Photosynth Res (2017) 132:235–243
DOI 10.1007/s11120-017-0380-0

HISTORY AND BIOGRAPHY

André Tridon Jagendorf (1926–2017): a personal tribute

Govindjee[1]

Published online: 12 April 2017

Abstract We present here our tribute to an outstanding unique scientist, a pioneer of plant biochemistry, best known for his seminal ground-breaking discoveries related to electron and proton transport, and their intimate relation to ATP synthesis in chloroplasts. His dedication and in-depth understanding of science was matched by his humor. Here, we offer a modest précis of his life and research. We have also included *Reminiscences* from: Leonard Fish, Eric Larson, Donald Ort, Thomas Owens, and Robert Turgeon.

Keywords ATP · Chemiosmosis · Proton gradient · Photophosphorylation

André Tridon Jagendorf, Liberty H. Bailey Professor Emeritus of Plant Biology, in the College of Agriculture and Life Sciences at Cornell University since 1997, was born on October 21, 1926 in Manhattan, New York City, and died on March 13, 2017 in Ithaca, New York.

Figure 1 shows a portrait of Jagendorf, reproduced, from the Cornell Chronicle, March 23, 2017 (Cramer 2017).

Personal

André's father, Moritz Jagendorf, was a dentist by profession, and collected and wrote folklore stories for children. His mother, Sophie, was a gourmet cook and an accomplished hostess. From a young age, André was an avid reader, especially of science fiction, and was enamored of classical music, learning to play the mandolin and then viola, which he later played as part of a trio in Baltimore, Maryland. André was married on June 12, 1952 to Jean Elizabeth Whitenack. They have 3 children: Suzanne,

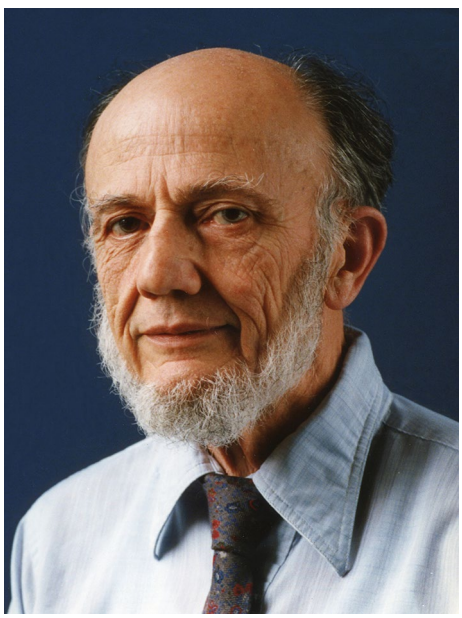

Fig. 1 André Jagendorf. *Source* Craig Cramer (2017) available at: http://www.news.cornell.edu/stories/2017/03/andr-jagendorf-pioneering-plant-biologist-dies-90

Read and approved for publication by Terry M. Bricker, Editor-in-Chief, Photosynthesis Research.

Electronic supplementary material The online version of this article (doi:10.1007/s11120-017-0380-0) contains supplementary material, which is available to authorized users.

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Judith, and Daniel (now deceased); 8 grandchildren, and 9 great grandchildren.

Education and service

In 1948, Jagendorf received a bachelor's degree in Plant Physiology from Cornell University. He earned his Ph.D. from Yale University in 1951 working with David Bonner; other members on his thesis committee were: James Bonner, Sam Wildman and Bernard Axelrod (for a research paper from that time, see Axelrod and Jagendorf 1951). Figure 2 shows a photo of André at Yale. André conducted post-doctoral research with Sam Wildman at the University of California at Los Angeles (1951–1953) as a Merck Fellow (see Jagendorf and Wildman 1954). In 1953 he joined the faculty at The Johns Hopkins University, where in 1958 he was promoted to Associate Professor. Figure 3 shows a photograph of André when he was on the faculty at The Johns Hopkins University. In 1966, he became a full Professor, but in the same year, he joined Cornell University as Professor of Plant Physiology, retiring there in 1997. In 1981 André became a Liberty Hyde Bailey Professor at Cornell.

