Photosynthesis Research (2019) 139:45–52
https://doi.org/10.1007/s11120-018-0531-y

HISTORY AND BIOGRAPHY

Honoring eight senior distinguished plant biologists from India

Rajagopal Subramanyam[1] · Suleyman I. Allakhverdiev[2] · Govindjee[3]

Received: 23 May 2018 / Accepted: 7 June 2018 / Published online: 14 June 2018

Abstract

We summarize here research contributions of eight stalwarts in photosynthesis research from India. These distinguished scientists (Shree Kumar Apte, Basanti Biswal, Udaya C. Biswal, Agepati S. Raghavendra, Attipalli Ramachandra Reddy, Prafullachandra Vishnu (Raj) Sane, Baishnab Charan Tripathy, and Dinesh C. Uprety) were honored on November 2, 2017, at the School of Life Sciences, University of Hyderabad. We include here two group photographs of this special event, which was organized by the Department of Plant Sciences, during the 8th International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability—2017 (https://prs.science/wp-content/uploads/2017/10/Photosynthesis-Research-for-Sustainability-2017.pdf, also available at: http://www.life.illinois.edu/govindjee/world-historical.html). The main conference had honored three international scientists: William Cramer (Purdue University. West Lafayette, Indiana, USA), Govindjee (University of Illinois at Urbana-Champaign, Illinois, USA, one of the authors here); and Agepati S. Raghavendra (University of Hyderabad, India, one of those honored here as well); see papers in this Special Issue, edited by Suleyman Allakhverdiev, one of the authors here.

Keywords Shree Kumar Apte · Basanti Biswal · Udaya C. Biswal · Agepati S. Raghavendra · Attipalli Ramachandra Reddy · Prafullachandra V. (Raj) Sane · Baishnab C Tripathy · Dinesh C. Uprety

Introduction

The event honoring eight senior distinguished plant biologists from India was coordinated by Saradadevi Tetali, a faculty member of the University of Hyderabad, along with a student representative Sreeharsha Rachapudi. The eight eminent Indian scientists, who were honored for their research contributions in the field of photosynthesis, were from different institutes of India: Shree Kumar Apte from the Bhabha Atomic Research Centre (BARC), Trombay, Mumbai, Maharashtra; Basanti Biswal, and Udaya C. Biswal, both from the Sambalpur University, Sambalpur, Odisha; Agepati S. Raghavendra and Atipalli R. Reddy, both from the University of Hyderabad, Hyderabad, Telangana & Andhra Pradesh; Prafullachandra Vishnu (Raj) Sane from the National Botanical Research Institute (NBRI), Lucknow (Uttar Pradesh, UP); Baishnab C. Tripathy from the Jawaharlal Nehru University, New Delhi; Dinesh C. Uprety from the Indian Agricultural Research Institute (IARI), New Delhi. The ceremony and the entire event was attended and witnessed by the Vice Chancellor of the University of Hyderabad, Appa Rao Podile; the Dean of the School of Life Sciences, Reddana Pallu; and the Head of the Department

This *News Report* was invited, checked, and approved for publication by the editors of the Special Issue of Photosynthesis Research on 'The 8th International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability—2017'.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11120-018-0531-y) contains supplementary material, which is available to authorized users.

✉ Govindjee
gov@illinois.edu

Rajagopal Subramanyam
srgsl@uohyd.ernet.in

Suleyman I. Allakhverdiev
suleyman.allakhverdiev@gmail.com

1 Department of Plant Sciences, School of Life Sciences, University of Hyderabad, Hyderabad 500046, India

2 Controlled Photobiosynthesis Laboratory, Institute of Plant Physiology, Russian Academy of Sciences, Moscow 127276, Russia

3 Department of Plant Biology and Department of Biochemistry, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA

of Plant Sciences, Chintalapati Venkata Ramana. All the honored ones who were present received a gift of a shawl, bouquet of flowers, and a plaque in recognition of their outstanding contributions to photosynthesis-related research. See Supplementary Material for individual photographs. One of us (Rajagopal Subramanyam), who was the organizing secretary of the main conference (https://prs.science/wp-content/uploads/2017/10/Photosynthesis-Research-for-Sustainability-2017.pdf), also witnessed and participated in the felicitation ceremony. He was also presented with a shawl and a bouquet of flowers as a token of respect by students for his passion and hard work in organizing the 8th International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability—2017. This event paved the way for the speakers and the audience to recollect the great contributions of the honored scientists in the field of photosynthesis. Figure 1 shows six of the eight awardees on the dais, with Appa Rao Podile addressing the audience; an informal photograph of Basanti and Udaya Biswal, who could not attend the function, is in the Supplementary Material.

We now present below significant research contributions of the eight honored scientists, in alphabetical order, along with a maximum of seven publications for each, cited within their texts.

