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James Barber (1940–2020): A very remarkable biochemist of our time

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Introduction

I present below a brief tribute to James Barber, one of my dearest friends, who is known to his innumerable friends, colleagues, and family as Jim. He was born on 16 July 1940 in Letchworth, Hertfordshire, U.K., and passed away on 5 January 2020 in London, U.K., after battling cancer for several years. Jim was a unique human being and one of the most dedicated of all scientists amongst us. He was also one of the friendliest and most curiosity-driven biochemists of our century, a gem of a person, a great mentor, and one who fervently shared his deep thoughts with all. Jim was one of the greatest communicators of all times. He has left us behind to make his dreams come true: to use the molecular and structural knowledge of photosynthesis to solve the problems of food insecurity around the globe.

Jim is survived by his wife, Lyn, and their children, Julie and Neil, their spouses, six grandchildren (*see* Fig. 1), and an enormous number of followers in science around the world.

First, a bit of Jim's academic background. From the age of 11, he attended Portsmouth Southern Grammar School for Boys, but left school when he was just 16 to mix working and studying (including engineering-related courses) before completing his B.Sc. in 1964 at University College, Swansea; initially Jim studied chemical engineering but later focused on chemistry. He earned both his M.Sc. in 1965 and Ph.D. in 1967 in Biophysics with Jack Dainty (1919–2009) at the University of East Anglia. Jim then did a year of postdoctoral research in the laboratory of the world-famous biophysicist Louis Nico Marie (L.N.M.) Duysens (1921–2015; *see* Govindjee and Pulles 2016). In 1968, Jim joined Imperial College in London as Lecturer in the Department of Botany and Plant Technology. He was promoted first to Reader and in 1979 to Professor, all in Plant Physiology, where he

Fig. 1. (*A*) A November 2019 photograph of James Barber (*top right*), his wife Lyn (*bottom right*), daughter Julie (*top left*), and son Neil (*bottom left*), Sussex, UK. Source: Julie Barber (Lovell). (*B*) A May 2019 photograph of James Barber and his entire family, taken at his home in London, UK. Back row (*left to right*): Jessica Barber, Toby Barber, Neil Barber, Lizzie Barber, Julie Lovell, Harry Lovell, and Tom Lovell. Sitting (*left to right*): Ben Lovell, Lyn Barber, James Barber, and Zoe Lovell. Sitting in the front is Theo Barber. Source: Julie Barber (Lovell).

Acknowledgments: I thank Helena Synková of Photosynthetica for the invitation to present this brief personal and special tribute to James Barber, FRS. I am highly grateful to Alison Telfer (a long-time associate of Jim), Julie Barber (Jim's daughter), and Robert Blankenship (an authority on photosynthesis) for reading this manuscript before its publication. Also, I thank Gyözo Garab for his personal reminiscence of Jim Barber and Barbara Zilinskas for editing the final version of this tribute. Further, I urge the readers to see Appendix 1 for a selected list of his key publications in chronological order, and Appendix 2 for some links to informative web pages. I would be remiss if I did not mention that Jim and I had an interest in recording what took place at conferences that we attended together (*e.g.*, *see* Govindjee and Barber 1980). However, the more significant joint thought is our 'opinion', entitled 'Running on Sun' (Najafpour *et al.* 2012).

worked until 1989. From 1988–1989, he also served as Dean of the Royal College of Science, London, U.K. For the following decade, Jim was Professor and Head of the Biochemistry Department at Imperial College until he retired.

Many times I asked myself '*What did Jim Barber really do for the understanding of oxygenic photosynthesis?*'. My answer was/and still is '*much more than any one person I can think of can do in his/her lifetime*' – and to do him justice, I would need to write a book about all of it. Jim published more than 650 original papers and reviews both in natural as well as artificial photosynthesis. To top it all, he edited many advanced books in photosynthesis (*see e.g.*, Barber 1987, 1992; Barber and Malkin 1989, Barber and Ruban 2017), including two with me (Govindjee *et al*. 1987, Singhal *et al*. 1989).