Research

André's ground breaking work demonstrating that protons accumulated in the thylakoid lumen by incubating

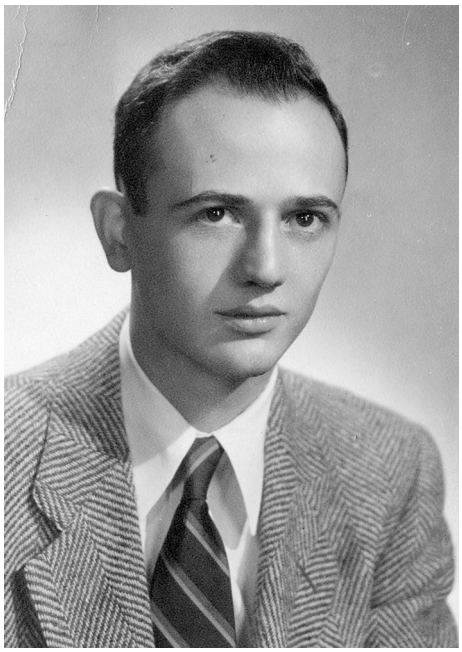

Fig. 2 André Jagendorf (1951, Yale University, New Haven, CT); photo by Samuel Kravitt. From the personal collection of Jean Jagendorf

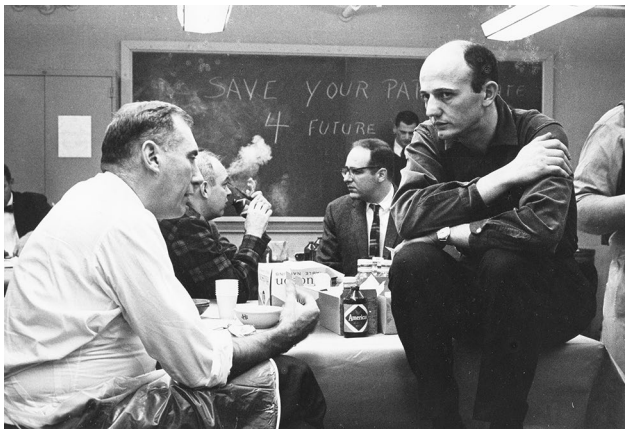

Fig. 3 André Jagendorf (~1958, Johns Hopkins, Baltimore, MD) sitting, thinking and discussing photosynthesis with another scientist; photo by William C. Hamilton. From the personal collection of Jean Jagendorf

in an "acid bath" in the dark or by preillumination could then drive the synthesis of ATP in dark, upon the addition of ADP, was among the most compelling evidence that won broad acceptance for Peter Mitchell's chemiosmotic hypothesis (cf. Mitchell 1978). Showing that ATP could be produced in darkness by protons accumulated within the thylakoid was really convincing because of the elegant simple experiments and the intuitive nature of the results [see e.g., Hind and Jagendorf (1963), Jagendorf and Hind (1963), Jagendorf and Uribe (1966), Jagendorf (1967), Kaplan et al. (1967) and Uribe and Jagendorf (1967a, b)]. For reviews on ATP synthesis, see e.g., Junge (2004) and Junge and Nelson (2015). To get a complete picture, it is best to read the in-depth personal perspectives by Jagendorf (1998) and Jagendorf (2002), and the papers cited in Appendix 1, which is a chronological list of some of André's selected publications. André also provided innovation in chloroplast molecular biology discovering among other things a gene for an enzyme responsible for DNA repair and recombination in chloroplasts (see e.g., Cerutti et al. 1992; Binet et al. 1993).

André's long list of Ph.D. students began with David (Dave) Krogmann (see Avron et al. 1958; Krogmann et al. 1959; and, see Brand et al. 2017, for a tribute to Dave).

