transformation system in place.

The first mutation I successfully made was arginine-269 to glycine (on D1), which was essentially a deletion mutation of the positively charged residue near the non-heme iron-binding site. The deletion was shown to have abolished the bicarbonate/formate binding and even herbicide binding. In collaboration with Richard Sayre and his postdoc Ron Hutchison, we also found that the mutation had caused a much broader structural perturbation on PS II by impacting its donor side electron transfer and the Mn cluster assembly. The result was initially perplexing as to how the acceptor side mutation could be transduced to the donor side.

To help rationalize the mutagenesis work, I decided to build a computational model of the PS II reaction center. Govindjee again showed considerable tolerance for me doodling on the computer. In collaboration with Shankar Subramaniam, and under the guidance of Govindjee, the modeling work was successful with a complete D1/D2 model constructed based on homology with the bacterial reaction center. The model revealed that D1-R269 was located at the interface between D1 and D2 and that the deletion must have caused a minor "earthquake" in the reaction center, which explained a range of phenotypes observed, from bicarbonate binding, herbicide binding to donor side assembly. A more sensible choice, arginine-257 at the Q_B binding pocket, was selected and mutated, with additional help from Tony Crofts's lab. The mutation of the residue into glutamate and methionine disrupted the formate binding and Q_A–Q_B equilibrium but not the herbicide binding. The results seemed to suggest that Arg-257 was a more specific formate-binding residue. Further modeling work helped Govindjee and I to propose a bicarbonate-mediated proton shuttling mechanism as well as a putative "bicarbonate transport channel" for diffusion of the small ion to the key binding site. The ideas and research on the role of bicarbonate in PS II, which had been built upon the work of two former students of Govindjee (Danny Blubaugh and Julian Eaton-Rye, the Editor of this Special Issue) has become more of a reality.

A lesson that I learned from the homology-modeling project was the importance of computation in experimental research. If computing tools were used properly in conjunction with an intimate knowledge of the field, they could facilitate major progress that was previously unattainable. This realization has been the main motivation for my entering bioinformatics later in a big way."

Richard T. Sayre, from Ohio State University, adds:

"My earliest collaborations with Govindjee were most memorable. We had just engineered the first *psbA* mutants in *Chlamydomonas* and Govindjee was passionate about exploring the bicarbonate binding-site as well as oxidizing-side mutations. Robin Roffey, a graduate student in the lab, went to Urbana with her first mutants to work with Govindjee and Dave Kramer. It was Robin's first immersion in an environment where photosynthesis was "King". Govindjee was involved in all aspects of the experiments. This was most unusual for such a senior scientist. Govindjee's passion for science and critical engagement with young scientists was transforming Robin and she went on to publish many of the early papers on engineering photosystem II in *Chlamydomonas*, often with Govindjee as a co-author (see e.g., Roffey et al. 1994)."

Even after his retirement in 1999 Govindjee remained engaged with students. **Xinguang Zhu** who received his PhD in 2004 (Plant Physiology/Plant Molecular Biology with Professor Steve Long) writes:

"I felt extremely fortunate to get my Ph.D on photosynthesis research in Urbana. One of the major reasons to say so is being able to work closely with Prof. Govindjee. His expertise, together with those of the others, enabled me to develop a mechanistic and dynamic model of photosynthesis. His great advice for my research will always accompany me for my whole research career. His encouragement and love for young scientists will always be a source of great inspiration for me to embark on new scientific

expeditions. My paper with Govindjee is published in Planta (Zhu et al. 2005).

And active collaborations have carried on into Govindjee's retirement. **Robert M. Clegg,** Physics Department, University of Illinois at Urbana-Champaign, writes:

"It is a great pleasure to congratulate Govindjee on so many years of successful and profitable years in photosynthesis research. Before coming to the University of Illinois at Urbana Champaign (UIUC) 10 years ago, he was known to me only by name. I was after all (and still am), a neophyte in photosynthesis. The only reason I had a short-sighted awareness of the photosynthesis literature is because I had used leaves of plants to test a new instrument I had built in the late 1980s, a fluorescence lifetime-resolved imaging microscope (FLIM). This was done in the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany several years before deciding to come to UIUC. Shortly after arriving at UIUC, I met Govindjee, probably at a party somewhere. Due to his wonderful open and sympathetic personality, his curiosity and his exceptionally broad interests, it is easy to meet him if you are in the same room with him—no matter what you do. The conversation eventually turned to our scientific research, and he became excited hearing that we had a FLIM apparatus. He had previous experience with fluorescence lifetime measurements over many years, and he realized immediately the importance of lifetime imaging for photosynthetic systems. So began an unexpected, but highly profitable, and more importantly a wonderfully rewarding, cooperation (professionally and personally). A graduate student of mine, Oliver Holub, and a post doc of Govindjee, Manfredo Seufferheld, carried out many measurements over the next few years, under the guiding eye and scrutiny of Govindjee. This resulted in two major publications (see e.g., Note 41), and the cooperation is still ongoing, despite his busy schedule, traveling around the world, editing books, and writing an authoritative history of photosynthesis research. For me it was quite an experience. It was like going to school again: learning about photosynthesis from him. He is a great teacher. He is an impatient fellow; however, not in an impolite way. It often seems that he has so much information stored in the crevices of his mind that you have to stop him now and then so you can digest what he is pouring into your knowledge cup. It is like walking in a forest through all sorts of winding paths with someone who can tell you details about all the plants and animals. Now and then, when you arrive at a meadow, you have to tell him that you want to sit there for a while, and peruse and review all you have just seen. Luckily for me, he did not mind repeating several times certain aspects of what I, especially as a physicist, consider to be an incredibly complex biological system, which has been biologically taken apart, pounded, kicked and scrutinized by so many investigators in the past. He was able to take the critical information, and eventually squeeze it into an understandable form, so that we could then pick up, and continue the walk through his knowledge forest; and I could continue to pick a few of the berries as we walked. Of course, it was not all a simple walk—detailed discussions about our cooperative research also took place, and then came the interpretations and the writing of the papers. This is where his critical analysis would cut in as—"No, no, no! That cannot be the reason because ...". It is the way science should be done: inquisitive, exciting, sometimes naïve, and always challenging. We continue to have discussions, sometimes in our gardens, sometimes on the phone or over email, and plan experiments, even though he now has many other obligations. But I am looking forward to where the path leads in the future. It has been, and continues to be, a delight to carry on and discuss science with Govindjee. The two volumes of *Photosynthesis Research*, edited by Julian Eaton-Rye, is testimony to his inspiration to many scientists, in addition to his own significant contributions to the great story that has unfolded in the last 50 years of photosynthesis research."

A Letter from **Oliver Holub** (from the Laboratory for Fluorescence Dynamics, Department of Biomedical Engineering, University of California, Irvine)**,** who had worked on FLIM (Fluorescence Lifetime Imaging Microscopy) while a PhD student with Robert Clegg ends this series of reminiscences. He writes:

"Dearest friend,

It fills me with greatest pleasure to hear about the special volume celebrating thy research. And if I am allowed to contribute some sentences, praise thee I will. Each field of research has its heroes and heroines. Heroes, who overlook the field, who know everybody and are known by everybody in the community. Who are approached by others for advice and give good advice. Not only because they know more than oneself, but also because they already have been where one wants to tread. And slippery the road of photosynthesis research is: slimy algae or plants (and let's not forget cyanobacteria or prochlorophytes) grow everywhere and Biology is just lurking

to knock down the Physicist with his simplistic models, Chemistry waiting to teach the Biologist its lessons and Physics to frustrate the Chemist by switching a sign of some wave function. The flood of growing knowledge makes it difficult for the newcomer to see the light at the end of the thylakoid (if some left there is). Good that there are heroes in each field to give you perspective. Who guide you from the important basics to mind-boggling complexity.

Ars longa, *vita brevis*, and who can encompass the totality of a complex field of research? No one better than thou, my Govindjee! Thou art such hero in the field of photosynthesis! Who (with interest in photosynthesis) does not know Govindjee, I ask thee? But perhaps not every reader is aware that also thou knowest everybody! I have not forgotten the day we were discussing a new journal and thou immediately started chatting with the editors (whom thou knew of course) to find out more about it. When I first met thee, I walked into thy laboratory to 'dismantle' it. (Thou were closing thy laboratory to move into thy new Emeritus office.) Surely that must have made a good impression (because my personality never does)....and since we had already thy equipment, it laid the foundation for a great collaboration. Let me first tell the readers that a walk through thy laboratories was like a visit to a museum, which I enjoyed enormously. Of course thou were using modern equipment, but there were all these wonderful old instruments (which thou thyself had inherited from thy teachers Robert Emerson and Eugene Rabinowitch) from times when instrument manufacturing was still an art. I was looking for good application for our new lifetime microscope and talking with thee and Manfredo Seufferheld, I realized that I had come to the right address. And lucky I can call myself for the privilege to learn about photosynthesis directly from thee. From thee, who has been the teacher of whole generations of researchers through thy educational work. And thy interest in the history of science has been the delight to many, who have read thy papers on historic topics. But perhaps not every reader had the honor to follow thy historic walk over the campus of the University of Illinois at Urbana-Champaign. Still historic instruments are hidden in unused small chambers along the campus and nothing can bring history back alive as thy account of the more personal aspects of the feud (if I am allowed to call it in this way–turning off the building heating in winter seems to justify such description) between the Nobel laureate Otto Warburg and thy Professor Robert Emerson. I remember also being involved in one of thy historic discoveries: Thou had discovered the address of Otto Warburg's residence in Urbana and both of us went for a walk, found the house and took pictures of it. The picture of the house survived, but the picture of me in front of it got destroyed during the film development—History decides, whose faces she wants to record! Thou liked to quote Pliny the Younger: *"It is a noble employment to rescue from oblivion those who deserve to be remembered"*. I think, I speak in everybody's name, if I foretell that the name Govindjee never will be in need of any rescue mission of this kind.