Jim has interacted with hundreds of scientists and students around the globe. Figs. 2, 3, and 4 show a selection of some of his photos with others.

To me, Jim was a scientist of the highest order: open with his research and ideas and curious about all aspects of photosynthesis. Above all, he was fearless. He never stopped 'giving' and 'expressing' his ideas publicly to anyone, even when he was seriously ill. I remember that during this period, he flew to Moscow (Russia), delivering an exciting lecture with great enthusiasm (as ever before)

Fig. 2. (*A*) James (Jim) Barber in the UK in 2005. (*B*) John Walker and Jim Barber sightseeing in China in 2010. (*C*) Jim Barber with G. Govindjee (*middle*) and Chuck Dismukes at a Gordon Conference in the USA. Source: Rajni Govindjee.

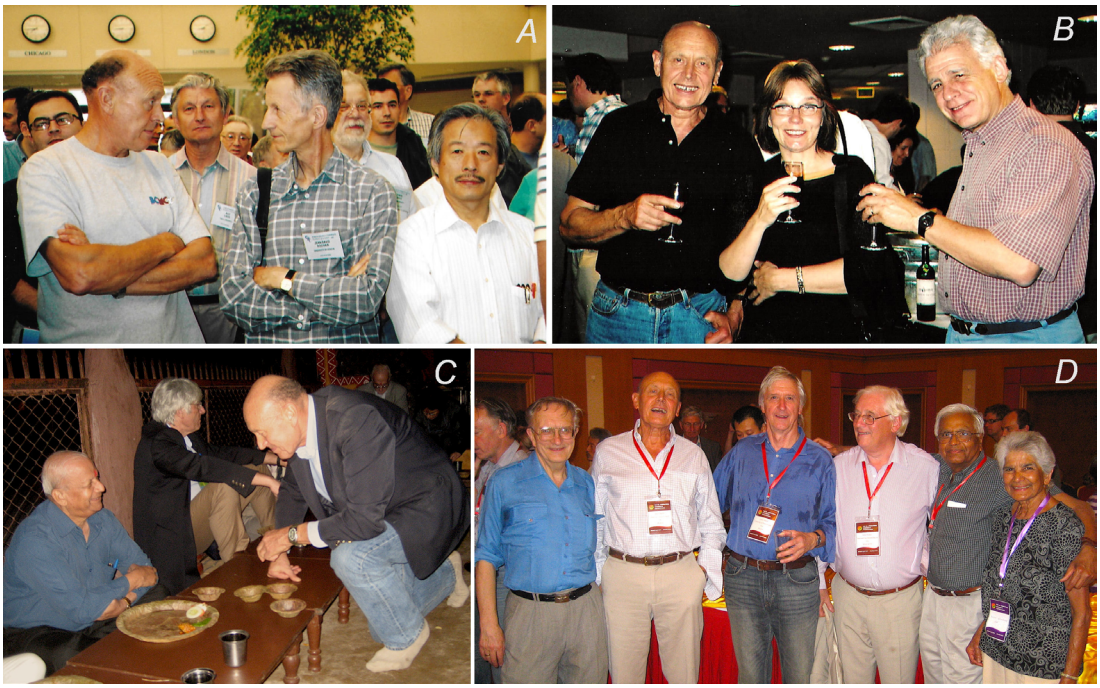

Fig. 3. (*A*) A photograph of James (Jim) Barber (*on the left in the front*) having a discussion with Jean-Davide Rochaix (of Switzerland); Agu Laisk (of Estonia) is between them; on the extreme right is Masami Kusunoki from Japan. (*B*) At a reception at a photosynthesis congress (*left to right*): Jim Barber, Eva-Mari Aro (of Finland), and the late David Knaff (of USA; *see* Malkin 2016). (*C*) Jim Barber (*extreme right*) chatting with Raj Sane (of India); in the middle is Reto J. Strasser at a 2008 International Conference on Photosynthesis, held in India. (*D*) A group photograph at the 15th International Congress on Photosynthesis in Beijing, China. *Left to right*: the late Gernot Renger (of Germany; *see* Siggel *et al*. 2016), Jim Barber (of UK), Les Dutton (of USA), John Walker (of UK), Govindjee Govindjee (of USA), and Rajni Govindjee (of USA). Source: Rajni Govindjee.

