tion. The susceptibility of young chicks and of adult birds of other species makes entirely understandable the massive concentration of the virus of equine encephalomyelitis which develops in chick embryos as contrasted with the low titre of the virus in the brain of horses. The susceptibility of many birds to certain strains of encephalomyelitis has been demonstrated experimentally; notably the pigeon,[1] a species of vulture, the stork, the duck, the goose, the European blackbird and the common harrier of Europe.[2]

On preliminary study of stained sections of brain and cord of the pheasant infected in nature, perivascular lesions are found distributed unevenly throughout the cerebrum and there is also a meningitis. Around the small blood vessels there are prominent infiltrations composed of lymphocytes, plasma cells and large mononuclears. Cells of the same types occur in the pia. Polymorphonuclear cells are so rare as to be demonstrable with difficulty. The brains of inoculated quail and chickens show less conspicuous lesions. The cerebrum of the infected guinea pig presents numerous ill-defined foci of polymorphonuclear infiltration, distributed superficially in the brain substance. The lesions of the mouse brain are less obvious and are chiefly of a degenerative nature.

Summary: The recognition of a series of cases of equine encephalomyelitis in pheasants adds valuable information concerning the distribution of this disease, and the designation "equine" becomes an unfortunate misnomer. Indeed, it may be seriously questioned whether the horse or other domestic animals play any essential rôle in assuring the perpetuation of this disease. The present demonstration of the natural occurrence of the infection in game birds and the experimental evidence obtained by Remlinger and Bailly of the susceptibility of migratory birds to certain strains of encephalomyelitis suggest an easy mode for the wide distribution of this virus. A search for spontaneous infection in migratory birds is indicated. Extensive surveys will be required in order to know just how widely the infection is spread in nature. It may be only under accidental circumstances or when the infection rises to a certain level that it overflows and becomes a serious problem as regards the horse and even the human being.

ERNEST EDWARD TYZZER
ANDREW WATSON SELLARDS
BYRON L. BENNETT

DEPARTMENT OF COMPARATIVE PATHOLOGY AND TROPICAL MEDICINE, SCHOOLS OF MEDICINE AND PUBLIC HEALTH, HARVARD UNIVERSITY

1 L. T. Giltner and M. S. Shahan, SCIENCE, 1933, 78: 62, 1933.

2 P. Remlinger and J. Bailly, *Compt. Rend. Soc. Biol.*, 120: 1067, 1935; *ibid.*, 121: 146, 1936; *ibid.*, 122: 518, 1936; *ibid.*, 123: 562, 1936.

THE ABSORPTION OF CARBON DIOXIDE IN PHOTOSYNTHESIS

IT is often stated that enzymatic processes are reversible. It is also a commonplace that photosynthesis is in many respects the reverse of respiration. Now there is every reason to believe that the CO_2 formed in oxidations arises from organic acids, probably by the same reactions as in fermentation, namely, from pyruvic acid by the action of carboxylase, from formic acid by the hydrogenlyase, from oxalacetic acid in its breakdown to pyruvic acid, from acetoacetic acid in the acetone fermentation, etc. What could be more natural than to suppose that in photosynthesis the absorption of carbon dioxide takes place in the reverse way, by combination with an aldehyde, or, more probably, with an organic acid, to produce a new carboxyl group? Specifically, a probable reaction is the combination of CO_2 with pyruvic acid to produce oxalacetic or perhaps with lactic acid to produce malic. The light reaction would then be the reduction, not of CO_2 as such, but of the carboxyl group.

This simple assumption would make the first reactions in photosynthesis much easier to comprehend. It is usually assumed, following Willstätter and Stoll, that the CO_2 combines with the chlorophyll, but for this there has never really been sufficient evidence. For formaldehyde ("activated" or otherwise) as the first reduction product of CO_2 there is even less evidence, and the persistence of these unsupported theories must be ascribed to the absence of any plausible substitute. It is hoped that the suggestion here made may provide a working hypothesis which at least is consistent with a number of facts.

Both in photosynthesis and chemosynthesis there is evidence pointing to such a reaction. In the *Athiorhodaceae,* in light, Gaffron[1] showed that CO_2 is absorbed in presence of mono- or di-carboxylic acids and there was a corresponding disappearance of carboxyl groups. In the *Propionibacteriaceae,* Wood and Werkman[2] have shown that CO_2 is absorbed, non-photosynthetically, probably by combination with an organic acid. The reversible equilibrium between CO_2, hydrogen and formic acid in *bacterium coli*[3] is also suggestive. Whether or no we may safely generalize from individual biochemical processes, it is a remarkable fact that recent work gives increasing evidence for the role of intermediate products themselves as catalysts or carriers in a catalytic cycle. There is the action of arginine in the formation of urea,[4] the dicarboxylic

1 H. Gaffron, *Biochem. Zeit.*, 260: 1, 1933; 275: 301, 1935.

2 H. G. Wood and C. H. Werkman, *Biochem. Jour.*, 30: 48, 1936; 32: 1262, 1938.

3 D. D. Woods, *Biochem. Jour.*, 30: 515, 1936.

4 H. A. Krebs and K. Henseleit, *Zeit. Physiol. Chem.*, 210: 33, 1932.

acid hydrogen carriers of Szent-Györgyi and co-workers[5] and the acetic-succinic-pyruvic-acetic cycle, while the cyclic processes of alcoholic and lactic fermentation are closely comparable. The combination of CO_2 with an organic acid, the photo-reduction of the carboxyl group and the consequent intramolecular changes leading finally to the setting free of the organic acid again, would be just such a cycle. Doubtless some of the organic acid would be reduced to sugar in each cycle.