Philosophy and some quotes

André's research philosophy is said to have been "Take a hammer and hit it at the right place." (For me this would have been to grab a hammer, and whack your dysfunctional machine at the right place to start it, or get rid of the unessential, i.e., concentrate on throwing the dart at the bull's eye!) André's ability to think for himself was obvious when

he was a child and he had created, with available blocks and boxes (big and small), a 2-story "ship", with stairs going up from the deck to the next floor. I am told that his kindergarten teacher had never seen anything like it!

Some of his quotes that I like are (cited from Jagendorf 1998):

> The probability of any one event occurring is amazingly small; in retrospect, each step seems like a minor miracle. Any person's career has to be shaped by interactions with other people.
> …doing science is fun

About his research, he wrote: "I had heard Peter Mitchell talk about chemiosmosis at a bioenergetics meeting in Sweden. His words went into one of my ears and out the other, leaving me feeling annoyed [that] they had allowed such a ridiculous and incomprehensible speaker in. But …… Geoffrey (Hind) was from England, both better trained and more intelligent than I was. He read Peter Mitchell's paper, came to me, and said 'André, could this possibly explain X_E [something that preceded ATP formation]?"

> At this point I began to communicate with Peter Mitchell himself... and [he] invited me to spend a week [with him] so he could educate me about the chemiosmotic hypothesis in more detail. I was happy to go, and enjoyed very much meeting his family and the family donkey, and ……I doubt that I learned enough about chemiosmosis, however.
> Later that summer I did the experiment that convinced me…that we were really seeing a chemiosmotic mechanism at work. The amount of ATP that was made depended on the height of the pH difference between acid and base stages, more than on their absolute values (Jagendorf and Uribe 1966).

Figure 4 shows André discussing his research (and discoveries) with two contemporaries (Bessel Kok and Roderick Clayton) who were also major discoverers in the field of photosynthesis research.

Fig. 4 A photograph at one of the conferences of photosynthesis sometimes in early 1960s. *Left to right* Bessel Kok, André Jagendorf, and Roderick Clayton. *Source* from the personal collection of Govindjee. For a tribute to Kok, see Myers (1987); and for a tribute to Clayton, see Wraight (2014)

Honors and awards

André appropriately received many awards and honors in his lifetime of which I list just a few: 1967: President of the American Society of Plant Physiology (now Biology) (ASPP, now ASPB); 1978: Charles F. Kettering Award of the ASPB; 1980: Elected Member, National Academy of Sciences, USA; 1989: Charles Reid Barnes Life Membership Award of ASPB; 2007: Elected Fellow of the American Society of Plant Biology (ASPB); 2013: 2012 Lifetime Achievement Award for Excellence in Biological Sciences, the Rebeiz Foundation, USA.

Quoted below is a testimonial, read at the 2013 ceremony for André. Chanoch Carmeli (of Tel Aviv, Israel) wrote "André Jagendorf, a brilliant and an original scientist, has made seminal contributions to the development of photophosphorylation and the elucidation of its mode of action. …… During his scientific career André Jagendorf proved himself as a nonconformist who broke new grounds in science using a rare combination of imagination, meticulous scrutiny of experimental results and the ability to devise ingenious experiments that gave answers to major unsolved mechanisms in science." From the web site of the Rebeiz Foundation: http://vlpbp.org/.

Figures 5 and 6 show André at the 2013 Award ceremony, with Wolfgang Junge (a co-recipient of the 2012-Lifetime Achievement Award of the Rebeiz Foundation) and with Govindjee (the author, the 2007 recipient of the same Award), respectively. Figure 7 shows André enjoying and celebrating, with his wife Jean, the very enjoyable ceremony at the Rebeiz Foundation in Champaign, Illinois.

Appendix 2 reproduces a part of the last e-mail I had from André; it reflects his enthusiasm for life and research. André was known for his almost *impromptu* jokes, which he told because he liked to see people smile. We, and many others I know, loved him, and will miss him.