Shree Kumar Apte (Bhabha Atomic Research Centre (BARC), Mumbai, Maharashtra; e-mail: aptesk@barc.gov.in)

Shree Kumar Apte and his coworkers have made outstanding contributions to our understanding of interactions between the two most energy-intensive biological processes, i.e., photosynthesis and nitrogen fixation in the photo-diazotrophic cyanobacterium *Anabaena* (Apte 1996). As organisms believed to be progenitors of modern chloroplasts and credited with the early oxygenation of earth's atmosphere, cyanobacteria occupy a special place in evolutionary biology. They are naturally abundant in tropical paddy fields, where they contribute to the carbon (C) and the nitrogen (N) economy of the soil and are excellent model systems for studying responses of oxygenic photosynthetic organisms to environmental stresses.

Apte's early work from the laboratory of Sir William Duncan Paterson Stewart (past president, Royal Society of Edinburgh, Scotland) established a pathway for electron donation to nitrogenase from photosynthetically generated sugars in the vegetative cells. He also showed that electron donation to ferredoxin in heterocysts occurs through two pathways: the oxidative pentose phosphate pathway and the reversal of ferredoxin-$NADP^+$ oxidoreductase. In addition, his research led to the availability of the purified forms of the key components of this system (Apte et al. 1978). Furthermore, this work led to an understanding of the mechanism for the regulation of the redox state of the system by light (and possibly by thioredoxin).

Apte's subsequent work at the Bhabha Atomic Research Centre (BARC), Mumbai, revealed the molecular and cellular basis of the responses of cyanobacteria to a variety of environmental stressors, such as nutrient deficiency (N, Na^+, and K^+), salinity, dehydration, heat-shock (Rajaram et al. 2014), herbicides (e.g., methyl viologen) (Panda et al. 2014), pesticides (e.g., lindane), heavy metals (e.g., uranium), and ionizing radiations (e.g., ^{60}Co, γ-rays) (Singh et al. 2013). Furthermore, Apte and coworkers identified photosynthesis and nitrogen fixation as the key stress-sensitive metabolic targets in *Anabaena*. Work from his laboratory also demonstrated that the generation of intracellular oxidative stress is central to all environmental stresses, and its alleviation is

Fig. 1 Photograph at the occasion of honoring eight senior distinguished plant biologists from India during the 8th International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability—2017 (November 2, 2017, School of Life Sciences, University of Hyderabad, India). This event was presided by Appa Rao Podile, Vice Chancellor, University of Hyderabad (he is shown here addressing the gathering). Sitting on the dais from left to right are: Chintalapati Venkata Ramana, Reddanna Pallu, Attipalli Ramachandra Reddy, Agepati S. Raghavendra, Prafullachandra Vishnu (Raj) Sane, Shree Kumar Apte, Dinesh C. Uprety, and Baishnab Charan Tripathy. Photo by Venkatesh, Sai Photo Studio, Hyderabad

very important for cyanobacterial stress tolerance (Banerjee et al. 2013).

Comparative proteomic analysis of *Anabaena* exposed to methyl viologen (Panda et al. 2014) and uranium has (a) unraveled oxidative stress-sensitive genes and proteins, and (b) identified desirable candidate genes that can be manipulated to obtain stress-tolerant cyanobacterial strains. Employing recombinant DNA technology, Apte's research group has constructed *Anabaena* strains overexpressing genes encoding Mn/Fe superoxide dismutases, catalases, and peroxiredoxins (Banerjee et al. 2013) which significantly protect photosynthesis and nitrogen fixation and improve stress tolerance (Chaurasia and Apte 2011). This approach has the potential to enhance the nitrogen biofertilizer potential of cyanobacteria growing in rice fields, especially under stressful environments.

Basanti Biswal (Sambalpur University, Sambalpur, Odisha; e-mail: basanti_b@hotmail.com)

Basanti Biswal has worked on the factors that modulate the formation of mature chloroplasts during leaf development and their regulated dismantling during leaf senescence. Her work has implications for the field of agricultural biotechnology, since the efficient capture of carbon by well-developed chloroplasts (during leaf development) and nutrient recycling (during leaf senescence) are the two major events that largely determine plant growth and yield. Her specific contributions are described below.

During the early years of her research, Basanti examined the role of plant axis and environmental stress factors in modulating photosynthetic efficiency of young and developing chloroplasts in leaves. Her findings suggested the involvement of phytohormone signaling in axis-mediated regulation of plastid development.

Leaf senescence, photosynthetic changes, and regulation have been major areas of Basanti's research at Sambalpur University. Her work on the patterns of changes of chloroplast demolition, mechanism, and regulation of leaf senescence, both in higher plants and in ferns, has significantly contributes to our understanding of the process. During the time when senescence was ill defined, she was among the few to demonstrate the nuclear control of plastid degradation, which was, subsequently, confirmed by her work on the stability of PSII proteins of thylakoids in a nuclear gene mutant of *Festuca* (Biswal et al. 1994). In addition, plant senescence was shown to be modulated by light through the action of phytochrome and blue light receptors (Biswal and Choudhury 1986); she was the first to report the action of blue light in the modulation of leaf senescence. Furthermore, Basanti suggested that the action of phytochrome is through the G-protein signaling.

In addition to the above, Basanti has worked, with several others, on the temporal expression of senescence-associated genes, including the *din2* gene that codes for cell-wall-bound β-glucosidase and its regulation by Ca^{2+}—calmodulin and sugar signaling. The involvement of photosynthesis and sugar signaling for the induction of cell-wall-bound hydrolases including β-galactosidase (Pandey et al. 2017), β-glucanase, and β-glucosidase (Mohapatra et al. 2010; Patro et al. 2014) is the focus of her current research.