Fig. 4. (*A*) A group photograph at the 15th International Congress on Photosynthesis in Beijing, China (2010); *left to right*: Ting-Yun Kuang (of China), Jim Barber, Sir John Walker and two organizers. (*B*) Jim Barber (*2nd from right*) at a 2011 International Congress on Photosynthesis in Baku, Azerbaijan, socializing with young scientists, along with Govindjee (*2nd from left*). (*C*) Jim Barber (*extreme right*), next to him is Ali Abbasov, and William (Bill) Rutherford (of UK) at a dinner at the 2011 International Congress on Photosynthesis in Baku, Azerbaijan. Source (*B* and *C*): Allakhverdiev *et al.* (2012). (*D*) A sightseeing trip at the 2013 International Congress on Photosynthesis in Russia; *left to right*: G. Govindjee, Robert Blankenship (of USA), Jim Barber, and Mathias Rögner (of Germany). Source: Rajni Govindjee.

in Pushchino, and then flew back to the U.K. for his cancer treatment with his dedicated and beloved wife Lyn by his side. Indeed, Jim Barber was a unique scientist amongst us. When I asked Jim what he thought was his greatest research contribution, he answered that it was the high-resolution determination of the structure of Photosystem II. He had clearly learned that experimental results are the 'masters' – not what one may expect from one's own thinking, and from theories (even from the Nobel laureates) in the literature. Further, he strongly believed (and spoke with a bright glow in his eyes) that harnessing solar energy efficiently for the benefit of all is the most important direction on which we all must focus. As an aside, Jim loved to garden, growing his vegetables, and to build fun things around the house.

Research

To get just a glimpse into Jim Barber's research, see the following summary:

(*1*) Jim was one of the key scientists to unravel the intricate molecular details at the atomic level of the structure of Photosystem II. *See* Shen (2015), and Shevela *et al.* (2021) for important reviews on PSII, the unit that oxidizes water to oxygen and reduces plastoquinone. Also *see* Jim's famous paper, on the fully refined PSII structure at 3.5 Å resolution: Ferreira *et al.* 2004, cf. Barber 2004, also *see* Rhee *et al.* 1997, Nield and Barber 2006, and Kargul *et al.* 2007. Finally, view a later Youtube presentation on this topic by Jim Barber himself: https://www.youtube.com/watch?v=IscZxBYEtD4.

Determining the structure of Photosystem II has been a holy grail of photosynthesis research for many decades. The first X-ray diffraction paper on the structure of PSII was by Zouni *et al.* (2001) at 3.8 Å resolution. Jim's 2004 paper at 3.5 Å resolution was a significant advance (Ferreira *et al.* 2004). In addition, Jim's search and identification of the binding site(s) of chloride ions in PSII was a major finding (*see* Murray *et al.* 2008). The Umena *et al.* (2011) structure at 1.9 Å resolution is still the highest resolution structure available.

(*2*) Jim was the topmost 'master and chef' of the role and function of ions in photosynthetic membranes (*see e.g.*, Barber 1976, 1980, 1982, 1986, 1987, and 1989; also *see* chapters in Papageorgiou *et al.* 1986); for further insight on this topic, *see* Kaňa and Govindjee (2016), who not only discussed the impact of Jim's work in this area but dedicated their paper to Jim's pioneering research on many aspects of photosynthesis, including the electrostatic properties of the chloroplast thylakoid membrane.

(*3*) Jim was indeed the world's leader in exploring artificial photosynthesis, based on his extensive in-depth knowledge of natural photosynthesis (*e.g.*, *see* Barber 2009, Barber and Tran 2013). His research in this area was supported by two international laboratories (*i*) in Singapore [where he was Visiting Canon Professor at the Solar Fuels Laboratory at the School of Material Science at Nanyang Technological University (NTU)]; *e.g.*, *see* Barber (2009), Tran *et al.* (2012), and Gurudayal *et al.* (2015); and (*ii*) in Italy [where he served as a Visiting Professor at the BioSolar Laboratory in the Applied Science and Technology Department (DISAT) at the Polytechnic of Turin (Politecnico di Torino, University of Turin] (*e.g.*, *see* Barera *et al.* 2012).

