Meetings

McCollum-Pratt Symposium

A symposium, "Light and Life," was held at the McCollum-Pratt Institute of the Johns Hopkins University 28–31 March 1960. The meeting brought together researchers in biology, biochemistry, physical chemistry, and physics, all concerned with some aspect of the interaction of visible radiation with organic chemicals and, ultimately, with living organisms.

There were five sessions, which started with the quantum mechanical description of excited states of molecules, narrowed down to excited states of molecules of biological interest, and then focused on the specific and complementary reactions of chemiluminescence (including bioluminescence) and photosynthesis. The final session was devoted to gross physiological aspects of light—in particular, phototropism and photoperiodism.

W. Robinson discussed the nature of electronic excited states of simple molecules such as formaldehyde using the molecular orbital approximation and the differences in molecular geometry obtained upon excitation in various environments. These differences can be observed as spectral shifts due to changes in charge density. The polarizability of a molecule increases in the excited state, giving rise to attractive forces. However, repulsion also increases since the orbitals become larger. The difference between these two determines the nature of the shift.

M. Kasha discussed "solvent shifts" in terms of lone-pair electrons in molecules and $n \rightarrow \pi^*$ transitions. In the nitrogen heterocyclics, which are nonfluorescent, the $n \rightarrow \pi^*$ transitions can be identified by several criteria: (i) comparison with $\pi \rightarrow \pi^*$ transitions of parent hydrocarbons; (ii) blue-shift on hydrogen-bond formation and disappearance upon the addition of H^+; (iii) comparison of fluorescence versus phosphorescence; (iv) $n \rightarrow \pi^*$ transitions are usually of low intensity, with molecular extinction coefficients of less than 2000; and (v) $\pi \rightarrow \pi^*$ transitions are polarized parallel to the plane of the molecule, while $n \rightarrow \pi^*$ transitions should be polarized perpendicular to the plane of the molecule. These criteria were discussed in relation to pyridine, quinoline, and phenazine, the latter being nonfluorescent but exhibiting a strong infrared phosphorescence at low temperature. The polarization of the $n \rightarrow \pi^*$ transitions may be observable in the oriented fibers of deoxyribonucleic acid. The $\pi \rightarrow \pi^*$ transitions should be in the plane perpendicular to the helical axis, and conversely, $n \rightarrow \pi^*$ transitions should be polarized parallel to the axis of the helix. The long-wavelength shoulder around 3000 A in the absorption spectrum of deoxyribonucleic acid is characteristic of $n \rightarrow \pi^*$ transitions.

