Photosynthesis

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Photosynthesis has long been known to be composed of two parts, one photochemical and temperature independent and the other thermal. The average life of the thermal reaction has been determined by measurements made in flashing light.[1, 2]

Several explanations of the nature of the thermal (or Blackman) reaction have been advanced, some postulating the return of the plant chlorophyll to its original state after having been involved in the reduction of carbon dioxide. Franck and Herzfeld[3] describe the mechanism of the reaction as the decomposition of per-acids and per-aldehydes to formic and carbonic acids in chain processes started by light. However, the results of Emerson and Arnold[1] show the Blackman reaction to be inhibited by hydrogen cyanide, a characteristic of certain enzyme processes.

The mechanism of photosynthesis here presented is one in which the initial processes result in the formation of an organic compound of the general formula $C_NH_{2N}O_N$ and a peroxide—probably hydrogen peroxide. The formation of hydrogen peroxide is not eliminated by Franck and Herzfeld's[3] calculation of the energy involved in photosynthesis. The Blackman reaction is then the enzymatic decomposition of the peroxide. This latter would be the rate determining process in oxygen evolution at high light intensities and high carbon dioxide concentrations. Conclusions about photosynthesis drawn from measurements made under such conditions are not reliable. Our opinions are the result of experiments, performed in this laboratory, which are described below.

Into a suspension of cells (*chlorella vulgaris*), contained in a Warburg manometer apparatus illuminated by a 150-watt tungsten lamp at a distance of 5 cm, was introduced a small amount of catalase solution and the effect on the production of oxygen was observed. In all cases there was an increase in oxygen pressure beyond the amount due to normal cell activity. Figs. 1 and 2 show the results of two typical experiments. In each case a control run was made parallel to the test. Into the control there was placed, at the same time as the catalase solution was added to the test, an equivalent amount of distilled water. The solid curve in Fig. 1 represents this control. In Fig. 2 we see the results of adding catalase solution first to one cell suspension and later to the other. Attention is called to the fact that, at the end, the difference in oxygen pressures was approximately the same as at the start although there was a large difference before the addition of catalase to the second cell suspension. The experiments were run at 25 ± 0.02 degrees centigrade.

Similar experiments we performed with solutions of sodium magnesium chlorophyllin gave like sharp discontinuities in oxygen pressure on the addition of catalase solution and can be interpreted as a duplication of photosynthesis *in vitro* without the intervention of living cells.

Therefore, chlorophyll, in the plant, can be supposed to fill the dual role of light absorber and energy utilizer and,

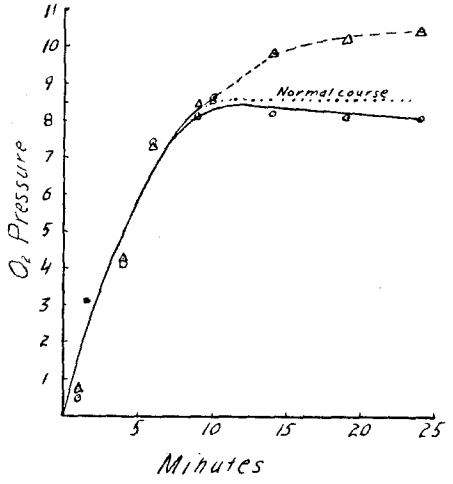

FIG. 1. Effect of catalase on oxygen production during photosynthesis. The broken lines represent oxygen production after the addition of catalase solution.

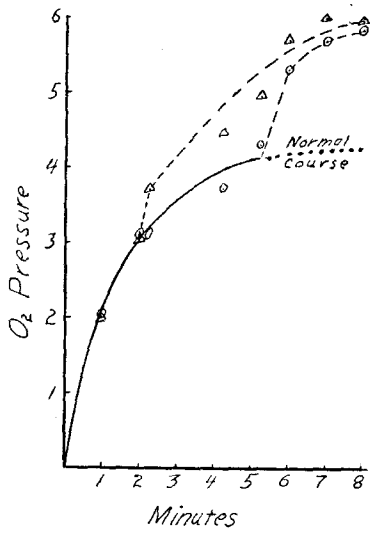

FIG. 2. Effect of catalase on oxygen production during photosynthesis. The broken lines represent oxygen production after the addition of catalase solution. Both systems were opened to and equilibrated with air at the end of two and six minutes in order to add catalase and water. The curves are corrected for the lag.

in conjunction with the fat-protein to which it is connected, as an enzyme which decomposes hydrogen peroxide.

A complete account of the experimental methods and a fuller presentation of the theory will follow in a short time.

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[1] Emerson and Arnold, J. Gen. Phys. **15**, 391 (1932).
[2] Emerson and Arnold, J. Gen. Phys. **16**, 191 (1932).
[3] Franck and Herzfeld, J. Chem. Phys. **5**, 237 (1937).