Reminiscences

I end this Tribute by quoting reminiscences from several who knew André better than I. They are arranged alphabetically by last names.

Fig. 5 A 2013 photograph of Wolfgang Junge (*left*) and André Jagendorf (*right*), both engrossed in thinking of the future; photo by Laurent Gasquet, *Source* from the personal collection of Wolfgang Junge. (For a presentation by Govindjee on Junge, see: http://www.life.illinois.edu/govindjee/Electronic%20Publications/2013/2013junge.pdf)

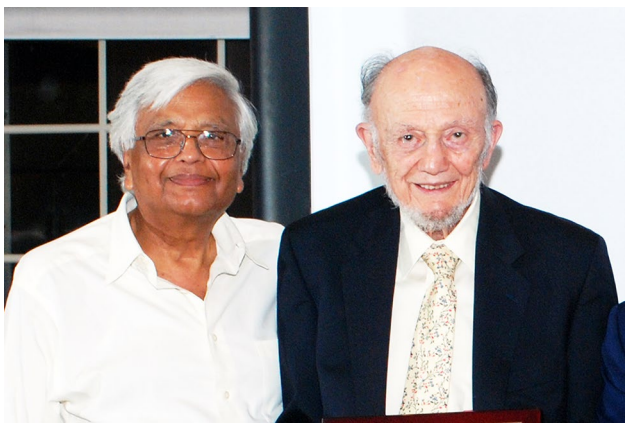

Fig. 6 A 2013 photograph of Govindjee (*left*) and André Jagendorf (*right*), both thinking of the present; photo by Laurent Gasquet. *Source* from the personal collection of Wolfgang Junge

Leonard (Len) Fish (San Diego, CA; e-mail: lfish983@att.net) wrote:

> I have great memories of my 5 years in André's lab, during which time I met my wife, Evelyne Delorme, who was a graduate student in another lab there. I showed up in André's office in the summer of 1977 with long hair down my back, a beard, a mustache, a leatherhead band, ragged cutoffs, and sandals. He didn't miss a beat, and welcomed me to Ithaca. During my time, André took in stride every idiosyncrasy that was manifested in the many post docs, graduate students, and undergraduates who worked in his lab. It was a very tolerant and terrific environment in which to explore new ideas that arose. My all-time favorite memory was arriving at the lab to discover that the second floor of the Plant Science building where our lab was located was shut down because tritiated water that André was using to label some component of coupling factor (I can't remember what) had escaped the hood and contaminated the entire area! It was bound to everything! Ultimately all was well … In any case, we had a great time working with André and in his Lab. I cite here two of my papers with him: Fish and Jagendorf (1982), and Fish et al. (1983).

Fig. 7 A 2013 photograph of André Jagendorf with Jean Jagendorf, photo by Laurent Gasquet; from the personal collection of Wolfgang Junge

Eric M. Larson (University of Illinois at Urbana-Champaign; e-mail: elarson@illinois.edu) wrote:

> One day as a graduate student at Cornell University I was looking through a file cabinet and came upon what were the original charts that showed the effect light had on the pH of a suspension of naked thylakoids. This was the first demonstration of proton pumping across membranes, which ultimately ended up supporting the theory of ATP synthesis by chemiosmosis. It also explained why André let me play all summer with a system that sampled a suspension of naked thylakoids, with and without light, where a continuous dye-based process monitored free phosphate release from ATPase activity. I was playing around, professionally, and that was the attitude André created in the lab—*play* "*professionally*" *as you never know where it will go*. And I did publish,

in addition to my PhD thesis, an interesting paper on sulfite stimulation of chloroplast coupling factor ATPase, where mutual interdependence of kinetic constants for ATP and for sulfite was observed (Larson and Jagendorf 1989).

