MEETING REPORT

Photobiology in the genomics and post-genomics era*

Photobiology is a multidisciplinary science embracing diverse disciplines such as photochemistry, photophysics, photomedicine, photobiology of vision, photosynthesis and photomorphogenesis. Research in these areas has been immensely rewarding and promises many exciting applications not only in basic sciences, but more so in medicine, agriculture and industry. To focus attention on emerging trends in photobiology research, more than 100 scientists from all over the country converged on the South Campus of Delhi University to share their passion at a national symposium.

Delivering the Presidential address, B. B. Biswas (Calcutta University, Kolkata) emphasized how light has defined and modulated life on this planet. How the light signal is perceived, computed and transduced to regulate changes in expression of thousands of genes, is a question of utmost importance. To address this question in the global context, genomics and proteomics approaches have gained importance in recent years. In fact, it is an opportune time to harness the information available in the genomes for better understanding of biological processes.

How plants perceive the light signal to regulate photomorphogenesis was discussed to depth at this meeting. The comparative analysis of bacterial and cyanobacterial genomes has revealed that higher plant phytochromes act as bacterial two-component sensor-regulators. S. K. Sopory [International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi] provided evidence for the role of phytochrome in regulating topoisomerase II activity in pea and for the presence of some light-responsive upstream promoter elements by deletion analysis in transgenics. J. P. Khurana [University of Delhi South Campus (UDSC), New Delhi] enumerated the potential utility of *Arabidopsis* mutants in understanding phototransduction mechanisms in plants. The mutant analysis has been useful in identifying unique signalling components, including 26S proteasome, and implicating the role of brassinosteroids in light-regulated plant development. S. Chattopadhyay [National Centre for Plant Genome Research (NCPGR), New Delhi] discussed the role of COP1 and HY5, two nuclear components identified by mutant analysis, in regulating light-induced gene expression. Work from his laboratory has defined a role for HY5 in light-regulated expression of *Z*-box containing promoters in *Arabidopsis*. The analysis of *Z*-box binding factors and their genes is in progress.

Blue light also regulates many developmental and physiological responses in diverse organisms, including microbes, fungi, plants, insects and mammalian systems. M. M. Laloraya (Devi Ahilya Vishwavidyalaya, Indore) gave a historical account of the events over the past 100 years, starting with the work of Charles Darwin (1881), that led to the discovery of flavin-based blue-light receptors, cryptochromes and phototropins in plants in the last decade. He presented experimental evidence for the role of active oxygen species in initializing blue-light signal transduction for phototropism in wheat coleoptiles. R. P. Sharma (University of Hyderabad) discussed the work from his laboratory on the identification and characterization of several phototropism mutants in tomato. One of these mutants impaired in phototropism, however, retains normal chloroplast avoidance response. Whether this mutant is defective in the blue-light photoreceptor per se or in a downstream signalling component, will be interesting to decipher.

The light-regulated development of chloroplast is vital for all green plants. A. K. Tyagi (UDSC) enumerated the significance of genome analysis, and as an example, provided genome-wide distribution of genes representing components of the photosynthetic apparatus and those involved in photoperception and signal transduction in rice. This will indeed pave the way for functional genomics and understanding the global networking for light-regulated expression of genes. R. Oelmuller (Jena, Germany), a guest speaker, described the expression analysis of nuclear-encoded plastid protein genes. Using *Arabidopsis* mutants, microarray and proteome analysis, his group has identified new polypeptides involved in the regulation of assembly of multiprotein complexes in plastids. To understand the regulation of plastidial *psbB* operon in *Arabidopsis*, the mutant approach followed by A. P. Sane [National Botanical Research Institute (NBRI), Lucknow], during his stay in Germany, led to the identification of *Hcf107* gene encoding a tetratricopeptide repeat (TPR) family protein. The mutants defective in this protein were unable to accumulate 5′-end processed *psbH* transcripts. The organization and expression of PSII genes in the chloroplast of a tree species, *Populus deltoides*, was discussed by P. K. Trevedi (NBRI). The data suggest that light plays a crucial role in processing of the polycistronic transcripts of PSII operons. P. Nath (NBRI) described the structural characteristics and transcriptional regulation of *RBCL* gene from *P. deltoides*. Some nuclear-encoded proteins that interact with mRNA have been identified, which could affect the abundance of the message under diverse conditions. A. S. Raghavendra (University of Hyderabad) presented evidence for the stimulation of PEP carboxylase activity by light and warm temperatures in the leaves of *Amaranthus* sp. However, the phosphorylation status of PEP carboxylase is altered by light but not with increase in temperature; it may have a bearing on the mechanism of stimulation of the enzyme activity.