Congratulations and Happy 75th Birthday on October 24, 2007!

Thy truly, Olli"

Conclusion

Govindjee has given a great deal to the field of photosynthesis over the last 50 years and he is still going! Above, in particular, we have seen evidence of his excellent mentoring of those he has trained. In Appendix I, a list of all PhD theses, from Govindjee's lab, both in Biophysics and Biology, is provided. Above, we have also "heard" from Gov's collaborators; however, many other scientists visited Govindjee's lab during these years (Fig. 5) and a list of his many co-authors is provided as Appendix II.

In Part B of this Special Issue many who passed through Govindjee's lab have contributed together with other colleagues from across the different sub-disciplines of photosynthesis research. In fact, this issue, like Part A, is characterized by contributions from scientists from around the world (more than 80 researchers from 12 countries in Part B) and is again a testament to the many and varied contributions Govindjee has made to the photosynthesis community.

I end this tribute, on behalf of all his graduate students, postdoctoral associates, a large number of co-authors, and all the authors in this and the earlier volume (Eaton-Rye 2007) by showing two recent photographs: the first is a 2007 photograph of Govindjee with his grand daughter Sunita (Fig. 6—top) with Govindjee holding the *Communication Award* he received at the 14th International Congress of Photosynthesis Research. The final photograph is of Govindjee and Rajni together on a trip to New Mexico in May 2007 (Fig. 6—bottom). They were married on October 24 1957, Govindjee's 25th birthday, and they just celebrated their 50th anniversary this year.

Dear Govindjee and Rajni: congratulations and our best wishes for many more happy years together.

Fig. 5 Some of Govindjee's research collaborators. *Top row*: (Left) Rajni Govindjee[30] and Govindjee in California in 1959. (Middle) Ashish Ghosh[31] and Govindjee, photo taken in 2005. (Right) Mrinmoyee Das[32] and Govindjee, photo taken in 2005. *Second row*: Gauri S. Singhal[33], photo taken in 1990. (Middle) Govindjee and Jean-Marie Briantais[34], photo taken in 1995. (Right) A 1999 group photograph of Teruo Ogawa[35], Jin Xiong, Govindjee and André Jagendorf. *Third row*: A 1999 group photograph of Jack J.S. van Rensen[36], Thomas Wydrzynski, Julian Eaton Rye, Alan Stemler, Govindjee, Rita Khanna and Govindjee's grand daughter Sunita. *Fourth row*: (Left) Vladimir Shinkarev[37] and Govindjee. (Middle) Govindjee, Christa Critchley[38] and Wim Vermaas, photograph taken in ~1990. (Right) Subhash Padhye[39] and Govindjee, photograph taken in 2005. *Fifth row*: (Left) Adam Gilmore[40], photo taken in ~1997. (Right) Rhanor Gillette (with whom Govindjee taught Biology 121 at Urbana), Govindjee, Manfredo Seufferheld[41], and his wife Alejandra Maria Seufferheld, photo taken in 2007. A very large number of Govindjee's collaborators, including, e.g., Laszlo Szalay[42], Ralph Gasanov[43], S. Rajan[44], G. Sarojini[45], Don deVault[46], A. William Rutherford[47], T. Kambara[48] and Michael Wasielewski and Michel Seibert[49] are missing in this Figure (see Wasielewski in Fig. 4.)