Donald (Don) R. Ort (University of Illinois at Urbana-Champaign; email: d-ort@Illinois.edu) wrote:

In the early 1970s when I was a graduate student in Norman Good's laboratory the chemiosmotic theory was still being debated and the famous "X_E" and "acid-bath" experiments of Jagendorf that were its definitive proof were very exciting to me in their simplicity. I got to meet André while still a student after which we shared a longstanding joint interest in the mechanisms of photophosphorylation. Over the years I would get random phone calls from André on which he would simply begin speaking without identifying himself but I always knew instantly who it was. These calls always included, as did any encounter with Andre, one and often several of his jokes …… I always laughed but actually didn't "get" very many of them. While I don't aspire to being a joke teller, I do aspire to contributing just a fraction of what André accomplished scientifically.

Thomas (Tom) G. Owens (Cornell University; email:tgo2@cornell.edu) wrote:

I have two remembrances of André that will be with me forever. Both are from when I was a grad student at Cornell. André was in the lab every day (including weekends) and many nights. I told him what a bad example he was setting for young faculty who were hoping that there was life beyond the lab and office. André was also a member of my PhD committee, along with Rod Clayton, Andy Albrecht, and Dick McCarty (André kindly took over from Rod when Rod had his troubles). During my qualifying exams when Andy Albrecht asked me to derive the spin Hamiltonian for a hydrogen anion, André was sound asleep, head tipped back and snoring gently. Of course, he then went on to ask very probing questions about ATP synthesis and photosynthesis! I am so grateful to have been a colleague of his for 35 years.

Robert Turgeon (Cornell University; e-mail:ert2@cornell.edu) wrote:

André officially retired in 1997, giving up a corner lab on the second floor of the Plant Science Building, overlooking the Quad. I moved into that space and, knowing that André wanted to keep working, I asked if he would be an honorary lab member. He readily accepted and began what was to become a long and productive time at the bench. At first, André devoted himself primarily to helping undergraduate and graduate students and post docs. He was a true inspiration to them. I recall him telling Ashlee McCaskill, a graduate student at the time, that he had run leaf extracts of transgenic *Verbascum phoeniceum* for her in the HPLC and was "surprised" to find that they did not contain raffinose and stachyose. Ashlee was overjoyed. André knew, of course, that this was her main objective, and that blocking that pathway allowed her to test the polymer trap mechanism (McCaskill and Turgeon 2007). It meant, essentially, that she had a PhD thesis.

André continued in this fashion for many years, helping with experiments and general lab activities while refusing authorship so that he would not compromise students' academic advancement. A few years ago, André began a new study analyzing the biological activity of compounds transported in the xylem. The work he began continues. Figure 8 is a befitting Tribute to André as it shows him working in the laboratory, in 2016.

When the lab members had lunch together, André was almost always prepared with one of his jokes. Some he would tell only if no women were present. Many were fit for a general audience. All of them were funny.

Fig. 8 A 2016 photograph of André Jagendorf working at Cornell University in Robert Turgeon's laboratory; from the personal collection of Robert Turgeon

Acknowledgements The above text is based on my earlier presentation (see Supplementary Material) which is also available at: http://vlpbp.org/ltaawardJagendorf2012govindjeetestimonial.pdf as well as on my honor page on my web site at: http://www.life.illinois.edu/govindjee/honorsfrom.html. I thank Jean Jagendorf, Robert Turgeon, Wolfgang Junge & Constantin (Tino) Rebeiz for providing me most of the photographs used in this paper, and for supporting me in the preparation of this manuscript. I am grateful to Leonard (Len) Fish, Eric M. Larson, Donald R. Ort, Thomas G. Owens, and Robert Turgeon for providing me their reminiscences. Further, Tom Owens and Don Ort checked carefully the language and punctuations in this manuscript. I also thank Dominick Paolillo for alerting me to the sad news of André s death. Edward Cobb, Craig Cramer, and Randy Wayne, all at Cornell University, helped me in obtaining the photograph in Fig. 1; Figs. 2, and 3 were scanned by Robert H. Silsbee. I thank Rajni Govindjee for reading this Tribute and for her support during its preparation. My very special thanks go to Jean Jagendorf and André's daughters, Suzanne and Judy, for reading and approving the content of this Tribute.