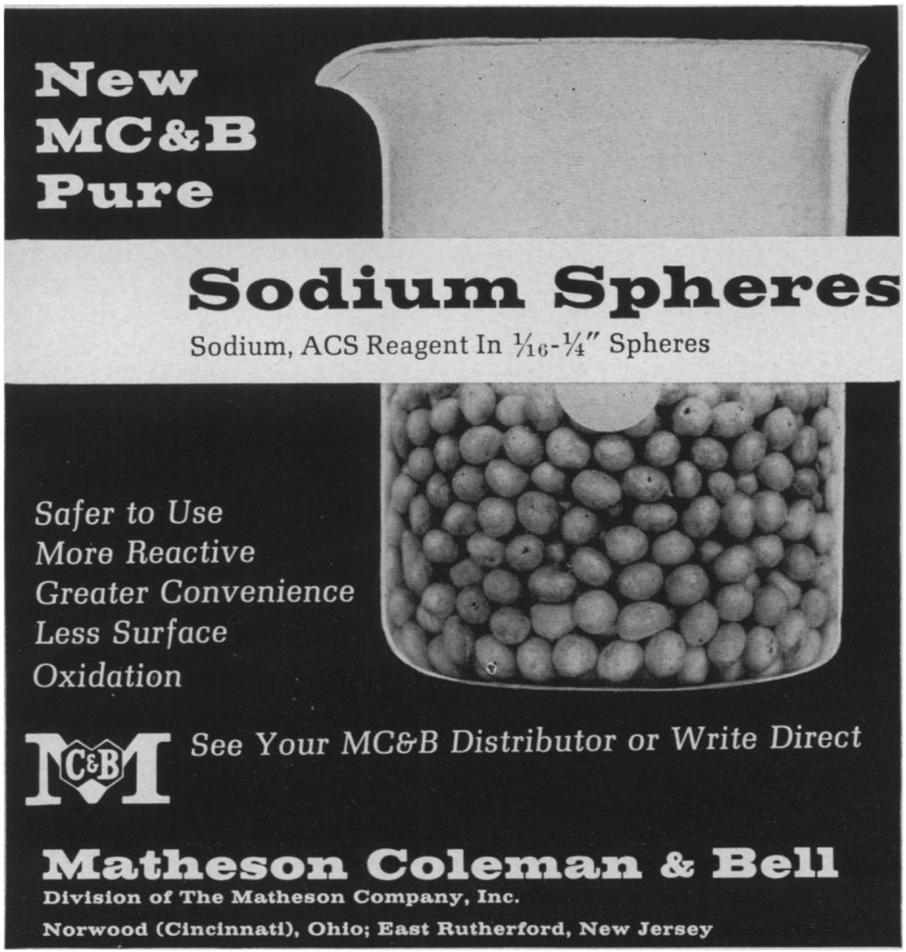
J. Platt discussed qualitative methods of assigning electron density distributions to ground and excited states of simple organic molecules and to the geometry of chain molecules such as stilbene in its cis- and trans- configuration and the cyanine dyes. The interesting speculation was made that in the latter case a donor molecule could attach at one end and an acceptor molecule at the other end, the chain serving in effect as a connector in a charge-transfer type of reaction.

Next, G. Porter presented the results of a beautifully conceived series of experiments in oxygen-free solutions, giving direct experimental evidence of triplet-triplet energy transfer. Briefly, the experiments consisted in using solutes where ${}^1\Gamma_B > {}^1\Gamma_A$ and ${}^3\Gamma_B < {}^3\Gamma_A$. In this case, addition of B to a phosphorescent solution of A quenched the ${}^3\Gamma_A$ phosphorescence and resulted in ${}^3\Gamma_B$ phosphorescence. These experiments could have important biological significance as a means of energy transfer. The slightest trace of oxygen quenches all phosphorescence.

G. Weber presented data on the absolute fluorescence yield of the aromatic amino acids as related to their *pK* values and of the depolarization of their fluorescence at low temperatures as a function of concentration. There is a divergence from the results expected on the basis of the Förster theory of energy transfer.

S. Velick described experiments on the depolarization of the fluorescence of the flavin coenzymes where it can be inferred that oxidation and reduction are accompanied by changes in molecular configuration. Energy transfer from adenine to pyridine in reduced diphosphopyridine nucleotide implies a folding of the nucleotide. The binding of these coenzymes onto the lactic dehydrogenase enzyme also affects the molecular configuration. In the discussion period, H. Beinert presented data on the flavin mononucleotide absorption in various states of reduction, and B. Commoner discussed electron spin resonance data on succinic dehydrogenase and pig-heart mitochondria, showing the existence of free radicals in enzyme complexes.

In the session on chemiluminescence, H. Linschitz presented data on the chemiluminescence of tetralin hydroperoxide catalyzed by porphyrin molecules. The mechanism is interpreted in



terms of a bimolecular reaction, and the catalytic action of the porphyrin molecule was discussed. E. White summarized the available data on hydrazide chemiluminescence and presented several possible mechanisms for the general case of chemiluminescence. Experiments by White and his co-workers and by H. H. Seliger indicate that the luminol chemiluminescence in aqueous solution is the fluorescence of the excited oxidized product molecule. Seliger found that the quantum yield, fluorescence yield, and spectral emission support this hypothesis. W. D. McElroy and Seliger presented a summary of present information on the physics and biochemistry of the chemiluminescence reaction in biological systems where catalysis is by enzymes. In the firefly the chemiluminescence efficiency is practically 100 percent. Spectral data, quantum-yield data, and a series of ingenious biochemical investigations on both firefly and bacterial bioluminescence have brought the subject at least to the place where meaningful questions concerning the detailed mechanism of oxidation can be put to experimental test. F. McCapra reported on the partial success in elucidating the structure of firefly luciferin as a hydrocarbon-linked thiazole and benzthiazole ring.