Unraveling the blueprint of '*how photosynthesis gives us food, oxygen and fuel*' and '*how we can improve it to feed the future generation*' was Jim's lasting goal as it is for many others today. It is not surprising that Bertil Andersson (European Science Foundation, Strasbourg) dedicated a special issue of Photochemical and Photobiological Sciences in October 2005 to James Barber on his 65th birthday (Andersson 2005, Nield and Nixon 2005), the same year that Jim had done wonders in 'digging' into the structure of the 'water-plastoquinone oxido-reductase' of Photosystem II at atomic level resolution.

Jim's research and his many other accomplishments are enormous and unmatched in the field of photosynthesis. The best description of his research is written by himself in a remarkable book (*see* Barber 2020). Jim wrote this tome in a unique manner, unmatched in the history of photosynthesis. I have provided in Appendix 1 a selected list of Jim Barber's key publications in chronological order. (I am personally pleased to note that Jim included me as one of 20 scientists with whom he interacted that continues to provide benefit and encouragement to others in photosynthesis.) In an effort to educate and stimulate young graduate students interested in plant biology, biochemistry, and biophysics, Jim initiated the writing and editing of an invaluable series of books entitled 'Topics in Photosynthesis' (*see e.g.*, Barber 1992); Jim's initiative led me later to initiate another series (Advances in Photosynthesis and Respiration, Springer, now in its 48th volume; *see*: https://www.springer.com/series/5599).

Awards and honors

I have been one of the many who have been deeply 'touched' by Jim's way of asking and answering questions. Throughout his life, Jim was honored with countless awards; the list is indeed very long (*see* below) – unmatched in the history of scientists working in the field of 'oxygenic photosynthesis', an area which both of us loved and chatted about – including at parties that Jim and Lyn hosted at their home. Once he had a one-of-a-kind party for me and many others – following my lecture at the Imperial College. Having been invited to stay overnight at his home provided me with a special feeling of belonging to his family.

I believe that it is important to list all of Jim's many awards and honors as it shows both the depth and breadth of Jim's academic as well as his social life.

1989: Member of Academia Europaea (https://en.wikipedia.org/wiki/Academia_Europaea)
1992: Honorary doctorate from Stockholm University
1995: Selby Fellow of the Australian Academy of Science (https://www.science.org.au/supporting-science/awards-and-opportunities/selby-fellowship-0)
2002: Flintoff Medal by the Royal Society of Chemistry, UK (https://www.wikidata.org/wiki/Q42736999)
2003: Foreign Member of the Royal Swedish Academy of Sciences (https://en.wikipedia.org/wiki/Royal_Swedish_Academy_of_Sciences)
2005: ENI (an Italian oil and gas company) Award for innovation (https://www.eni.com/en-IT/about-us.html)
2005: Fellow of the Royal Society (FRS) of UK (https://royalsociety.org/fellows/)
2006: Novartis International Medal (of the Biochemical Society) and earlier the Italgas Prize for energy and the environment (https://www.novartis.com/)
2006: The International Conference on Photosynthesis in the Post-Genomic Era: Structure and Function of Photosystems in Pushchino, Russia, honoring Jim (*see* Govindjee and Telfer 2007)
2007: George W. Wheland Medal and Prize, Chemistry, University of Chicago, USA (2010https://chemistry.uchicago.edu/wheland-lecture)
2007–2010: President of the International Society of Photosynthesis Research
2008: Lee Kuan Yew Distinguished Visiting Professor to Singapore
2010: Honorary doctorate from the University of East Anglia, UK
2013: Royal Society of Chemistry Interdisciplinary Prize (https://www.rsc.org/prizes-funding/prizes/find-a-prize/interdisciplinary-prizes/)
2016: The George Porter Medal of the European Photochemistry Association (https://www.photochemistry.eu/)
2016: Communication Award of ISPR (International Society of Photosynthesis Research https://www.photosynthesis-research.org/)
2020: Norman Heatley Medal and Prize of the Biochemical Society, U.K. (https://www.biochemistry.org/grants-and-awards/awards/the-heatley-medal-and-prize/)