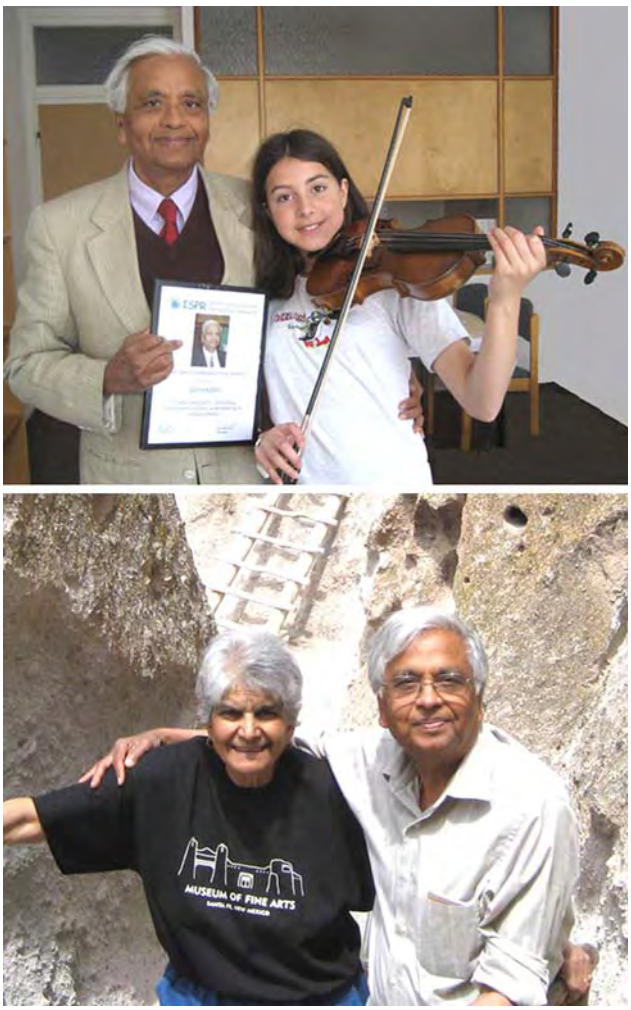

Fig. 6 *Top*: A 2007 photograph of Govindjee and his grand daughter Sunita. Govindjee is holding the 2007 *Communication Award* given to him by the International Society for Photosynthesis Research (ISPR) on July 23, 2007, at the 14th International Congress of Photosynthesis Research, held in Glasgow, UK. *Bottom*: Govindjee and Rajni Govindjee in a 2007 photograph taken in New Mexico

Acknowledgments I thank all the past students, research associates, and several collaborators of Govindjee who kindly sent their reminiscences to be included here. I also thank Hyungshim Yoo for careful preparation of the photographic plates used in the Figures and George Papageorgiou for a careful reading of the text and excellent suggestions.

Notes added in the proofs

Christopher Batory (of Westmount, Quebec, Canada), who has been having a yearlong e-mail discussion with Govindjee on the subject of possible life/photosynthesis in outer space, wrote:

"Dear Govindjee,

I always find some excuse around here to say something nice about you, or promote one of your quotes. You are a mentor and guide *par excellence*, and you can instill a passion for *Photobiology* in most anyone who crosses your path. But foremost, you can show what life really is and what a kind, loving and patient person you are, a great scientist with humility of the highest order.

With relentless vitality, you are the most youthful 75-year-old I have ever seen.

I enjoyed your recent papers with Nancy Kiang (Kiang et al. 2007a,b) on possible photosynthesis on M-planets, and the excellent commentary on it by John Raven (2007).

May all good things come your way, and may your youth forever prevail.

With warmest wishes of health and happiness,

Chris

Montreal

October 24th, 2007"

Manfredo Seufferheld, Govindjee's last postdoc associate (1998–2001), wrote on November 22, 2007, the Thanksgiving Day:

"What can I say about Govindjee that already has not been said? I had the privilege to be his last post doc, which is a big honor but at the same time a big responsibility. For me, the most striking characteristic of Govindjee is his love for people and for the subject he studies: Photosynthesis. Love is patient and Govindjee's patience was an important factor in my success in his lab. I had done my PhD in 'Stress Physiology' and 'Photosynthesis' was a new challenge for me. Govindjee always had time to discuss a particular paper or a concept that was hard to chew. I still remember how much enthusiasm, dedication and especially patience he devoted to me. I treasure all the diagrams, figures and notes that he wrote in my lab book, which are a testimony of his love for what he always did, science, and thus, he had real disciples.

One of the first things I did when I arrived in Urbana was to observe the class he taught. When I entered the class, an introductory undergraduate course in plant biology, I could not believe my eyes; there were about 300 students trying to get a seat with the associated "entropy"! When the class started, I was amazed by how he taught with passion, creativity, simplicity and his endless patience. He climbed stairs, threw tennis balls as flying "electrons", took pictures, walked up and down the amphitheater, and used great visual aids…. all to be sure that every one got "the important message". Only the greatest teachers are able to make such a profound impact on students as he did. I will add: only the greatest teachers are able to

simplify a very complex and difficult subject matter in a way that everyone feels that it is "as easy as eating a pie". Love is kind, and Govindjee's kindness is the virtue that evaporated any concerns I may have had in working with him, and allowed me to feel connected with him. Love is not arrogant or rude.