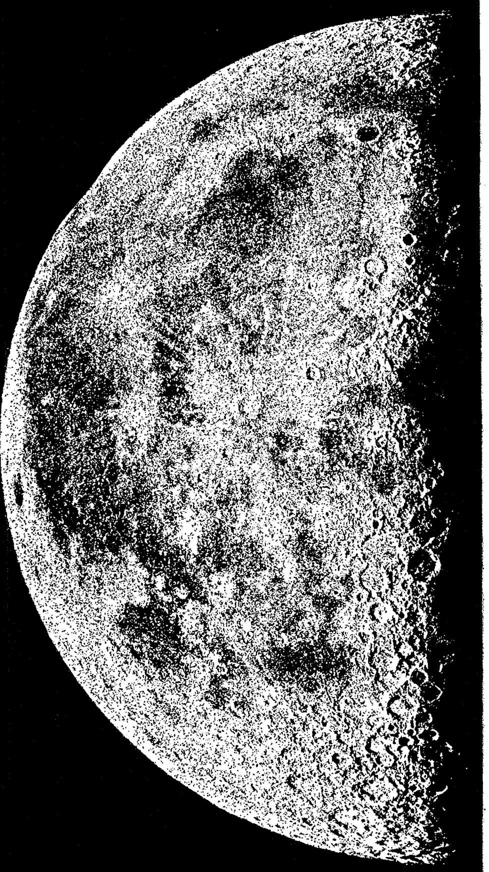
The subject of conversion of light to chemical energy in photosynthesis provided some of the most active discussions of the session. M. Calvin described model solid-state experiments in which light energy absorbed by phthalocyanine led to the reduction of *o*-chloranil in an adjoining layer. These reactions in the solid state were contrasted with reactions of chlorophyll or of other dyes in solution. Some evidence was presented suggesting that the photophysical chemistry occurring in chloroplasts might be more closely related to the solid-state model than to the reactions occurring in solution.

The seed-yeast provided by the late R. Emerson, in the form of experiments showing that photosynthesis may require the cooperation of light quanta absorbed by two different pigments, showed signs of increasingly vigorous fermentation at the meeting. While J. Franck had proposed earlier, and discussed further at this symposium, an explanation for the effect in terms of photochemistry and energy transfer, the alternative possibility has remained open—that different excited pigments might be performing different biochemical tasks. Some such differential function was strongly suggested in a number of kinds of experiments described by C. S. French. In particular, the time course of photosynthesis immediately after turning the light on, and the time course of respiration immediately after turning the light off, show very significant differences, depending on the pigment which is illuminated (the "chromatic transients" discovered by Blinks). A highly significant finding is that the cooperation between pigments can occur over time intervals of the order of seconds, indicating that ephemeral excited states cannot be the meeting ground for light energy coming from the two pigments. Another new finding of considerable interest (supported in papers by Rabinowitch and Govindjee, and by Mary Belle Allen) is the existence of different in vivo forms of chlorophyll *a*, some of which evidently perform the same function that the accessory pigments do.

B. Kok and G. Hoch reported on various experiments with both whole cells and isolated chloroplasts, in which illumination at different wavelengths led to specific changes in the absorption spectra of the photosynthetic material. This work may be at the point of bridging the gap between photochemistry and biochemistry, in that a number of reagents with known effects on electron-transport processes in chloroplasts apparently had a consistent series of effects on the absorption-spectrum shifts. Kok and Hoch have also apparently found that light absorption by chlorophyll *a* by itself is basically able to carry out photosynthetic phosphorylation with isolated chloroplasts, even though light absorption by two pigments is needed for over-all photosynthesis.