Appendix 1: A chronological list of selected publications of André Jagendorf (1950s–1990s)

1950s

Axelrod B, Jagendorf AT (1951) The fate of phosphatase, invertase, and peroxidase in autolyzing leaves. Plant Physiol 26: 406–410

Jagendorf AT, Wildman SG (1954) The proteins of green leaves. VI. Centrifugal fractionation of tobacco leaf homogenates and some properties of isolated chloroplasts. Plant Physiol 29: 270–279

Jagendorf AT (1955) Purification of chloroplasts by a density technique. Plant Physiol 30: 138–143

Avron (Abramsky) M, Jagendorf AT (1956) A TPNH diaphorase from chloroplasts. Arch Biochem Biophys 65: 475–490

Jagendorf AT (1956) Oxidation and reduction of pyridine nucleotides by purified chloroplasts. Arch Biochem Biophys 62: 141–150

Avron M, Jagendorf AT (1957) An extractable factor in photosynthetic phosphorylation. Nature 179: 428–429

Avron M, Krogmann DW, Jagendorf AT (1958) The relation of photosynthetic phosphorylation to the Hill reaction. Biochim Biophys Acta 30: 144–153

Jagendorf AT, Avron M (1958) Co-factors and rates of photosynthetic phosphorylation by spinach chloroplasts. J Biol Chem 231: 277–290

Avron M, Jagendorf AT (1959) Evidence concerning the mechanism of ATP formation by spinach chloroplasts. J Biol Chem 234: 967–972

Krogmann DW Jagendorf AT, Avron M (1959) Uncouplers of spinach chloroplast photosynthetic phosphorylation. Plant Physiol 34: 272–277

1960s

Jagendorf AT (1961) Photophosphorylation and the Hill reaction. Nature 191: 679–680

Jagendorf AT (1962) Biochemistry of energy transformations during photosynthesis. In: Glass HB (ed) Survey of Biological Progress, Vol IV, pp 181–344. Academic Press, New York

Jagendorf AT, Smith M (1962) Uncoupling phosphorylation in spinach chloroplasts by absence of cations. Plant Physiol 37: 135–141

Hind G, Jagendorf AT (1963) Separation of light and dark stages in photophosphorylation. Proc Nat Acad Sci USA 49: 715–722

Jagendorf AT and Hind G (1963) Studies on the mechanism of photophosphorylation, In: Kok B and Jagendorf AT (eds) Photosynthetic Mechanisms of Green Plants, pp 599–610. Publication 1145 of National Academy of Sciences–National Research Council, Washington, DC

Jagendorf AT, Patchornik A, Sela M (1963) Use of antibody bound to modified cellulose as an immunospecific adsorbent of antigens. Biochim Biophys Acta 78: 516–528

Neumann J and Jagendorf AT (1964) Light-induced pH changes related to phosphorylation by chloroplasts. Arch Biochem Biophys 107: 109–119

Hind G, Jagendorf AT (1965) Light scattering changes associated with the production of a possible intermediate in photophosphorylation. J Biol Chem 240: 3195–3201

Jagendorf AT, Neumann J (1965) Effect of uncouplers on the light-induced pH rise with spinach chloroplasts. J Biol Chem 240: 3210–3214

Jagendorf AT, Uribe E (1966) ATP formation caused by acid base transition of spinach chloroplasts. Proc Natl Acad Sci USA 55: 170–177

Kaplan J, Uribe E, Jagendorf AT (1967) ATP hydrolysis caused by acid-base transition of spinach chloroplasts. Arch Biochem Biophys 20: 365–375

Uribe E, Jagendorf AT (1967a) Organic acid specificity for acid induced ATP synthesis by isolated chloroplasts. Plant Physiol 42: 706–711

Uribe E, Jagendorf AT (1967b) On the localization of organic acids in acid-induced ATP synthesis. Plant Physiol 42: 697–705