Concluding remarks

I end this brief personal tribute by referring the readers to Jim's own story in his own words (*see* Barber 2004). In 2004, he briefly described, upon my invitation, his journey in research showing his concern for accuracy, as well as his humility and recognition of others. For me, this paper is of personal interest since his research (*see* Barber 2020) and mine (*see e.g.*, Govindjee 2019, Kumar *et al.* 2021) have overlapped in the area of '*the primary photochemistry and biochemistry of photosystem II*', on the '*role of ions (cations and anions) in thylakoid membranes*', and in the exploitation of both '*prompt and delayed chlorophyll a fluorescence*'. The final word and the most sophisticated and personal description of Barber's own life and work is in his latest book (on the big bang of evolution and

the engine of life; *see* Barber 2020). In addition to Jim's important research, as well as his spreading the gospel of photosynthesis through books, Jim also was keen to remember and recognize those who are no more with us (*see e.g.*, a tribute, coauthored by him, for Slava Klimov: Allahkhverdiev *et al*. 2018).

Let Jim's persona guide the young scientists through his research and his deep curiosity in science – and let the questioning attitude reign the future for our quest for a better life for us all – as Jim would have wanted it!

Messages

Julie, Jim's daughter wrote: 'This is a wonderful Tribute to my Dad. Many thanks for all your hard work in creating this lovely tribute. I must tell you that he will be very chuffed to read your kind words.'

I have included below an eloquently written reminiscence received from Gyozo Garab just before the publication of this tribute. It captures precisely and beautifully why Jim Barber is well-deserving of this tribute and why he will be sorely missed by all who had the opportunity to know him.

Gyözo Garab (e-mail: gyozo@brc.hu): Jim Barber, in addition to his great contributions to the advancement of our knowledge on the molecular mechanism of photosynthesis, spared no effort to call the attention of policy makers and scientists to the global problems of climate change facing us all, and the use of solar energy to deal with it. He gave passionate talks with mind-capturing illustrations and expressions about photosynthesis, '*as the most important chemical reaction on planet Earth*', a process occurring in this '*macroscopic reaction vessel*'. Jim, during his long and outstanding scientific career, was one of the blessed scientists who succeeded in changing our picture of Photosystem II and '*the magic reactions of water splitting*' '*from black box to atomic-level resolution structures*'. His talks about the '*Engine of Life*', and how oxygenic photosynthesis instigated '*about 2.5 billion years ago the big bang of evolution*' were presented in majestic style, spiced with great humor. These and his enthusiastic vision about artificial leaf ('*if leaves can do it, we can do it, too*') inspired many young scientists to start or continue their research on both natural and artificial photosynthesis. His long-lasting legacy will be remembered by the scientific community; many of us who had the chance to meet Jim in person will also cherish memories of his highly friendly personality.

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Barber J. (ed.): The Photosystems: Structure, Function and Molecular Biology. Topics in Photosynthesis. Vol. 11. Pp. 557. Elsevier, Amsterdam 1992.

Barber J.: Engine of life and big bang of evolution: a personal perspective. – Photosynth. Res. **80**: 137-155, 2004.

Barber J.: Photosynthetic energy conversion: natural and artificial. – Chem. Soc. Rev. **38**: 185-196, 2009.

Barber J.: The Big Bang of Evolution and the Engine of Life: Climbing a Mountain. A Personal Journey of James Barber. Pp. 552. World Scientific, Singapore 2020.

Barber J., Malkin R. (ed.): Techniques and New Developments in Photosynthesis Research. Pp. 608. Springer, Boston 1989.

Barber J., Ruban A.V. (ed.): Photosynthesis and Bioenergetics. Pp. 368. World Scientific, Singapore 2017.

Barber J., Tran P.D.: From natural to artificial photosynthesis. – J. R. Soc. Interface **10**: 20120984, 2013.

