Light-dark transients in oxygen exchange of blue-green algae

The dark-light transition curves (DLTC) of photosynthetic gas exchange (induction phenomena) have been investigated by several authors[1,2,3] as well as the related induction phenomena in chlorophyll fluorescence[1,4]. On the other hand, the light-dark transition curves (LDTC) have received much less attention. During investigations both of the general course and of the fine details of oxygen exchange in assimilating organisms[5] some remarkable characteristics of the LDTC were observed.

The method of BLINKS AND SKOW[6,7], with some modifications, was used for registration of the oxygen exchange rates. Some of the details have been given previously[5], and a further description will be published later. Blue-green thermal algae (*Oscillatoria, Symploca, Mastigocladus*), cultivated in a thermostat on mineral agar media, were used as the most convenient experimental material. Nearly identical results were also obtained with *Chlorella* and other algae.

In Fig. 1 some representative records of photosynthetic oxygen exchange are reproduced. They were chosen to demonstrate the following salient points:

1. On darkening—under aerobic conditions—the oxygen line moves from the light steady state to the dark one only gradually, often taking several minutes. This is not due to the hysteresis of the method. The LDTC curves are of various shapes, but they nearly always have definite characteristic features, *e.g.*, two inflections or minima, which are most clearly seen on records 240b, 474 and 996 (Fig. 1), also on R 478 and 844 (in the latter case with a third minimum). The perfectly exponential course of LDTC, as seen in R 643b, was observed only exceptionally, with low light intensities, and could not be reproduced at will.

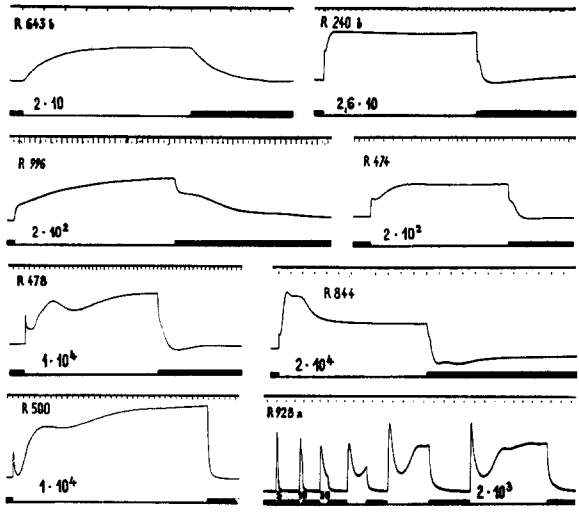

Fig. 1. Records of oxygen exchange. (For method, see previous paper[8].) On the lower margins of the records, dark strips are found representing intervals of darkness and figures indicating light intensity in lux. Other marks as in previous paper. R 643b – *Symploca*, 25° C, pH 7, air, sensitivity[8] $2.7 \cdot 10^{-2}$; R 240b – *Oscillatoria*, 25° C, pH 5, air + 1 % CO_2, sensitivity $6.75 \cdot 10^{-2}$; R 996 – *Oscillatoria*, 5° C, pH 7, air, sensitivity $2.7 \cdot 10^{-2}$; R 474 – *Symploca*, 15° C, pH 7, air + 1 % CO_2, sensitivity $6.75 \cdot 10^{-2}$; R 478 – *Symploca*, 15° C, pH 7, air, sensitivity $4.05 \cdot 10^{-2}$; R 844 – *Oscillatoria*, 35° C, pH 7, air, sensitivity $9.5 \cdot 10^{-1}$; R 500 – *Symploca*, 15° C, pH 7, nitrogen + 1 % CO_2, sensitivity $4.05 \cdot 10^{-2}$; R 928a – *Oscillatoria*, 10° C, pH 7, nitrogen + 1 % CO_2, sensitivity $4.05 \cdot 10^{-2}$.