These considerations suggest an important connection between photosynthesis and organic acid metabolism, a connection which, to the writer's knowledge, has never been investigated. If photosynthesis were to require a small supply of organic acid as intermediate, this would explain such observations as the failure of isolated chloroplasts to photosynthesize. In any event, it is believed that investigations along the above lines would be profitable.

KENNETH V. THIMANN
HARVARD BIOLOGICAL LABORATORIES,
CAMBRIDGE

AIRPLANE COLLECTIONS OF SUGAR-BEET POLLEN

THE localized area in the Rio Grande Valley in southern New Mexico in which sugar beets were being grown for seed production in 1938 afforded opportunity for making collections to determine presence of sugar-beet pollen at various altitudes. The area planted to sugar beets for seed comprised about 900 acres and was concentrated into a few districts lying between El Paso, Texas, and Las Cruces, New Mexico. Source of the sugar-beet pollen caught was assignable with some sureness, since no other sugar beets were grown within a 125-mile radius. The period of flowering of the sugar beet extended from late April until the middle of June, the height of blooming being between May 15 and June 1.

Through the cooperation of the U. S. Army Air Corps an airplane flight in the general region of concentration of beet fields was made on June 3, 1938, by Major Guy Kirksey, commanding officer at Biggs Field, El Paso, Texas, with F. C. Meier as observer.[1] The flight was made from 10:30 A.M. to 1:00 P.M. of a hot, fairly quiet day. Series of short exposures of agar plates were made at the various altitudes.

Flights in other years in this region had indicated presence of sugar-beet pollen fairly high in the air.[2] Special precautions were taken in making the 1938 collections to eliminate possibility of contamination either prior to exposure or during examination of the agar plates. Using 40 per cent. sucrose agar, Petri dishes were prepared in Washington a few days previous to the flight. After solidification of the agar, the covers of the dishes were bound in place by a strip of Cellophane adhesive running across the lid and fastening to the bottom dish. The Petri dishes were also sealed with ordinary surgical adhesive tape to prevent contamination and drying. The small wooden Petri dish holder devised by F. C. Meier was used in exposing the agar plates outside the plane. This holder consists of a circular wooden base about the size of the Petri dish and is fitted with short projecting brass strips which, slipping between the overlapping side walls of the lid and base, clamp the bottom half snugly. In making an exposure the adhesive seal was removed in the cockpit, and the covered Petri dish pushed in place in the holder. The observer held the plate outside the plane with one hand, twisted the top with the other to cut the Cellophane binder and then removed the cover. When the exposure was completed, the lid was replaced outside the plane. The covered dish was then resealed with the surgical adhesive tape in the cockpit.

In order to avoid outside contamination, the exposed plates were taken directly from the landing field to an air-conditioned room for the examinations for presence of sugar-beet pollen. In the systematic study of the plates under the microscope, magnification with the 16-millimeter objective was ordinarily adequate for the identification. Magnification with the 4-millimeter objective to bring out more sharply the characteristic markings of sugar-beet pollen,[3] which differentiate it from allied pollens of somewhat similar size, was frequently used to verify identifications, and also whenever the pollen was more deeply embedded in the agar film. The data obtained from the examination of the plates for the various exposures are given in Table 1.

TABLE 1

SUGAR-BEET POLLEN GRAINS TRAPPED ON AGAR PLATES EXPOSED IN AIRPLANE FLIGHT, RIO GRANDE VALLEY, SOUTHERN NEW MEXICO, ON JUNE 3, 1938

Elevation above valley floor	Number of pollen grains and exposure period in minutes				
	1	2	3	4	5
1,000	–	17	19*	5	15†
2,000	–	–	14	4	7*
3,000	0	3*	7*	4	–
4,000	1; 0	0	–	2	6
5,000	5	2	6	6	9*

* One germinating pollen grain found.
† At least two pollen grains germinating.

Pollen grains were found at all altitudes with the number becoming fewer at four thousand feet. At the 5,000-foot level, which corresponds to the so-called "dust horizon," the number seemed appreciably larger

[5] *Zeit. Physiol. Chem.*, 236: 1, 20, 31, 58, 66, 1935.

[1] The senior author while continuing his research in aerobiology was lost with the Hawaii Clipper on July 29, 1938.

[2] G. H. Coons, U. S. Dept. Agr. Yearbook, 1936, p. 646.

[3] Ernst Artschwager and R. C. Starrett, *Jour. Agr. Res.*, 47: 823–843, 1933.