High UV-B radiation usually causes damage to the DNA, membranes and proteins in all living organisms. In higher plants, algae and cyanobacteria, PSII is particularly sensitive to UV-B radiation. P. Mohanty (Bhubaneswar, Orissa) showed that phycobilisomes serve as the target of UV-B-induced damage in *Spirulina*, whereby the macroaggregation of chlorophyll–protein complexes is altered. Similarly, the damaging effects of UV-B radiation on the photosynthetic apparatus in wheat seedlings were presented by M. K. Pradhan (Padampur, Orissa). Although the supplemental white light ameliorated the damaging effect of UV-B radiation in both these studies, the underlying mechanism, remains unknown.

Light energy in excess of that utilized for driving photosynthetic electron transport can cause photoinhibition. P. Pardha Saradhi (Delhi University) provided evi-

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dence for the role of compatible solutes, proline and glycinebetaine, in preventing damage due to photoinhibition by maintaining the ratio of NAD(P)H to $NAD(P)^+$, reducing the generation of toxic oxygen species, and maintaining higher carboxylase to oxygenase ratio of rubisco. The evidence for the role of antioxidants and abscisic acid in preventing photooxidative damage in sorghum leaves was provided by P. K. Sharma (Goa University). This study suggested that abscisic acid plays a role in energy dissipation, probably by stimulating the xanthophyll cycle.

R. K. Chopra [Indian Agricultural Research Institute (IARI), New Delhi] discussed progressive hybrid necrosis in leaves of wheat hybrids during development and the role of chloroplasts in cell death during necrosis. Ascorbate and glutathione levels were low in chloroplasts from hybrid leaves and so were the levels of antioxidant enzymes, and their levels further declined with the progression of necrosis. Leaf senescence is another form of programmed cell death. The mechanism of induction of leaf senescence, however, is not clearly understood. B. Biswal (Sambalpur University, Orissa) proposed that a decline in photosynthesis is probably the signal for senescence-associated genes. In another presentation related to senescence, D. Mukherjee (Kurukshetra University) showed the possible involvement of amino acids and the plant hormone, kinetin, in regulating senescence of leaf dics of *Cajanus cajan*.

B. C. Tripathi (Jawaharlal Nehru University, New Delhi) provided a glimpse of research done in outer space! To study the effect of micro-gravity, plants were grown in the International Space Station orbiting the earth. The physiological parameters (such as photosynthetic CO_2 fixation, quantum yield, and PSI and PSII activity) examined in plants revealed that there is no drastic effect of micro-gravity on plant productivity, and it should thus not be a problem to grow plants in space to sustain life. Suggestions on how photosynthetic rate in wheat may be improved by altering leaf area and stomatal frequency were provided by S. G. Bhagwat [Bhabha Atomic Research Centre (BARC), Mumbai]. Employing the tools of classical and modern genetics, attempts are being made to create desirable variation in these traits to improve photosynthesis. A. S. Bhagwat (BARC) discussed how understanding the regulation of activase, improving its thermostability, and increasing its total amount in the chloroplast could be targetted for increasing photosynthesis. Based upon studies on *Brassica campestris* genotypes, M. Z. Abdin (Jamia Hamdard, New Delhi) showed that increase in photosynthetic rate and leaf nitrogen can be accomplished by split application of nitrogen and sulphur.

One of the sessions was exclusively devoted to chloroplast molecular biology and genetic engineering. S. K. Mukherjee (ICGEB) described the salient properties of replicative DNA polymerase (70 kDa) of the chloroplast. He provided evidence that it employs multiple accessory factors (including a 43 kDa DNA-binding protein and a thylakoid-bound LHCP-p27) for organellar DNA replication. Presentations by V. S. Reddy (ICGEB), S. Raghuvanshi (UDSC) and K. C. Bansal (IARI) highlighted the virtues of chloroplasts as biofactories. The strategies for vector construction and delivery of the genes to plastids were discussed threadbare. Some of the success stories of chloroplast transformation, including engineering for insect resistance, glyphosate resistance and pathogen resistance, were the hallmark of these deliberations.