Based on the effects of stress on higher plants and on cyanobacteria, as well as the experimental findings on senescence of higher plants, Basanti has contributed greatly to the formulation of theoretical models with β-carotene, zeaxanthin and PsbS protein as the basic components of the model for the protection of photosynthetic apparatus during senescence and stress response.

Basanti Biswal has also provided thorough overviews of her research, and mechanisms for the regulation of plastid formation and demolition during leaf development and senescence (see, e.g., Biswal et al. 2003, 2013).

Udaya Chand Biswal (Sambalpur University, Sambalpur, Odisha; e-mail: Biswaluc@yahoo.co.in)

Udaya has been working in the area of photosynthesis since 1975. He established his laboratory in the School of Life Sciences, Sambalpur University, Odisha, India, in 1978. He has contributed extensively to establish the fact that the senescence of a chloroplast is a developmental process, not merely a degradation of this subcellular organelle. In several research articles, book chapters, and reviews published from his laboratory, he discusses and explains the developmental events during the senescence of chloroplasts in green leaves of higher plants. Furthermore, his research group has examined the stability of isolated chloroplasts modulated by several factors during the aging of the organelle in vitro. The mechanism and the regulation of changes in the primary photochemistry of photosystems during senescence and stress response have remained the focus of his research (see, e.g., Joshi et al. 1993; Nayak et al. 2003). Furthermore, results from his studies on the structure and function of photosystem II (PSII), the key pigment–protein complex in the thylakoids of chloroplasts, have played a prominent role in describing the evolutionary steps involved in this process. The photosynthetic response of green leaves to UV radiation is another area that has been extensively investigated in his laboratory (Nayak et al. 2003; Joshi et al. 2007). His research shows that the differential response of PSII photochemistry to UV-A and UV-B radiation significantly contributes to our understanding of the mechanism of sensitivity of the photosystem(s) to these radiations. We note that multidisciplinary approach to photosynthesis research has been an important feature of all his investigations. His research group has provided one of the few theoretical models of the oxygen evolving system explaining the organization of the Mn center and a molecular mechanism with energetics of photooxidation of water in the 1980s (Raval and Biswal 1984). Several theoretical papers explaining different aspects of PSII including exciton migration and photoprotection have been published from his laboratory (see e.g., Nayak et al. 2002).

A widely acclaimed monograph 'Chloroplast Biogenesis: From Proplastid to Gerontoplast', which summarizes the basic knowledge from several diverse fields of research in photosynthesis, stands as a mark of Udaya Biswal's achievements (Biswal et al. 2003).

Agepati Srinivasa Raghavendra (University of Hyderabad, Hyderabad, Andhra Pradesh & Telangana; e-mail: asrsl@uohyd.ernet.in)

Raghavendra has contributed immensely to studies on C4 photosynthesis with his discovery of several C4 plants as well as C3–C4 intermediates on the Indian subcontinent. Furthermore, his studies on the characterization and regulation of C4 phosphoenolpyruvate carboxylase (PEPCase) are highly recognized (Raghavendra and Sage 2011). In addition, Raghavedra and coworkers have demonstrated the beneficial role of mitochondrial metabolism for photosynthetic carbon assimilation and have proposed that photorespiration is an adaptive response of plants to oxidative stress.

Chloroplasts and mitochondria are traditionally considered to be autonomous organelles, but they are not as independent as they were once thought to be. Mitochondrial oxidative metabolism and photorespiration not only optimize photosynthesis, but also protect plants against photoinhibition (Raghavendra and Padmasree 2003). Mitochondrial respiration can dissipate excess reducing equivalents and energy, either directly (using ATP, NAD(P)H and reduced ferredoxin) or indirectly (e.g., via alternative oxidase (AOX), providing an internal CO_2 pool). Thus, photorespiration can mitigate oxidative stress under conditions such as drought (i.e., water stress) or salinity (Voss et al. 2013). This concept has triggered further experiments to understand the molecular basis of redox signals targeting the photorespiratory reactions (Hodges et al. 2016).

The interaction between chloroplasts, mitochondria, and peroxisomes is facilitated by two major phenomena: sharing of the energy and metabolite resources, and the maintenance of optimal levels of reactive oxygen species (ROS) (Sunil et al. 2013). The resource-sharing among different compartments of plant cells is based on the production/utilization of reducing equivalents (such as NADPH and NADH) and ATP, in addition to the metabolite exchange. Since the bioenergetic reactions tend to generate ROS, the cells modulate chloroplast and mitochondrial reactions, to ensure that the ROS levels do not rise to toxic levels.

Attipalli Ramachandra Reddy (University of Hyderabad, Hyderabad, Andhra Pradesh & Telangana; e-mail: attipalli.reddy@gmail.com)

Attipalli Ramachandra Reddy has made significant research contributions toward unraveling the relationship between the photosynthetic carbon assimilation and the biomass yield in several plant species. His first entry into the field of photosynthesis was through a graduate program, where he gained an understanding of the basic differences in carbon assimilation patterns in C4 and CAM plants. This later led to his investigation of the mechanism for the regulation of the enzymes in carbon metabolism leading to biomass production in higher plants. His further work demonstrated the role of fructose 2,6-bisphosphate as a signal metabolite controlling sucrose, as well as sucrose biosynthesis in the leaves of both rice and sorghum, under limited environmental plant growth conditions (Reddy and Das 1987a, b).

