THE DISSIPATION REACTION IN THE ASSIMILATION PROCESS II

by

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I. STATEMENT OF THE PROBLEM

In the preceding paper it was stated that although the theory of chemical kinetics cannot by itself give information about the mechanism of the assimilation process, very little information from an outside source may be sufficient to enable conclusions to be drawn. An important question with regard to this mechanism is how the energy from different absorption processes is collected to bring about the reduction of one CO_2-molecule. Some investigators[2] think that the CO_2 molecule itself travels around in its different reduction stages to collect the necessary energy. Others[1, 3] think that an energy acceptor starts migrating through the assimilation apparatus after it has accepted a quantum of energy. This acceptor may be, for instance, H_2O or H_2A, and the migrating particle the H-atom[1]. Finally one can suppose[4 5], that the energy travels as such through the assimilation apparatus as in crystals or in the polymolecules of SCHEIBE[6]. We can try to solve the problem of energy transport if we know at which point in the reaction chain a quanta-collecting reaction appears. To obtain information on this we can investigate the action of poisons. A poison, in the theory of the previous paper, is a dissipator of energy. Either the poison blocks certain absorption spots for the normal acceptors and thus enhances the normal dissipation, or it takes up energy itself and gives it off in a form unsuitable for assimilation. In both cases the ratio of an assimilation constant to the corresponding dissipation constant $\frac{k_1}{k_{4a}}$ or $\frac{k_2}{k_{4b}}$ decreases. It follows from the preceding paper that a more pronounced S-shape will result when the poison spoils a polymolecular reaction, whereas the S-shape is not influenced when the poison acts upon a monomolecular reaction.

II. THE EXPERIMENTS ON ASSIMILATION AND FLUORESCENCE OF CHLOROPHYLL

From simultaneous measurements of photosynthesis and fluorescence as carried out by WASSINK and collaborators[1], also[7, 8], it possible to obtain information about the point in the reaction chain at which a certain poison acts. It was found in this way, in experiments on both chlorella and thiorhodaceae, that some poisons such as KCN and NH_2OH impede the assimilation without influencing the fluorescence of the chlorophyll. Since these poisons influence the assimilation chain without influencing the energy transfer

* Most of the work on this article was done when the author and engaged in the laboratory of Philips Gloeilampenfabrieken, Eindhoven.

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from the chlorophyll, they apparently act at the end of the assimilation chain. On the other hand, poisons like urethane and Na_3N influence the fluorescence and the assimilation at the same time: these substances exert their influence on the fluorescence even when no energy acceptor is present, so apparently they act immediately with the chlorophyll. The point we wish to stress here is *that poisons of the first type do not influence the S-shape of the assimilation curve* (fig. 45 and 61 of [3]), *whereas poisons of the second type make the S-shape definitely more pronounced* (fig. 70, 74, 75, 76, 77 of [3]).

III. CONCLUSIONS

From these facts we conclude that a quanta-collecting reaction is one of the very first steps in the assimilation process, in fact, a step already taken before the energy is transferred to the energy acceptor. The most probable picture seems to be that the quanta are collected in packets of two or more quanta immediately on the chlorophyll layer. Apparently the energy transfer is accomplished in the same way as in crystals and in the polymolecules of SCHEIBE[6]. Theoretically this is possible only if the potential for the excited electron is strictly periodic, which suggests that the structure of the chlorophyll layers must be remarkably regular.

IV. DISCUSSION

As the conclusions we have drawn are rather far-reaching, we shall now consider their reliability.

That urethane acts immediately on the chlorophyll seems to be beyond any doubt. It is, however, possible that it acts in a later stage of the assimilation process also and that its influence on the S-shape is exerted in that stage.

WASSINK, KATZ and DORRESTEIN suppose that intra-cellular donors are responsible for the S-shape. Their explanation is in accordance with ours in so far as we have already stated that intra-cellular donors have to be considered as dissipators when CO_2-uptake is measured. However, in our picture the quanta-collecting reaction is essential for the explanation of the S-shape, since, in para. 4 of the previous article, we have shown that the mere competition of a dissipation reaction with a saturation reaction is not sufficient to produce an S-shape. Thus the mechanism proposed by these authors involves certain rather special assumptions. On the other hand, the S-shaped curve is the most general conclusion from chemical kinetics and must therefore be expected, especially when dissipation is promoted in the way it is with poisons. This does not, of course, affect the arguments set out by WASSINK *et al.* on the important role played by intra-cellular donors. Indeed from these arguments it seems to be very probable that of our non-specified dissipation reactions the auto-assimilation reaction is an important example. This should mean that Nature works very efficiently and that very little energy is lost in the building of organic substances such as carbohydrates.

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SUMMARY

The theory of the preceding paper is applied to experiments of WASSINK *et al.* on the action of poisons on the assimilation reaction. From the conbined investigation of the influence of poisons on

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the fluorescence of chloropyll and on the assimilation, it follows that certain poisons interfere with the assimilation at the beginning of the assimilation chain, while others do so at the end. Further, it is found that the poisons that act in the beginning of the chain produce a very definite. S-shape in the assimilation curve, whereas poisons of the other class have no such effect. This leads to the conclusion that at the beginning of the chain a quanta-collecting reaction is inserted, and thus we are able to answer the question of the mechanism of energy transportation. The theory points to a mechanism of transport of energy as such like that found in crystals and in some polymolecules.

RÉSUMÉ

La théorie du travail précédent est appliquée aux expériences de WASSINK et Col. sur l'action de substances toxiques vis à vis de l'assimilation. Combinant les résultats obtenus concernant l'influence de ces substances sur la fluorescence de la chlorophylle et sur l'assimilation, on conclut que certains toxiques bloquent l'assimilation au début de la chaîne, alors que d'autres la bloquent en agissant sur la fin de la chaîne. En outre, on constate que les poisons agissant au début de la chaîne donnent à la courbe d'assimilation une forme en S très accentuée, alors que les autres toxiques n'ont pas cette action. On en conclut qu'une réaction collectrice de quanta se trouve ainsi placée au début de la chaîne, et on peut ainsi résoudre la question du mécanisme du transfert de l'énergie. La théorie conduit à envisager un mécanisme de transfert de l'énergie analogue à celui que l'on rencontre dans les crystaux et dans certaines molécules complexes.

ZUSAMMENFASSUNG

Die Theorie der vorhergehenden Arbeit wird auf Versuche von WASSINK *et al.* Über die Wirkung von Giften auf die Assimilationsreaktionen angewandt. Aus der kombinierten Untersuchung des Gifteinflusses auf die Chlorophyllfluoreszenz und die Assimilation folgt, dass gewisse Gifte die Assimilation am Beginn der Assimilationskette stören, während andere Gifte dies am Kettenende tun. Weiter wird gefunden, dass die Gifte, die am Kettenanfang eingreifen, eine sehr deutliche S-Form in der Assimilationskurve produzieren, während Gifte der anderen Klasse keine derartige Wirkung haben. Diese Ergebnisse führen zu der Schlussfolgerung, dass am Kettenanfang eine quantensammelnde Reaktion eingefügt ist, und dadurch können wir die Frage des Mechanismus des Energietransports beantworten. Die Theorie weist auf einen solchen Transportmechanismus, wie diejenigen, die in Kristallen und in manchen Polymolekülen gefunden wurden.

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