No matter what the situation or the person with whom he interacted, Govindjee's humility stood out as reflection of his great wisdom and humanity. Yes, love and his passion for truth is what made Govindjee the great scientist and person that he is. Thank you very much Govindjee for being such a great mentor and for all the great things you are doing for science and its promotion."

Notes

Here, we provide below one selected paper per student or collaborator in order to provide an idea of the area of research in Govindjee's laboratory (see the figure legends and the text). A complete list is available under *publications* at: http://www.life.uiuc.edu/govindjee

1. Krey A, Govindjee (1964) Fluorescence changes in *Porphyridium* exposed to green light of different intensity: a new emission band at 693 nm and its significance to photosynthesis. Proc Nat Acad Sci USA 52:1568–1572
2. Govindjee, Yang L (1966) Structure of the red fluorescence band in chloroplasts. J Gen Physiol 49:763–780
3. Papageorgiou G, Govindjee (1968) Light induced changes in the fluorescence yield of chlorophyll *A* in vivo. I. *Anacystis nidulans*. II. *Chlorella pyrenoidosa*. Biophys J 8:1299–1328
4. Munday JC Jr, Govindjee (1969) Light-induced changes in the fluorescence yield of chlorophyll *a* in vivo. III. The dip and the peak in the fluorescence transient of *Chlorella pyrenoidosa*. IV. The effect of preillumination on the fluorescence transient of *Chlorella pyrenoidosa*. Biophys J 9:1–35
5. Cho F, Govindjee (1970) Low temperature (4–77 K) spectroscopy of *Anacystis*: temperature dependence of energy transfer efficiency. Biochim Biophys Acta 216:151–161
6. Mar T, Govindjee (1972) Kinetic models of oxygen evolution in photosynthesis. J Theoret Biol 36:427–446
7. Bazzaz MB, Govindjee (1973) Photochemical properties of mesophyll and bundle sheath chloroplasts of maize. Plant Physiol 52:257–262
8. Mohanty P, Govindjee (1973) Light-induced changes in the fluorescence yield of chlorophyll *a* in *Anacystis nidulans*. I. Relationships of slow fluorescence changes with structural changes. Biochim Biophys Acta 305:95–104
9. Bedell G, Govindjee (1966) Quantum yield of oxygen evolution and the Emerson enhancement effect in deuterated *Chlorella*. Science 152:1383–1385
10. Cederstrand CN, Govindjee (1966) Some properties of spinach chloroplast fractions obtained by digitonin solubilization. Biochim Biophys Acta 120:177–180
11. Stemler A, Govindjee (1973) Biocarbonate ion as a critical factor in photosynthetic oxygen evolution. Plant Physiol 52:119–123
12. Zilinskas BA, Govindjee (1975) Silicomolybdate and silicontungstate mediated dichlorophenyldimethylurea-insensitive Photosystem II reaction: electron flow, chlorophyll *a* fluorescence and delayed light emission changes. Biochim Biophys Acta 387:306–319
13. Jursinic P, Govindjee (1977) Temperature dependence of delayed light emission in the 6 to 340 microsecond range after a single flash in chloroplasts. Photochem Photobiol 26:617–628
14. Schooley RE, Govindjee (1976) Cation-induced changes in the circular dichroism spectrum of chloroplasts. FEBS Lett 65:123–125
15. VanderMeulen DL, Govindjee (1977) Binding of modified adenine nucleotides to isolated coupling factor from chloroplasts as measured by polarization of fluorescence. Eur J Biochem 78:585–598
16. Wydrzynski TJ , Marks SB , Schmidt PG , Govindjee, Gutowsky HS (1978) Nuclear magnetic relaxation by the manganese in aqueous suspensions of chloroplasts. Biochemistry 17:2155–2162
17. Wong D, Merkelo H, Govindjee (1981) Estimation of energy distribution and redistribution among two Photosystems using parallel measurements of fluorescence lifetimes and transients at 77 K. Photochem Photobiol 33:97–101
18. Khanna R, Govindjee, Wydrzynski T (1977) Site of bicarbonate effect in Hill reaction: Evidence from the use of artificial electron acceptors and donors. Biochim Biophys Acta 462:208–214
19. Fenton JM, Pellin MJ, Govindjee, Kaufmann K (1979) Primary photochemistry of the reaction center of Photosystem I. FEBS Lett 100:1–4
20. Vermaas WFJ, van Rensen JJS, Govindjee (1982) The Interaction between bicarbonate and the herbicide ioxynil in the thylakoid membrane and the effects of amino acid modification. Biochim Biophys Acta 681:242–247
21. Coleman WJ, Govindjee (1987) A model for the mechanism of chloride activation of oxygen evolution in Photosystem II. Photosynth Res 13:199–223
22. Eaton-Rye JJ, Govindjee (1988) Electron transfer through the quinone acceptor complex of Photosystem