Reddy combined his interests in establishing the role of photosynthetic energy and carbon flow in the biosynthesis of polyisoprene with isopentenyl diphosphate (IDP) as a potential metabolic intermediate in a rubber-yielding shrub, guayule (*Parthenium argentatum* Gray). He unequivocally demonstrated the autonomy and ability of guayule chloroplasts to synthesize the precursors for rubber formation, using isolated and purified chloroplasts for the incorporation of carbon from ^{14}C-labeled bicarbonate, pyruvate, and 3-phosphoglycerate (Reddy and Das 1987a, b).

Reddy has also significantly contributed to the understanding of the role of environmentally unfavorable conditions including the low-water regime, the presence of heavy metals, and high salt (salinity) on photosynthetic productivity in different plant species including rice, sorghum, mulberry, and pigeon pea (Reddy et al. 2004). Of late, Reddy and his group have been actively involved in understanding the role of global climate change on photosynthetic productivity in certain fast-growing tree species, with particular reference to elevated atmospheric CO_2 levels (Reddy et al. 2010; Kumar et al. 2014). In a recent study, he examined the effects of 'CO_2 fertilization' (i.e., increased [CO_2] around the plants) on photosynthetic gas exchange characteristics as well as the responses of certain crucial photosynthetic enzymes related to the overall plant growth performance in selected fast-growing tree species, which included Gmelina, Mulberry, and Jatropha. These trees have been suggested to be excellent for agroforestry programs to mitigate rising atmospheric CO_2 in the quickly changing global climate (Sekhar et al. 2017).

Prafullachandra Vishnu (Raj) Sane (National Botanical Research Institute (NBRI), Lucknow, Uttar Pradesh; e-mail: rajsane@hotmail.com)

Raj Sane's major contributions in photosynthesis are on the elucidation of the relationship between the structure and function of the chloroplast membrane. His studies showed, for the first time (1970), that, in higher plant chloroplasts, PSII is almost exclusively located in the grana membranes, while PSI is located in the stroma lamellae and the end membranes of the grana (see Park and Sane 1971 and references therein). When he was in Germany as a Humboldt Fellow, his studies suggested that the presence of proton translocating proteins/proton channels is responsible for generating proton gradient in the chloroplast membranes.

Using measurements on thermoluminescence (TL), Sane's group, in collaboration with the late Vidyadhar Govind Tatake (Sane and Phondke 2006), demonstrated that TL arose from the recombination of the redox pairs generated during photosynthetic electron transport primarily in PSII. A one-to-one correlation between the TL peaks and components of delayed light emission (DLE) was also shown. These studies characterized activation energies and lifetimes of electrons in trap states (see reviews by Sane et al. 1977, 2012; Tatake et al. 1980), and these data formed the basis of theoretical papers on the origin of TL by DeVault et al. (1983) and DeVault and Govindjee (1990). TL was soon shown to be useful in monitoring stresses and adaptation in plants. Furthermore, Raj Sane's extensive and outstanding studies on the regulation of important enzymes in C4 malate formers have, indeed, explained the higher efficiencies of these plants. Furthermore, his investigations on photoinhibition have highlighted the role of dark respiration and oxidative phosphorylation in it and its reactivation (Shyam et al. 1993). On the ecological side, Sane's studies have explained the adaptation strategies evolved by tree species to survive under high summer temperatures on the sodic and high pH soils of North India. For an outstanding study on low-temperature stress, see Sane et al. (2002). Finally, his research group has sequenced and characterized most of the PSII-related genes encoded by the *Populus* chloroplast genome (see, e.g., Reddy et al. 1998).

Baishnab Charan Tripathy (Jawaharlal Nehru University, New Delhi; e-mail: baishnabtripathy@yahoo.com)

Baishnab Tripathy has significantly contributed to our knowledge of photosynthesis. His work on 5-aminolevulinic acid (ALA)—a precursor of heme and chlorophyll—as a photodynamic herbicide is, indeed, unique. ALA induces green plants to accumulate excess amounts of tetrapyrroles, which act as photosensitizers and cause singlet-oxygen mediated lethal damage to plants and their photosynthetic apparatus (Tripathy and Chakraborty 1991).

Baishnab, with his coworkers, has demonstrated the coregulation of chloroplast development, and chlorophyll and carotenoid biosynthesis. Hukmani and Tripathy (1994) demonstrated that chlorophyll biosynthesis takes place in senescing leaves in the face of extensive catabolic reactions. Baishnab Tripathy is recognized as an authority on the mechanism of chlorophyll biosynthesis and chloroplast biogenesis by chloroplast envelope membranes. His work pertaining to the response of the greening process of plants to environmental stresses has demonstrated the acclimation of the greening process, chloroplast biogenesis, protein import, and photosynthesis to chill-, heat-, drought-, and salt-stress (see e.g., Dutta et al. 2009; Dalal and Tripathy 2012). The demonstration of the role of roots and the root–shoot transition zone in the intra- and inter-cellular signaling system in relation to chloroplast development of wheat seedlings grown under red light is novel and, indeed, interesting. This photomorphogenic response of suppression of the greening process by red light is reversed by blue and far red light; this response is known to be mediated by phytochrome A (Roy et al. 2013).