Barera S., Pagliano C., Pape T. *et al*.: Characterization of PSII-LHCII supercomplexes isolated from pea thylakoid membranes by one-step treatment with α- and β-dodecyl-D-maltoside. – Philos. T. Roy. Soc. B **367**: 3389-3399, 2012.

Ferreira K.N., Iverson T.M., Maghlaoui K. *et al*.: Architecture of the photosynthetic oxygen-evolving center. – Science **303**: 1831-1838, 2004.

Govindjee G.: A sixty-year tryst with photosynthesis and related processes: an informal personal perspective. – Photosynth. Res. **139**: 15-43, 2019.

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Govindjee G., Barber J., Cramer W.A. *et al*. (ed.): Excitation Energy and Electron Transfer in Photosynthesis. Dedicated to Warren L. Butler. Pp. 388. Martinus Nijhoff Publishers, The Netherlands 1987.

Govindjee G., Pulles M.P.J.: Louis Nico Marie Duysens (March 15, 1921–September 8, 2015): A leading biophysicist of the 20th century. – Photosynth. Res. **128**: 223-234, 2016.

Govindjee G., Telfer A.: Six young research investigators were honored at an international conference in Russia. – Photosynth. Res. **92**: 139-141, 2007.

Gurudayal, Sabba D., Kumar M.H. *et al*.: Perovskite–hematite tandem cells for efficient overall solar driven water splitting. – Nano Lett. **15**: 3833-3839, 2015.

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Kargul J., Maghlaoui K., Murray J.W. *et al*.: Purification, crystallization and X-ray diffraction analyses of the *T. elongatus* PSII core dimer with strontium replacing calcium

in the oxygen-evolving complex. – BBA-Bioenergetics **1767**: 404-413, 2007.
Kumar A., Block J.E., Nonomura A.M.: Mister Photosynthesis of the 21st century, Govindjee. – Int. J. Life Sci. **10**: 61-80, 2021.
Malkin R.: Remembering David B. Knaff (1941–2016). – Photosynth. Res. **129**: 1-12, 2016.
Murray J.W., Maghlaoui K., Kargul J. *et al.*: X-ray crystallography identifies two chloride binding sites in the oxygen evolving centre of Photosystem II. – Energy Environ. Sci. **1**: 161-166, 2008.
Najafpour M.M., Barber J., Shen J.-R. *et al.*: Running on Sun. Chemistry World, 2012. https://www.chemistryworld.com/opinion/running-on-sun/5463.article.
Nield J., Barber J.: Refinement of the structural model for the Photosystem II supercomplex of higher plants. – BBA-Bioenergetics **1757**: 353-361, 2006.
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Appendix 1. A list of arbitrarily selected 60 papers of Jim Barber and his collaborators, which is ~10–15% of all of his publications, arranged in chronological order.

A.1. Role of ions in photosynthesis: General

1968
Barber J.: Light induced uptake of potassium and chloride by *Chlorella pyrenoidosa*. – Nature **217**: 876-878, 1968.

1970
Barber J., Kraan G.P.B.: Salt-induced light emission from chloroplasts. – BBA-Bioenergetics **197**: 49-59, 1970.

1971
Shieh Y.J., Barber J.: Intracellular sodium and potassium concentrations and net cation movements in *Chlorella pyrenoidosa*. – BBA-Biomembranes **223**: 594-603, 1971.

A.2. Role of ions in photosynthesis: Exploitation of light emission by plants, use of ionophores, and electrostatics

1972
Barber J., Varley W.J.: Stimulation of delayed light emission by salt gradients and estimation of the relative ionic permeabilities of the thylakoid membrane. – J. Exp. Bot. **23**: 216-228, 1972.

1974
Barber J., Telfer A., Nicolson J.: Evidence for divalent cation movement within isolated whole chloroplasts from studies with ionophore A23187. – BBA-Bioenergetics **357**: 161-165, 1974.

Barber J., Mills J.D., Nicolson J.: Studies with cation specific ionophores show that within the intact chloroplast Mg^{2+} acts as the main counter-ion for H^+ pumping. – FEBS Lett. **49**: 106-110, 1974.