II in bicarbonate-depleted spinach thylakoid membranes as a function of actinic flash number and frequency. Biochim Biophys Acta 935:237–247
23. Blubaugh DJ, Govindjee (1988) The molecular mechanism of the bicarbonate effect at the plastoquinone reductase site of photosynthesis. Photosynth Res 19:85–128
24. Shim H, Cao J, Govindjee, Debrunner PG (1990) Purification of highly active oxygen-evolving Photosystem II from *Chlamydomonas reinhardtii*. Photosynth Res 26:223–228
25. Xu C, Taoka S, Crofts AR, Govindjee (1991) Kinetic characteristics of formate/formic acid binding at the plastoquinone reductase site in spinach thylakoids. Biochim Biophys Acta 1098:32–40
26. Xiong J, Minagawa J, Crofts AR, Govindjee (1998) Loss of inhibition by formate in newly constructed Photosystem II D1 mutants, D1-R257E and D1-R257M, of *Chlamydomonas reinhardtii*. Biochim Biophys Acta 1365:473–491
27. Govindjee, Spilotro P (2002) An *Arabidopsis thaliana* mutant, altered in the gamma subunit of the ATP synthase, has a different pattern of intensity dependent changes in non-photochemical quenching and the kinetics of the P-to-S fluorescence decay. Funct Plant Biol 29:425–434
28. Cao J, Vermaas WFJ, Govindjee (1991) Arginine residues in the D2 polypeptide may stabilize bicarbonate binding in Photosystem II of *Synechocystis* sp. PCC 6803. Biochim Biophys Acta 1059:171–180
29. El-Shintinawy F, Govindjee (1990) Bicarbonate effect in leaf discs from spinach. Photosynth Res 24:189–200
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31. Ghosh AK, Govindjee (1966) Transfer of the excitation energy in *Anacystis nidulans* grown to obtain different pigment ratios. Biophys J 6:611–619
32. Das M, Govindjee (1967) A long-wave absorbing form of chlorophyll *a* responsible for the Red Drop in fluorescence at 298 K and the F723 band at 77 K. Biochim Biophys Acta 143:570–576
33. Merkelo H, Hartman SR, Mar T, Singhal GS, Govindjee (1969) Mode locked lasers: measurements of very fast radiative decay in fluorescent systems. Science 164:301–302
34. Govindjee, Briantais JM (1972) Chlorophyll *b* fluorescence and an emission band at 700 nm at room temperature in green algae. FEBS Lett 19:278–280
35. Ogawa T, Grantz D, Boyer J, Govindjee (1982) Effects of abscisic acid on chlorophyll *a* fluorescence in guard cells of *Vicia faba*. Plant Physiol 69:1140–1144
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37. ShinkarevVP, Govindjee (1993) Insight into the relationship of chlorophyll *a* fluorescence yield to the concentration of its natural quenchers in oxygenic photosynthesis. Proc Natl Acad Sci USA 90:7466–7469
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39. Padhye S, Kambara T, Hendrickson DN, Govindjee (1986) Manganese-histidine cluster as the functional center of the water oxidation complex in photosynthesis. Photosynth Res 9:103–112
40. Gilmore A. Shinkarev VP, Hazlett TL, Govindjee (1998) Quantitative analysis of the effects of intra-thylakoid pH and the xanthophyll cycle pigments on chlorophyll *a* fluorescence lifetime distributions and intensity in thylakoids. Biochemistry 37:13582–13593
41. Holub O, Seufferheld MJ, Gohlke C, Govindjee, Heiss GJ, Clegg RM (2007) Fluorescence lifetime imaging microscopy of *Chlamydomonas reinhardtii*: non-photochemical quenching mutants and the effect of photosynthetic inhibitors on the slow chlorophyll fluorescence transient. J Microsc 226:90–120
42. Szalay L, Rabinowitch E, Murty N, Govindjee (1967) Relationship between the absorption and emission spectra and the Red Drop in the action spectra of fluorescence in vivo. Biophys J 7:137–149
43. Gasanov R, Abilov ZK, Gazanchyan RM, Kurbanova UM, Khanna R, Govindjee (1979) Excitation energy transfer in Photosystems I and II from grana and in Photosystem I from stroma lamellae, and identification of emission bands with pigment-protein complexes at 77 K. Z Pflanzenphysiologie 95:149–169
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46. DeVault D, Govindjee, Arnold W (1983) Energetics of photosynthetic glow peaks. Proc Natl Acad Sci USA 80:983–987
47. Rutherford W, Govindjee, Inoue Y (1984) Charge accumulation and photochemistry in leaves studied by thermoluminescence and Delayed Light Emission. Proc Natl Acad Sci USA 81:1107–1111
48. Kambara T, Govindjee (1985) Molecular mechanism of water oxidation in photosynthesis based on the