Tripathy and his coworkers have also demonstrated that *por C* codes for light-inducible protochlorophyllide oxidoreductase C, which phototransforms protochlorophyllide to chlorophyllide and significantly contributes to chlorophyll biosynthesis. Transgenic plants overexpressing *por C* were found to be resistant to high-light stress, mediated by singlet oxygen. His research on the modulation of chlorophyll-*b* biosynthesis and its impact on enhancement of photosynthesis and plant productivity is another widely recognized significant contribution of Tripathy (Biswal et al. 2012). In addition, the genetic manipulation of genes involved in the biosynthesis of siroheme, the cofactor of nitrite reductase and sulfite reductase involved in nitrogen and sulfur assimilation, is another important finding of his research group. The overexpression of uroporphyrinogen III and sirohydrochlorin ferrochelatase involved in siroheme biosynthesis increases the nitrogen use efficiency, protein content, and photosynthetic efficiency of plants.

This has a great potential for the generation of crop plants that can tolerate nitrogen-deficient and sulfur-deficient soil. Higher protein content in plants will be of immense help for the nourishment of a great majority of the world population.

What is exciting to the authors is that in collaboration with the National Aeronautics and Space Administration (NASA), Tripathy sent plants on board the space shuttle *Discovery* to study the impact of zero (micro) gravity on photosynthesis, which could generate oxygen for human survival on a long-duration Mars mission (Tripathy et al. 1996).

Dinesh C. Uprety (Government of India and Indian Council of Agricultural Research (ICAR), New Delhi; e-mail: upretydc@gmail.com)

Uprety initiated (together with Yash Pal Abrol) analysis and investigation of the impact of rising atmospheric CO_2 on agricultural crops; this was done through an ICAR project at the Indian Agriculture Research Institute (IARI), New Delhi. Subsequently he developed, through a National Fellow Project Innovative approach, a long-term experimental approach to investigate the impact of rising atmospheric CO_2 levels on crops. The characterization of the responses of crop plants (Brassica, rice, mung bean, and wheat) to elevated CO_2 was done using open-top chamber technology (Uprety et al. 1995, 2003).

At IARI, the first South Asian free-air CO_2 enrichment (FACE) technology was designed and developed to generate realistic biological crop response data. The addition of these facilities has brought India into the GCTE (Global Change and Terrestrial Ecosystems) research network, which acts to tackle vulnerable issues and produce adaptation strategies for meeting the rise in global food demand during the current global environmental change. These CO_2-enrichment technologies were improved by Dinesh Uprety and made suitable to the South Asian region. A South Asian CO_2 crop research network, which includes Nepal, Bangladesh, Sri Lanka, Pakistan, and India, was established and coordinated by him at IARI, New Delhi, for the multicountry and multidisciplinary crop response studies. Crop response studies, using OTC (open-top chamber), FACE and FATE (free-air temperature enrichment), CO_2, and temperature enrichment technologies, demonstrated that the elevated CO_2 significantly mitigates the adverse moisture and temperature stress effects on plant processes in *Brassica* and rice species (Uprety and Tomar 1993; Uprety et al. 1995). His studies have also demonstrated the transfer of CO_2-responsive characters from the parent *Brassica campestris* to the hybrid *Brassica oxycamp*. Furthermore, Uprety and his coworkers initiated studies to understand the impact of elevated CO_2 on the grain quality of *Brassica* species. A significant increase in the oil content and changes in the plants' fatty acid composition demonstrated a positive change in the quality of oil. Similarly, in the case of rice cultivars, the grain structure, grain chemistry, and nutritional and cooking quality were found to be considerably affected by elevated CO_2 (Uprety and Reddy 2008). Uprety's studies also demonstrated that elevated CO_2 brought about significant changes in the grain structure (Sinha et al. 2011) and grain chemistry of wheat species with variations in their response depending on their ploidy level. On the basis of this study, Uprety et al. (2012) have identified and described various greenhouse gas mitigation technologies. These newly developed technologies are expected to help farmers, scientists, students, and policy-makers identify strategies to counter the challenges of rising atmospheric CO_2 and temperatures (Uprety and Reddy 2016).

Concluding remarks

We end this tribute to the honored eight by first stating that each of them received a beautiful plaque with their photograph on it, and with the following wonderful words: "For Significant Research Contributions to the Field of Photosynthesis", and each plaque was signed by Appa Rao Podile (the Patron), Rajagopal Subramanyam (the Organizing Secretary), and Suleyman Allakhverdiev (the Coordinator) on behalf of the 8th International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability—2017, held at the University of Hyderabad, October 30–November 3, 2017.

To commemorate this wonderful event, we end this News Report with a group photograph of six of the eight honored awardees; faculty members of the School of Life Sciences, University of Hyderabad; as well as some family members (see Fig. 2; also, see photographs in the Supplementary Material). We wish these wonderful scientists a long and fruitful research life forever.