1970s

Miles CD, Jagendorf AT (1970) Evaluation of electron transport as the basis of ATP synthesis after acid-base transition by spinach chloroplasts. Biochemistry 9: 429–434

Polya GM, Jagendorf AT (1971) Wheat leaf RNA polymerases. I. Partial purification and characterization of nuclear, chloroplast and soluble DNA-dependent enzymes. Arch Biochem Biophys 146: 635–648

Ryrie I, Jagendorf AT (1971) An energy-linked conformational change in the coupling factor protein in chloroplasts. Studies with hydrogen exchange. J Biol Chem 246: 3771–3774

Ryrie I, Jagendorf AT (1972) Correlation between a conformational change in the coupling factor protein and the high energy state in chloroplasts. J Biol Chem 247: 4453–4459

Gooding L, Roy H, Jagendorf AT (1973) Immunological identification of nascent subunits of wheat ribulose diphosphate carboxylase on ribosomes of both chloroplast and cytoplasmic origin. Arch Biochem Biophys 159: 324–335

Grebanier AE, Jagendorf AT (1977) Lack of specificity of spinach chloroplast coupling factor one. Biochim Biophys Acta 459: 1–9

Binder A Jagendorf AT, Ngo E (1978) Isolation and composition of the subunits of spinach chloroplast coupling factor protein. J Biol Chem 253: 3094–3100

1980s

Telfer A, Barber J, Jagendorf AT (1980) Electrostatic control of chloroplast coupling factor binding to thylakoid membranes as indicated by cation effects on electron transport and reconstitution of photophosphorylation Biochim Biophys Acta 591: 331–34

Fish, LE, Jagendorf AT (1982) High rates of protein synthesis by isolated chloroplasts. Plant Physiol 70: 1107–1114

Anthon GE, Jagendorf AT (1983) Effect of methanol on spinach thylakoid ATPase. Biochim Biophys Acta 723: 358–365

Fish LE, Deshaies R, Jagendorf AT (1983) A Mg^{2+} requirement for rapid ATP driven protein synthesis by intact pea chloroplasts. Plant Sci Lett 31: 139–146

Liu X-Q, Jagendorf AT (1984) ATP-dependent proteolysis in pea chloroplasts. FEBS Lett 166: 248–252

Doremus HD, Jagendorf AT (1985) Subcellular localization of the pathway of de novo pyrimidine nucleotide biosynthesis in pea leaves. Plant Physiol 79: 856–861

Anthon GE, Jagendorf AT (1986) Evidence for multiple effects in the methanol activation of chloroplast coupling factor one. Biochim Biophys Acta 848: 92–98

Larson EM, Jagendorf AT (1989) Sulfite stimulation of chloroplast coupling factor ATPase. Biochim Biophys Acta 973: 67–77

Larson EM, Umbach AL and Jagendorf AT (1989) Sulfite stimulated release of (3H)-ADP bound to chloroplast thylakoid ATPase. Biochim Biophys Acta 973: 78–85

1990s

Jagendorf AT, McCarty RE, Robertson D (1991) Coupling factor components: structure and function. In: Bogorad L and Vasil IK (eds) Cell Culture and Somatic Cell Genetics of Plants, Vol 7B, pp 225–254. Academic Press, New York

Cerutti H, Osman M, Grandoni P, Jagendorf AT (1992) A homolog of *Escherichia coli* RecA protein in

plastids of higher plants. Proc Natl Acad Sci USA 89: 8068–8072

Binet M-N, Osman M, Jagendorf AT (1993) Genomic nucleotide sequence of a gene from *Arabidopsis thaliana* encoding a protein homolog of *E. coli* RecA. Plant Physiol 103 (2): 673–674

Bushnell TP, Bushnell D, Jagendorf AT (1993) A purified zinc protease of pea chloroplasts, EP1, degrades the large subunit of Rubisco. Plant Physiol 103: 585–591