1975
Mills J.D., Barber J.: Energy-dependent cation induced control of chlorophyll *a* fluorescence in isolated intact chloroplasts. – Arch. Biochem. Biophys. **170**: 306-314, 1975.

B.1 and B.2: Exploitation of lifetime of chlorophyll *a* fluorescence to understand primary events, and A zig-zag path to release of things into the atmosphere

1975
Beauford W., Barber J., Barringer A.R.: Heavy metal release from plants into the atmosphere. – Nature **256**: 35-37, 1975.

1975
Beddard G.S., Porter G., Tredwell C.J., Barber J.: Fluorescence lifetimes in the photosynthetic unit. – Nature **258**: 166-168, 1975.

1977
Beauford W., Barber J., Barringer A.R.: Release of particles containing metals from vegetation into the atmosphere. – Science **195:** 571-573, 1977.

1978
Barber J., Searle G.F.W., Tredwell C.J.: Picosecond time-resolved study of $MgCl_2$-induced chlorophyll fluorescence yield changes from chloroplasts. – BBA-Bioenergetics **501**: 174-182, 1978.

Porter G., Tredwell C.J., Searle G.F.W., Barber J: Picosecond time-resolved energy transfer in *Porphyridium cruentum*. Part I. In the intact alga. – BBA-Bioenergetics **501**: 232-245, 1978.

1979
Butler W.L., Tredwell C.J., Malkin R., Barber J.: The relationship between the lifetime and yield of the 735 nm fluorescence of chloroplasts at low temperatures. – BBA-Bioenergetics **545**: 309-315, 1979.

1981
Brody S.S., Tredwell C.J., Barber J.: Picosecond energy transfer in *Porphyridium cruentum* and *Anacystis nidulans*. – Biophys. J. **34**: 439-449, 1981.

C. On the stacking and unstacking of thylakoid membranes; excitation energy distribution, and more

1980
Barber J.: An explanation for the relationship between salt-induced thylakoid stacking and the chlorophyll fluorescence changes associated with changes in spillover of energy from photosystem II to photosystem I. – FEBS Lett. **118**: 1-10, 1980.

1981
Rubin B.T., Barber J., Paillotin G., Chow W.S., Yamamoto Y.: A diffusional analysis of the temperature sensitivity of the Mg^{2+}-induced rise in chlorophyll fluorescence from pea thylakoid membranes. – BBA-Bioenergetics **638**: 69-74, 1981.

1982
Barber J.: Influence of surface charges on thylakoid structure and function. – Ann. Rev. Plant Physio. **33**: 261-295, 1982.

1983
Barber J.: Photosynthetic electron transport in relation to thylakoid membrane composition and organization. – Plant Cell Environ. **6**: 311-322, 1983.

Horler D.N.H., Dockray M., Barber J.: The red edge of plant leaf reflectance. – Int. J. Remote Sens. **4**: 273-288, 1983.

1984
Barber J., Ford R.C., Mitchell R.A.C., Millner P.A.: Chloroplast thylakoid membrane fluidity and its sensitivity to temperature. – Planta **161**: 375-380, 1984.

Canaani O., Barber J., Malkin S.: Evidence that phosphorylation and dephosphorylation regulate the distribution of excitation energy between the two photosystems of photosynthesis in vivo: Photoacoustic and fluorimetric study of an intact leaf. – P. Natl. Acad. Sci. USA **81**: 1614-1618, 1984.

D. Taking things apart and learning what they really do, and even putting them back together: the ultimate of Biochemistry and Biophysics

1985
Gounaris K., Barber J.: Isolation and characterisation of a photosystem II reaction centre lipoprotein complex. – FEBS Lett. **188**: 68-72, 1985.

1986
Nixon P.J., Dyer T.A., Barber J., Hunter C.N.: Immunological evidence for the presence of the D1 and D2 proteins in PSII cores of higher plants. – FEBS Lett. **209**: 83-86, 1986.

1987
Barber J.: Photosynthetic reaction centres: A common link. – Trends Biochem. Sci. **12**: 321-326, 1987.

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1988
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Appendix 2.

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