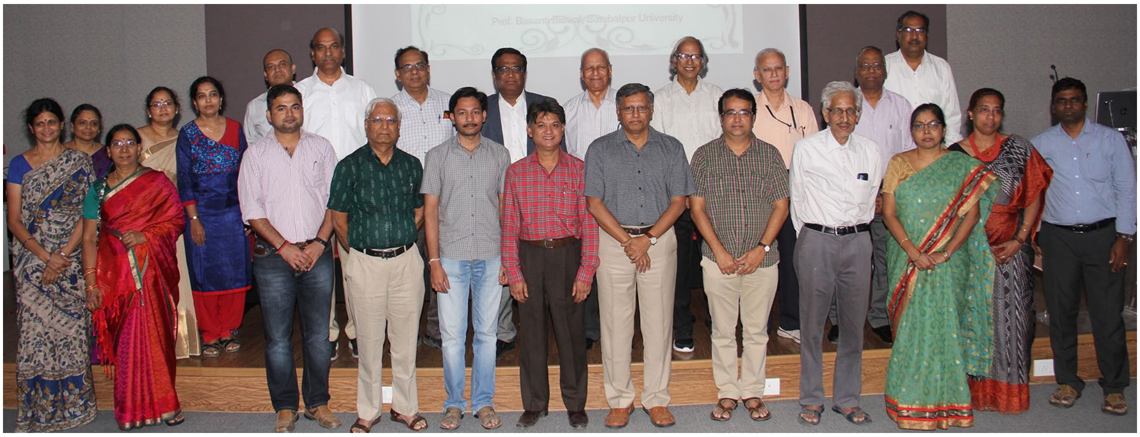

Fig. 2 Group photograph showing the honorees, faculty members of the School of Life Sciences, University of Hyderabad, as well as some family members. Front row (left to right): Mrs. Attipalli Jalaja Reddy (wife of A. R. Reddy), Mrs. Agepati Ramadevi (wife of A. S. Raghavendra), Rahul Kumar, Rameshwar P. Sharma, Jogi Madhuprakash, Irfan Ahmed Ghazi, Reddanna Pallu, Jogadhenu Syama Sundar Prakash, Kolluru V.A. Ramaiah, Gudipalli Padmaja, Ragiba Makandar, and Rajagopal Subramanyam (one of the authors). Back row on the wooden stage (from left to right): Kollipara Padmasree, Sarada Devi Tetali, Sreelakshmi, Chintalapati Venkata Ramana, Attipalli Ramachandra Reddy, Baishnab Charan Tripathy, Appa Rao Podile, Prafullachandra Vishnu (Raj) Sane, Dinesh C. Uprety, Shree Kumar Apte, Agepati S. Raghavendra, and Dayananda Siddavattam. Photograph by Venkatesh, Sai Photo Studio, Hyderabad

Acknowledgements We thank each of the honored awardees for helping us produce the description of their research. Our apologies to them for limiting the number of citations to a maximum of seven. We thank the staff and the many student volunteers for making the entire event a grand success. Student volunteers included: V. Sreeharsha Rachapudi, Konubothula Sitaramireddy, Divya K. Unnikrishnan, Shalini Mudalkar, Bobba Sunil, Ashwini Vetcha, Nisha Chauhan, Ranay Yadav, Elsin Raju Devadasu, and Jayender Pandey. We also thank Venkatesh, of Sai Photo Studio, Hyderabad, for the photographs in this report as well as in the Supplementary Material. Finally, we thank Govindjee's grandson, Rajiv Govindjee, for reading the manuscript before it was sent to the publishers.

References

Apte SK (1996) Inter-relationship between photosynthesis and nitrogen fixation in cyanobacteria. J Sci Ind Res 55:583–596

Apte SK, Rowell P, Stewart WDP (1978) Electron donation to ferredoxin in heterocysts of the N_2-fixing alga *Anabaena cylindrica*. Proc R Soc Lond B 200:1–25

Banerjee M, Raghavan P, Ballal A, Rajaram H, Apte SK (2013) Oxidative stress management in the filamentous, heterocystous, diazotrophic cyanobacterium, *Anabaena* PCC7120. Photosynth Res 118:59–70

Biswal B, Choudhury NK (1986) Photocontrol of chlorophyll loss in papaya leaf discs. Plant Cell Physiol 27:1439–1444

Biswal B, Rogers LJ, Smith AJ, Thomas H (1994) Carotenoid composition and its relationship to D1 protein and chlorophyll during leaf development in a normally senescing cultivar and a stay-green mutant of *Festu capratensis*. Phytochemistry 37:1257–1262

Biswal UC, Biswal B, Raval MK (2003) Chloroplast biogenesis: from proplastid to gerontoplasts. Springer, Dordrecht

Biswal AK, Pattanayak GK, Pandey SS, Leelavathi S, Reddy VS, Govindjee, Tripathy BC (2012) Light intensity-dependent modulation of chlorophyll b biosynthesis and photosynthesis by overexpression of chlorophyllide a oxygenase (CAO) in tobacco. Plant Physiol 159:433–459