Some interesting talks were presented in the area of photochemistry, photophysics and radiation biology, and a few were even at the interface of biology and physical sciences.

Photoinduced electron transfer (PET) plays an important role in various chemical and biological processes, including photosynthesis. T. Ganguly (Indian Association for Cultivation of Science, Jadavpur) discussed the mechanism of PET reactions in artificial photosynthetic devices. He also explained how the information obtained through PET reactions in these relatively simple systems may enrich our understanding of the natural but more complex processes occurring in reaction centres during photosynthesis. Samita Basu [Saha Institute of Nuclear Physics (SINP), Kolkata] shared the work from her laboratory on PET reactions in solutions by measuring the quenching of fluorescence of either donor or acceptor and the formation of exciplex or free ions. In these studies, geometrical and electronic structures of radical ion pairs were elucidated by steady-state and time-resolved absorption and fluorescence studies employing magnetic field.

Perspectives on the use of fluorescence spectroscopy to gain insights into the local environments of the bioactive molecules, like naturally-occurring flavonols and tryptophan derivatives (with chromophoric moieties), was the subject of presentation by P. K. Sengupta (SINP, Kolkata). These molecules are of therapeutic importance and aid in the study of protein structure, respectively. N. Chattopadhyay (Jadavpur University) explained the differential photophysical behaviour of pyrene-end-capped poly (ethylene oxide) in different cyclodextrin (CD) environments based on different modes of encapsulation of the fluorophore in CD with different cavity dimensions. The characterization of complexes of the micellar solution of a non-onic surfactant, igepal, with safranine T, using absorption and fluorescence spectroscopy, was presented by S. C. Bhattacharya (Jadavpur University). V. K. Gupta (Bilaspur) discussed the photochemical formation of supramolecular assemblies 'Jeewanu'. Whether these self-sustaining assemblies are capable of showing some degree of intelligence was debated intensely.

B. G. Maiya (University of Hyderabad) discussed the mechanistic aspects of DNA photocleavage by some photochemically active mixed-ligand complexes, which are being used increasingly in studies on development of probes for DNA and as DNA footprinting agents, etc. Using pBR322 plasmid DNA, he demonstrated that the intercalative ability of the photoactive polypyridyl ligands varies in relation to the extended aromaticity and planarity of the ligand, and also on the substituents present on it. A. K. Singh [Indian Institute of Technology (IIT), Mumbai] explained the utility of photochemical release of caged biomolecules in studying various biological processes. However, most of the chromophores absorb in the UV region and are insoluble in water, thus limiting their utility. His group has developed chromophores that are photocleavable under physiological conditions and at wavelengths less damaging to the living system. In recent years, excited state intramolecular proton transfer (ESIPT) reactions have become a field of intensive research because of their applications in chemistry and biology. Based upon ESIPT reactions in 1-hydroxy-9-fluorenone and 1-methoxy-9-fluorenone, S. K. Dogra (IIT, Kanpur) provided evidence that polarity of the solvents changes the relative energies of the singlet and triplet states.

To provide protection to living organisms against damaging radiation, S. N. Upadhyay (Institute of Nuclear Medicine and Allied Sciences, Delhi) proposed a radioprotective regimen composed of 5HTP

and AET. The radioprotective efficacy of this combination is enhanced with the addition of vitamin C and E, with Zn and Mn salts. The toxicity studies on Swiss albino mice have revealed that this combined regimen for radioprotection should be effective against haemopoetic, gastrointestinal and central nervous systems.

The hectic schedule of oral presentations was interrupted by a poster session that witnessed good discussion between the young and the not-so-young researchers! Awards (cash prize and a certificate) for best poster presentations were given to Sharmistha Dutta Choudhury (SINP) G. H. C. M. Hettiarachchi (ICGEB), Ritu Kulshreshtha (UDSC) and Vandana Yadav (NCPGR).