functioning of manganese in two different environments. Proc Natl Acad Sci USA 82:6119–6123
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Appendix I: Doctoral Theses under the Guidance of Govindjee

1960s

Cederstrand, Carl Nelson (**1965**) Spectrophotometric and spectrofluorometric characterization of the two pigment systems of photosynthesis, 107 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois (*jointly under Eugene Rabinowitch*)

Papageorgiou, George (**1968**) Fluorescence induction in *Chlorella prenoidosa* and *Anacystis nidulans* and its relation to photophosphorylation, 140 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

Munday, John Clingman, Jr. (**1968**) The fluorescence transient of *Chlorella pyrenoidosa*, 168 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

Cho, Frederick Yi-Tung (**1969**) Low temperature spectroscopy of algae, 136 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

1970s

Mar, Ted (**1971**) Primary photoprocesses in the photosynthesis of algae, 199 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

Bakri (Bazzaz) Maarib Darwish Lufti (**1972**) A photosynthetic study of olive necrotic 8147 mutant and normal maize (*Zea mays* L.), 132 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Bedell, Glenn Wesley II (**1972**) Photophosphorylation in algae, 106 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Mohanty, Prasanna Kumar (**1972**) Regulation of chlorophyll fluorescence during photosynthesis: A study of the factors affecting changes in yield and emission of chlorophyll fluorescence in intact algal cells and isolated chloroplasts, 433 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Stemler, Alan James (**1974**) The bicarbonate ion and photosynthetic oxygen evolution, 87 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Zilinskas, Barbara Ann (**1975**) Photosystem II reactions in thylakoid membranes, 162 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Jursinic, Paul Andrew (**1977**) Photosystem II charge stabilization reactions in isolated chloroplasts, 200 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

VanderMeulen, David Lee (**1977**) Partial characterization of adenine nucleotide binding to isolated coupling factor, 153 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

Wydrzynski, Thomas John (**1977**) The role of manganese in photosynthetic oxygen evolution, 208 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Wong, Daniel (**1979**) Regulation of electronic excitation energy distribution in the primary photoprocess of photosynthesis in thylakoids, 225 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

1980s

Khanna, Rita (**1980**) Role of bicarbonate and of manganese in Photosystem II reactions of photosynthesis, 180 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Blubaugh, Danny J. (**1987**) The mechanism of bicarbonate activation of plastoquinone reduction in Photosystem II of photosynthesis, 226 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Coleman, William Joseph (**1987**) The mechanism of chloride activation of oxygen evolution in spinach Photosystem II, 209 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Eaton-Rye, Julian John (**1987**) Bicarbonate-reversible anionic inhibition of the quinone reductase in Photosystem II, 174 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

1990s

Cao, Jiancheng (**1992**) Effects of amino acid residue substitutions of bicarbonate function in the plastoquinone reductase in cyanobacteria, 244 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Shim, Hyunsuk (**1992**) Investigations of the water oxidation complex in PS II, 156 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois (*With Peter G. Debrunner)*

Xu, Chunhe (**1992**) Differential inhibition of the plastoquinone reductase activity by weak organic acids and its relationship to the bicarbonate effect in spinach thylakoids, 182 pages, **Biophysics**, University of Illinois at Urbana-Champaign, Illinois

Xiong, Jin (**1996**) Experimental and theoretical studies of the Photosystem II reaction center: Implications for bicarbonate binding and function, 268 pages, **Biology**, University of Illinois at Urbana-Champaign, Illinois

Appendix II: Co-authors and coeditors of Govindjee

[What follows is an almost complete alphabetical list of co-authors and co-editors of papers, reviews and general announcements of Govindjee. The names of Govindjee's Professors are in uppercase, *graduate students, postdocs and visiting scientists, who worked with him in his Lab, are in italics*, and **those who are deceased are in bold**.]