R. Hill presented a speculative working hypothesis for the mechanism of a two-quantum process in photosynthesis. The first quantum should oxidize cytochrome *f*; this, in turn, should (in a dark reaction) oxidize cytochrome *b*, generating adenosine triphosphate, and the oxidized cytochrome *b* should be reduced in a second light-requiring step which also liberates oxygen. W. D. Bonner described the more recent evidence for cytochromes in chloroplasts, and Lucile Smith reviewed their function in bacterial (*Rhodospirillum rubrum*) photosynthesis. M. D. Kamen suggested, as a possible first step in photosynthesis, the simultaneous production of a reductant (perhaps partially reduced chlorophyll) at a potential of −0.6 volt and an oxidant (his candidate being a heme in a valence state of + 4) with a potential of + 0.9 volt.

Arnon reviewed photosynthetic phosphorylation, with special emphasis on the possibilities for different electron transport pathways in chloroplasts. A. San Pietro described the reduction of triphosphopyridine nucleotide—a special case with its own special enzymes. Evidence relating to molecular oxygen as a terminal electron acceptor from the



photoreductant was discussed by Vennesland, Nakomoto, and Stern, by D. W. Krogmann, and by Jagendorf and Forti. In addition, Vennesland and his colleagues described an apparent confirmation of Warburg's recent discovery that carbon dioxide is required (but not consumed) in the Hill reactions.

The existence of adenosine triphosphatase reaction in chloroplasts under rather specialized conditions was described by Barbara Petrack and F. Lipmann. A lower level of adenosine triphosphatase activity was described by Strehler and Hendley.

K. V. Thimann reviewed the phototropic phenomena in plants and suggested a correlation between the orientation of plastids with respect to light and the phenomenon of lateral transport of growth substances under the influence of light. Further data on phototropism were presented by A. W. Galston and R. Kaur. C. Pittendrigh discussed photoperiodic phenomena, including both plant and animal mechanisms, and W. S. Hillman described experimental modifications of photoperiodic reactions in *Lemna minor*.

In the final session, on vision, discussion ranged from the biochemical basis, described by George Wald, to the electrophysiological responses, discussed by W. A. H. Rushton, T. Goldsmith, and E. F. MacNichol, Jr. The latter, in a very interesting paper, was able to show that the electrical discharges in the optic nerve fibers of the goldfish are differentially affected by changes in wavelength in such a manner as to provide a mechanism for color vision. Color vision in insects was reviewed by T. Goldsmith, with special emphasis on evidence for its occurrence and the spectral sensitivities found.

W. A. H. Rushton considered especially the problem of how nerve signals are generated after bleaching of the visual pigments. This question represents one of the major gaps in our understanding of the mechanism of vision at the present time and was not answered at this symposium. However, various characteristics of the system were defined by Rushton from the relationships between light threshold and the amount of pigment bleached, and between the light intensity and the kind of nerve signal generated.

The symposium volume, to be published shortly by the Johns Hopkins Press, should serve as a useful and up-to-date guide in the range of topics covered.

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Physicomathematical Aspects of Biology

A 3-week postgraduate course on physicomathematical aspects of biology was given in Varenna, Italy, from 11 to 30 July, under the sponsorship of the Italian Physical Society. It was the 16th of the series of postgraduate summer courses that were sponsored by the society.

N. Rashevsky, chairman of the committee on mathematical biology at the University of Chicago, was invited to organize and direct the course. The objective of the course was to present to the students a balanced program of theoretical and experimental research in selected subjects. This objective determined to a large extent the selection of the eight lecturers. Three of the lecturers—A. Bartholomay (Harvard), H. D. Landahl (Chicago), and N. Rashevsky—represented the theoreticians. The other five lecturers—E. Boeri (Ferrara, Italy), M. A. Bouman (Soesterberg, Holand), J. Defares (Leiden, Holland), M. Polissar (San Francisco), and M. Wise (Belmont-