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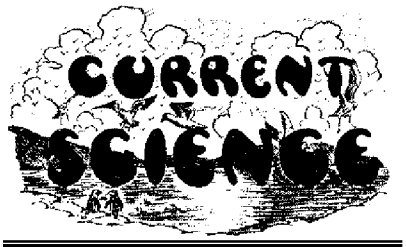
FROM THE ARCHIVES



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Science and the world of today

This note is intended to consider some general remarks made by [D. N. Wadia in his presidential address to the 29th Science Congress (Baroda)] on the now much-discussed subject of the relation between science and the world of today. He enters a protest against the suspicion and uneasiness expressed of late by some no doubt well-meaning people about the growing power of science. In this timely protest, Mr Wadia has voiced the feeling not only of scientists in general, but of all men of cultivated intelligence and just sensibility to benefits received. All alike will share his hope that 'science will, without doubt, re-build the damaged world on better foundations and reintegrate the stricken people to a new and more secure life'. To cherish such a hope is, however, to admit the social responsibility of the scientist; and if that social responsibility is admitted by the scientist, he cannot consistently repudiate the charge that till now science has gone on in forgetfulness of that responsibility; for if science had remembered that responsibility and taken thought as to ways of implementing it, we should not have had to witness the present wreckage of civilization. The difference between the present war and the wars of antiquity, in magnitude and in incidence of destructiveness, is the difference made by the progress of science. If science may claim, as Mr Wadia claims on its behalf, credit for having conquered 'many plagues and diseases' and 'probing truths about creation', she must just as well be prepared to take the blame that belongs to the discovery of fire-bombers and poison gas. Among her children are both angels and their opposites.

It is no use trying to plead that the scientist is innocent and lay the blame exclusively at the doors of the politician and the manufacturer. These no doubt have their share in this organization of disaster. But they have equally a share in science's record of regenerative service to mankind. What can be legitimately claimed for the scientist is that he has had no share in the profits reaped by the manufacturer or the applause elicited by the war-minister, and that he had no personal interest to promote. This plea, however, can be of no avail to him against the charge of negligence and want of wakefulness. Nobody would think of accusing the scientist of homicidal designs; but at the same time nobody could help thinking that, in not taking heed about the dangerous potentialities of his handiwork, he betrayed a singular lack of appreciation of his responsibility as a social being. In purest innocence, but equally in surest thoughtlessness, he helped to upset humanity's apple-cart. The lesson for him today is that he should beware of jingo-politicians and greedy merchants. Mr Wadia is on the hopeful track when he speaks of 'the democracy of science and altruistic knowledge' and suggests an international directorate of scientists as a means of preventing the abuse of science.

What can save mankind is the cultivation of a unified and synoptic view of life – a philosophy of world management in which the sciences and the arts – the achievements of the laboratory and the appeals of the music hall and the theatre, the findings of statistics and the messages of literature – are all brought into correlation in the service of a large and upward-looking humanism. It is for such a synthesis that the world is waiting. A corollary to this belief is that science should refuse to be controlled by narrownesses of geography and race miscalled patriotism and nationalism. Science should commit its achievements to the care and management of a truly international agency which can be trusted to function with every conscientious care for the welfare of the whole of mankind and in no partiality or favouritism for any section or division of it. Patents and monopolies must be destroyed; and all that is of value and significance should become available to the public of the entire international world. This is a condition of minimizing the evil possibilities inherent in the possession of lethal secrets.

With the progress of research and the increase of the armies of researchers, ramifications of science have become so many, and specialism has gone so far afield along every line, that anything like a unified and consistent message of science as a whole as to the principle of Nature and the meaning of life seems at the present stage to be impossible to arrive at. While some of the many mouths of science are speaking more or less clearly and others are just making inarticulate sounds, there are others that have not become even vocal yet. Until science has come to speak in one final voice, it is best she should have the candour to say that her final answer is not ready yet to the ultimate questions of life and reality. Perhaps it is inevitable that science should for ever remain as various in her speech as Nature appears to be in her plans – as various in its findings, as tentative, as wanting in definitiveness on questions pertaining to that which (it is exists) transcends all the shapes and forms and forces of Nature. If this position is accepted by the scientist, it would be a contribution of some real value to the needed philosophy of life. Elimination of exaggeration is also a step taken towards Truth.

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