1. Abilov, Z.K.
2. Abrol, Yash Pal (co-editor)
3. Adamec, F.
4. Aligizaki-Zorba, Aikaterni
5. Allen, John F.
6. **Amesz, Jan** (co-editor)
7. Anton, John A.
8. Armond, Paul
9. **Arnold, William A.**
10. Aro, Eva Mari
11. Astier, Chantal
12. Augur, Julie
13. **Babcock, Gerald T.**
14. *Baianu, Ion C.*
15. Baker, Neil
16. Barber, James (Jim) (co-editor)
17. *Bazzaz (Bakri), Maarib [Darwish Lufti]*
18. Beatty, J. Thomas (Tom)
19. *Bedell, Glenn Wesley II*
20. Berkowitz, Gerald
21. Bharti, Sudhakar
22. Björn, Lars
23. Blair, L.C.
24. Blankenship, Robert E. (Bob)
25. *Blubaugh, Danny J.*
26. Bohnert, Hans (co-editor)
27. Bose, Salil
28. Bottomley, W. (co-editor)
29. Boyer, John S.
30. Brezina, F.
31. ***Briantais, Jean-Marie***
32. Britt, David
33. Bryant, Donald A. (co-editor)
34. *Cao, Jiancheng*
35. *Cederstrand, Carl Nelson*
36. *Cho, Frederick Yi-Tung* (Fred)
37. *Chollet, Raymond (Ray)*
38. Chow, W-S. (Fred)
39. Clegg, Robert M. (Bob)
40. Cohen, Martin
41. *Coleman, William Joseph (Bill)*

Appendix continued

42. Cramer, William A. (Bill) (co-editor)
43. Crespi, Henry L.
44. Crisp, David
45. *Critchley, Christa*
46. Crofts, Antony R. (Tony)
47. Daniell, Henry
48. *Das, Mrinmoyee*
49. De Klerk, Hank
50. de Vos, Oscar
51. Debrunner, Peter G.
52. Decampo, R.
53. Demeter, Sandor
54. Desai, T.S.
55. DeSturler, E.
56. ***DeVault, Don***
57. Dilley, Richard A (Dick) (co-editor)
58. Döring, G.
59. Downie, Steve
60. **Downton, W.J.S.**
61. Ducruet, Jean-Marc
62. Duysens, L.N.M. (Lou)
63. *Eaton-Rye, Julian John (Julian)*
64. Eggenberg, Peter
65. *El-Shintinawy, Fatma*
66. **EMERSON, ROBERT (BOB)**
67. Etienne, Ann-Lise
68. *Fenton, James M. (Jim)*
69. Finkele, U.
70. Fork, David C.
71. Foyer, Christine
72. Freyssinet, Georges.
73. Funk, Christiane
74. Garab, Győző
75. *Gasanov, Ralph*
76. Gazanchyan, R.M.
77. Gest, Howard
78. *Ghosh, Ashish K.*
79. *Gilmore, Adam M.*
80. Gnanam, A. (co-editor)
81. Goedheer, J.H.C. (Joop) (co-editor)
82. Gohlke, C.
83. Goldstein, C.
84. Gorham, H.H.
85. *Govindjee (Varma), Rajni*
86. Grantz, David
87. Gratton, Enrico
88. Greenfield, Scott
89. ***Gross, Elizabeth L.***
90. Gunning, Brian
91. **Gutowsky, Herbert S.**

Appendix continued

92. *Halls, S.*
93. Hammond, J.H.
94. Hartman, S.R.
95. Haselkorn, Robert (co-editor)
96. Hazlett, Theodore L. (Chip)
97. Heiss, G.J.
98. Hendrickson, David N.
99. Hirschberg, J.
100. Hoch, George
101. **Hoff, Arnold J.**
102. *Holub, Oliver (Olli)*
103. Homann, Peter H.
104. Hope, A.B.
105. Hou, C.
106. *Hutchison, Ron*
107. *Ichimura, Shoji*
108. Inoue, Yorinao
109. Irrgang, K-D. (co-editor)
110. Itoh, Shigeru
111. Jajoo, Anjana
112. Johnson, Douglas G.
113. Jordan, Doug
114. Junge, Wolfgang
115. *Jursinic, Paul Andrew (Paul)*
116. *Kambara, Takeshi*
117. **Kamen, Martin D.**
118. Katz, Joseph J. (Joe)
119. Kaufmann, Kenneth (Ken)
120. Keranen, M.
121. Keresztes, Áron
122. *Khanna, Rita*
123. Kiang, Nancy Y.
124. Kirilovsky, Diana
125. Knaff, David
126. Knox, Robert (Bob)
127. Koenig, Friederike
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