Biswal B, Krupinska K, Biswal UC (eds) (2013) Plastid development in leaves during g growth and senescence. Advances in photosynthesis and respiration series, Springer, Dordrecht

Chaurasia AK, Apte SK (2011) Improved eco-friendly recombinant *Anabaena* sp. strain PCC7120 with enhanced nitrogen biofertilizer potential. Appl Environ Microbiol 77:395–399

Dalal VK, Tripathy BC (2012) Modulation of chlorophyll biosynthesis by water stress in rice seedlings during chloroplast biogenesis. Plant Cell Environ 35:1685–1703

DeVault D, Govindjee (1990) Photosynthetic glow peaks and their relationship with the free energy changes. Photosynth Res 24:175–181

DeVault D, Govindjee, Arnold W (1983) Energetics of photosynthetic glow peaks. Proc Natl Acad Sci USA 80:983–987

Dutta S, Mohanty S, Tripathy BC (2009) Role of temperature stress on chloroplast biogenesis and protein import. Plant Physiol 150:1050–1061

Hodges M, Dellero Y, Keech O, Betti M, Raghavendra AS, Sage R, Zhu XG, Allen D, Weber APM (2016) Perspectives for a better understanding of the metabolic integration of photorespiration within a complex plant primary metabolism network. J Exp Bot 67:3015–3026

Hukmani P, Tripathy BC (1994) Chlorophyll biosynthetic reactions during senescence of excised barley (*Hordeum vulgare* L. cv IB 65) leaves. Plant Physiol 105:1295–1300

Joshi PN, Ramaswamy NK, Raval MK, Desai TS, Nair PM, Biswal UC (1993) Alteration in photosystem II photochemistry of thylakoids isolated from senescing leaves of wheat seedlings. J Photochem Photobiol B 20:197–202

Joshi PN, Ramaswamy NK, Iyer RK, Nair JS, Pradhan MK, Gartia S, Biswal B, Biswal UC (2007) Partial protection of photosynthetic apparatus from UV-B induced damage by UV-A radiation. Environ Exp Bot 59:166–172

Kumar S, Chaitanya BS, Ghatty S, Reddy AR (2014) Growth, reproductive phenology and yield responses of a potential biofuel plant, *Jatropha curcas* grown under projected 050 levels of elevated CO_2. Physiol Plant 152:501–519

Mohapatra PK, Patro L, Raval MK, Biswal UC, Biswal B (2010) Senescence induced loss in photosynthesis enhances activity of cell wall β-glucosidase. Physiol Plant 138:346–355

Nayak L, Raval MK, Biswal B, Biswal UC (2002) Topology and photoprotective role of carotenoids in photosystem II of chloroplasts: a hypothesis. Photochem Photobiol Sci 1:629–631

Nayak L, Biswal B, Ramaswamy NK, Iyer RK, Nair JS, Biswal UC (2003) Ultraviolet-A induced changes in photosystem II of thylakoids: effects of senescence and high growth temperature. J Photochem Photobiol B 70:59–65

Panda B, Basu B, Rajaram H, Apte SK (2014) Methyl viologen responsive proteome dynamics of *Anabaena* sp. strain 7120. Proteomics 14:1895–1904

Pandey JK, Dash SK, Biswal B (2017) Loss in photosynthesis during senescence is accompanied by an increase in the activity of β-galactosidase in leaves of *Arabidopsis thaliana*: modulation of the enzyme activity by water stress. Protoplasma 254:1651–1659

Park RB, Sane PV (1971) Distribution of function and structure in chloroplast lamellae. Annu Rev Plant Physiol 22:395–430

Patro L, Mohapatra PK, Biswal UC, Biswal B (2014) Dehydration induced loss of photosynthesis in *Arabidopsis* leaves during senescence is accompanied by the reversible enhancement in the activity of cell wall β-glucosidase. J Photochem Photobiol B 137:49–54

Raghavendra AS, Padmasree K (2003) Beneficial interactions of mitochondrial metabolism with photosynthetic carbon assimilation. Trends Plant Sci 8:546–553

Raghavendra AS, Sage RF (2011) Introduction. In: Raghavendra AS, Sage RF (eds) C_4 photosynthesis and related CO_2 concentrating mechanisms. Advances in photosynthesis and respiration. vol 32. Springer, Dordrecht, pp 17–25

Rajaram H, Chaurasia AK, Apte SK (2014) Cyanobacterial heat-shock response: role and regulation of molecular chaperones. Microbiology 160:647–658

Raval MK, Biswal UC (1984) Oxidation of water in photosynthesis. Bioelectrochem Bioenergy 12:57–61

Reddy AR, Das VSR (1987a) Chloroplast autonomy for the biosynthesis of isopentenyl diphosphate in guayule (*Parthenium argentatum* Gray). New Phytol 106:457–464

Reddy AR, Das VSR (1987b) Modulation of sucrose content by fructose 2, 6-bisphosphate during photosynthesis in rice leaves growing at different light intensities. J Exp Bot 38:828–833

Reddy AR, Suhasini M, Das VSR (1987b) Impairment of photorespiratory carbon flow into rubber by the inhibition of the glycolate pathway in guayule (*Parthenium argentatum* Gray). Plant Physiol 84:1447–1450