Cerutti H, Jagendorf AT (1993) DNA strand transfer activity in pea (*Pisum sativum*) chloroplasts. Plant Physiol 102: 145–153

Chen GG, Jagendorf AT (1994) Chloroplast molecular chaperone-assisted refolding and reconstitution of an active multi-subunit CF1 core. Proc Natl Acad Sci USA 91: 11497–11501

Cerutti H, Jagendorf AT (1995) Movement of DNA across the chloroplast envelope: Implications for the transfer of promiscuous DNA. Photosynth Res 46: 329–337

Zhang S, Jagendorf AT (1995) Some unique characteristics of thylakoid unisite ATPase. J Biol Chem 270: 6607–6614

Cao J, Combs C, Jagendorf AT (1997) The chloroplast-located homolog of bacterial DNA recombinase. Plant Cell Physiol 38: 1319–1325

Jagendorf AT (1998) Chance, luck and photosynthesis research – an inside story. Photosynthesis Res 57: 215–229

Appendix 2: December 4, 2016 e-mail of Jagendorf to Govindjee

[It reflects the way **André** lived and thought during the last phase of his life: full of details, ideas, hope, and even discussion of lab research.]

Subject	Re: Congratulations on turning 90
From	"Andre Jagendorf" <atj1@cornell.edu>
Date	Sun, December 4, 2016 21:11
To	"Govindjee" <gov@life.illinois.edu>
Priority	Normal Gov:

This Sunday is a busy day for us: I make a large breakfast, which we eat between 10:45 and 12:00 [noon]. After freshening up and helping with the dishes, I go up to the main building and water plants in two of the common rooms. Then I collect our dinner from the main dining room, go home, take a nap. Then we leave at 3:00 [PM] to be up to get the bus which loads at 3:20; after waiting for everyone to come it takes us to the Kitchen Theater for a play (today's—a frenetic one man show called "Death Boogie"). Getting home I get supper ready and we eat, then watch a Netflix episode (a series, in Danish, called "Borgen"—all about Danish politics and the problems of a woman Prime Minister). Finally we settle down for the evening and I get to look at my Emails.

Yes, I was 90 on October 21. Didn't think I would make it. ……In May I started eating the leaves of *Houttuynia cordata*, an herbal remedy in China and India that's supposed to cure almost everything. Anyway everyone, including myself, is surprised that I've hit a steady state (low, but bearable) level this long. *I'm still working on trying to purify and identify the mysterious factor in xylem sap that helps discs from mature tobacco leaves grow* (*in 8 days*) *to 10 to 15 times their original fresh weight*.

We hope all is well with you.

Best regards,

André

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Axelrod B, Jagendorf AT (1951) The fate of phosphatase, invertase, and peroxidase in autolyzing leaves. Plant Physiol 26:406–410

Binet M-N, Osman M, Jagendorf AT (1993) Genomic nucleotide sequence of a gene from *Arabidopsis thaliana* encoding a protein homolog of *E. coli* RecA. Plant Physiol 103(2):673–674

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Jagendorf AT (2002) Photophosphorylation and the chemiosmotic perspective. Photosynth Res 73:233–241

Jagendorf AT, Hind G (1963) Studies on the mechanism of photophosphorylation. In: Kok B, Jagendorf AT (eds) Photosynthetic mechanisms of green plants. Publication 1145 of National Academy of Sciences—National Research Council, Washington, DC, pp 599–610

Jagendorf AT, Uribe E (1966) ATP formation caused by acid base transition of spinach chloroplasts. Proc Natl Acad Sci USA 55:170–177

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Kaplan J, Uribe E, Jagendorf AT (1967) ATP hydrolysis caused by acid-base transition of spinach chloroplasts. Arch Biochem Biophys 20:365–375

Krogmann DW, Jagendorf AT, Avron M (1959) Uncouplers of spinach chloroplast photosynthetic phosphorylation. Plant Physiol 34:272–277

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