2. Under anaerobic conditions the oxygen line on darkening follows a much simpler course (Fig. 1, R 500 and 928). No irregularities are observed on the falling leg of the oxygen production curve and it attains zero within a relatively short time.

3. The DLTC and LDTC on aerobic records are often found to be symmetrical. This symmetry is sometimes nearly perfect with curves obtained at low or medium intensities of illumination (Fig. 1, records 643b, 240b, 474, 996; with curves of the R 643b type the parameters of the exponential functions for the ascending and descending leg are equal). Striking symmetry is occasionally observed even on curves taken at high light intensities (R 844), and by comparative

analysis, analogous sections may be found on DLTC and LDTC in practically all records under aerobic conditions (even, for example, on R 478). Under nitrogen, the LDTC has a character of a rapid monophasic decay and it is never found to be symmetrical with the DLTC.

In a previous communication, the author has suggested that the shape of the aerobic LDTC records results from the (pseudo)monomolecular liberation of oxygen from an intermediary product present at the moment the light is shut off. To explain the two inflections or minima commonly observed on the LDTC, two oxygen-consuming processes were assumed to take place at the beginning of the dark period. This type of explanation, however, seems rather inadequate, if the striking symmetry of the LDTC and DLTC is taken into account. It would be strange if by mere chance similar time constants were to govern both the start of the complicated reaction chain in photosynthesis and the single reaction of oxygen liberation from an intermediary product. It seems more plausible that, in some way or other, the LDTC reflect changes in reservoir sizes of the same intermediates and variations in rates of the same reversible reactions, which are reflected by the DLTC when the opposite transition from dark to light takes place.

Before a reasonable interpretation of the phenomena observed can be attempted, more data must be collected. In particular, parallel determinations of oxygen exchange by a dropping mercury electrode and by the method of BLINKS AND SKOW are planned. It is the disadvantage of the latter method that it fails to give a clear discrimination between net oxygen production and uptake. Consequently, the point of basic interest cannot be established, *i.e.*, which sections of the records fall above the compensation point and which are below it. To know this is obviously of great importance for an adequate interpretation of the LDTC and for the correct evaluation of interactions existing between photosynthesis and respiration. That such interrelations influence the shape of aerobic LDTC records is suggested by the striking difference between aerobic and anaerobic light-dark transition curves.

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Inhibition of citrate oxidation by glyoxylate in rat liver homogenates

The mechanism of the inhibition produced by glyoxylate on a respiring tissue suspension, first shown by KLEINZELLER[1], has been investigated by studying the action of very small amounts of glyoxylate on the oxidative behaviour of the most important metabolites related to the tricarboxylic acid cycle.

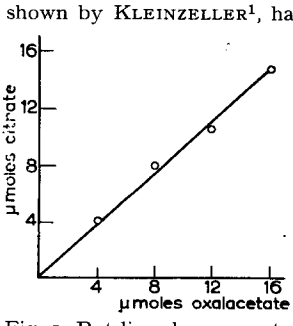

Fig. 1. Rat liver homogenate 1:10; glyoxylate 0.001 *M*; NaF 0.01 *M*.

For this purpose 0.001 *M* glyoxylate was added to a rat liver homogenate incubated in the presence of citrate, *cis*-aconitate, *iso*citrate, *α*-ketoglutarate, succinate, fumarate, malate, oxalacetate and pyruvate, each at a final concentration of 0.002 *M*. The final volume of the incubation mixtures was always 4.0 ml; the concentration of the homogenate was 1:10 (prepared in Krebs' phospho-saline medium free of Ca^{++} and with the addition of 0.025 *M* Mg^{++} and 0.01 *M* F^-). The incubation was for 60 min at 38° C in Warburg vessels of about 15 ml capacity; O_2 gas phase; pH 7.4. Another experiment was carried out under the same conditions with 0.001 *M* glyoxylate and differing concentrations of oxalacetate as shown in Fig. 1.

In all the experiments the oxygen uptake was followed manometrically, and at the end of the incubation citrate was determined