Reddy MSS, Trivedi PK, Tuli R, Sane PV (1998) Cloning and nucleotide sequence analysis of *psbD*/*C* operon from chloroplasts of *Populus deltoides*. J Genetics 77:77–83

Reddy AR, Chaitanya KV, Vivekanandan M (2004) Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. J Plant Physiol 161:1189–1202

Reddy AR, Rasineni GK, Raghavendra AS (2010) The impact of global elevated CO_2 concentration on photosynthesis and plant productivity. Curr Sci 2010:46–57

Roy A, Sahoo DB, Tripathy BC (2013) Involvement of phytochrome A in suppression of photomorphogenesis in rice seedling grown in red light. Plant Cell Environ 36:2120–2134

Sane PV, Phondke GP (2006) Vidyadhar Govind (Pandit) Tatake (1926–2004): an ingenious instrumentalist, an authority on thermoluminescence, and a lover of classical Indian music. Photosynth Res 89:49–51

Sane PV, Desai TS, Tatake VG, Govindjee (1977) On the origin of glow peaks in Euglena cells, spinach chloroplasts and sub-chloroplast fragments enriched in system I or II. Photochem Photobiol 26:33–39

Sane PV, Ivanov AG, Sveshnikov D, Huner NPA, Oquist G (2002) A transient exchange of the photosystem II reaction center protein D1:1 with D1:2 during low temperature stress of *Synechococcus* sp. PCC 7942 in the light lowers the redox potential of Q(B). J Biol Chem 277:32739–32745

Sane PV, Ivanov AG, Oquist G, Huner NPA (2012) Thermoluminescence. In: Advances in Photosynthesis and Respiration (series Editors Govindjee and Thomas D Sharkey), Vol 34 Photosynthesis: Plastid Biology, Energy Conversion and Carbon Assimilation, (Ed Julian J Eaton- Rye, Baisnab C Tripathy and Thomas D Sharkey). Chapter 19, Springer, Dordrecht, pp. 446–474

Sekhar KM, Reddy KS, Reddy AR (2017) Amelioration of drought-induced negative responses by elevated CO_2 in field grown short rotation coppice mulberry (*Morus* spp.), a potential bio-energy tree crop. Photosynth Res 132:151–164

Shyam R, Raghavendra AS, Sane PV (1993) Role of dark respiration in photoinhibition of photosynthesis and its reactivation. Physiol Plant 88:446–452

Singh H, Kirti A, Apte SK (2013) High radiation and desiccation tolerance of nitrogen-fixing cultures of the cyanobacterium *Anabaena* sp. strain PCC 7120 emanates from genome/proteome repair capabilities. Photosynth Res 118:71–80

Sinha PG, Pardha Saradhi P, Uprety DC, Bhatnagar AK (2011) Effect of elevated CO_2 concentration on photosynthesis and flowering in three wheat species belonging to different ploidies. Agric Ecosyst Environ 142(3–4):432–436

Sunil B, Talla SK, Aswani V, Raghavendra AS (2013) Optimization of photosynthesis by multiple metabolic pathways involving interorganelle interactions: resource sharing and ROS maintenance as the bases. Photosynth Res 117:61–71

Tatake VG, Desai TS, Govindjee, Sane PV (1980) Energy storage states of photosynthesis membranes: activation energies and lifetimes of electrons in the trap states by thermoluminescence method. Photochem Photobiol 33:243–250

Tripathy BC, Chakraborty N (1991) 5-Aminolevulinic acid induced photodynamic damage of the photosynthetic electron transport chain of cucumber (*Cucumis sativus* L) cotyledons. Plant Physiol 96:761767

Tripathy BC, Brown CS, Levine H, Kirkorian AD (1996) Growth and photosynthetic responses of wheat plants grown in space. Plant Physiol 110:801–806

Uprety DC, Reddy VR (2008) Rising atmospheric CO_2 and crops ICAR book, pp1-114. Indian Council of Agriculture Research, New Delhi

Uprety DC, Reddy VR (2016) Crop responses to global warming, Springer, Dordrecht, pp 1–125, ISBN 978-981-10-2004-9

Uprety DC, Tomar VK (1993) Photosynthesis and drought resistance of *Brassica carinata* and its parent species. Photosynthetica 29(3):321–327

Uprety DC, Mishra RS, Abrol YP (1995) Effect of elevated CO_2 and moisture stress on the photosynthesis and water relation in Brassica species. J Crop Sci Agron 175:231–237

Uprety DC, Dwivedi N, Jain V, Mohan R, Saxena DC, Jolly M, Paswan G (2003) Response of rice varieties to elevated CO_2. Biol Plant 46(1):35–39

Uprety DC, Dhar S, Hongmin D, Kimball BA, Garg A, Upadhyay J (2012) Technologies for climate change mitigation- agriculture sector. UNEP RISØ Centre on Energy Climate and Sustainable Development (URC), Roskilde, pp 1–117

Voss I, Sunil B, Scheibe R, Raghavendra AS (2013) Emerging concept for the role of photorespiration as an important part of abiotic stress response. Plant Biol 15:713–722