restricted to the periplasm. A fertilizing tube is now put out from the antheridium, into which passes a single nucleus derived from the division into two of one of the original antheridial nuclei, together with a small quantity of very deeply stained, finely granular protoplasm. The fertilizing tube penetrates deeply into the oosphere until it comes quite close to the female nucleus. The male nucleus is then expelled, and the fertilizing tube is gradually withdrawn from the oosphere, on which it then comes to lie obliquely. A delicate cell-membrane is produced around the oosphere, separating it from the periplasm. The male and female nuclei then fuse together in the centre of the deeply-stained protoplasm to produce the nucleus of the oospore. This nucleus then undergoes division into two, four, eight, sixteen, and thirty-two, and at the same time the thick endospore is produced on the inside of the primary membrane of the oosphere from the protoplasm of the oospore, the exosporial layers being formed at the same time from the periplasm and the degenerating periplasmic nuclei.

HAROLD WAGER.

CHAPEL ALLERTON, LEEDS.

PRELIMINARY NOTE ON THE RELATION BETWEEN CALCIUM AND THE CONDUCTION OF CARBOHYDRATES IN PLANTS.—In 1875 Boehm (1) came to the conclusion that one of the functions of calcium is to aid in the conduction of carbohydrates in plants.

In his two papers A. F. W. Schimper (2) (3) added considerably to our knowledge of the rôle of calcium. In his first paper he subscribed to Boehm's views to a certain extent. In his second paper he demonstrated that in plants which normally contain crystals of calcic oxalate, oxalic acid is a bye-product of the synthesis of proteids, and that in the absence of calcium there is an abnormal accumulation of acid potassic oxalate in leaves and buds. He showed farther that this soluble oxalate acts as a poison. He therefore concluded that the use of calcium is to neutralize this poisonous salt. Schimper also proved that sugar can travel in leaves containing no appreciable amount of calcium; that carbohydrates sometimes travel from the seeds up the stem of the seedling without any corresponding emigration of calcium. Finally, he pointed out that in plants cultivated without calcium, though the terminal bud might be dying, yet at the

same time new lateral buds might be shooting out. These considerations led Schimper to conclude that calcium plays no fundamental part in the conduction of carbohydrates.

This conclusion still left unexplained the abnormal accumulation of starch in plants cultivated in solutions devoid of calcium. It appeared to me that the explanation might be very simple, namely, that though potassic oxalate did not prevent the transport of sugar, it was capable of arresting the change of starch into sugar. It naturally suggested itself that acid potassic oxalate should either prevent diastase from being formed or should stop its action. I therefore made some experiments on the influence of acid potassic oxalate on diastatic action.

In these experiments a strong solution of 'extract of malt' was used in place of pure diastase, to act upon a clear portion of a .5 per cent. solution of arrowroot-starch. Bacteria were kept at bay by means of traces of thymol. In each case 10 cc. of starch-solution were mixed with 10 cc. of certain strengths of acid potassic oxalate solution; then 10 cc. of the solution of 'extract of malt' were added. The following table shows the result of experiments conducted at a temperature of about 30° C, and commenced at 11 a.m.

Solutions.	Resulting percentage of acid potassic oxalate in the whole mixture.	Colour when treated with iodine at		
		12 a.m.	1.30 p.m.	4.30 p.m.
A. B. C. D.	.6, .5, .3, .26	Blue	Blue	Blue
E.	.13	Dirty brown	Lighter brown	Yellow
F. G. H. K.	.04, .02, .013, 0	Yellow	Yellow	Yellow

This preliminary set of experiments roughly showed that the action of diastase is retarded by even dilute solutions of acid potassic oxalate. I subsequently found that similar rough observations had been made by Detmer, whose investigations are quoted in Schleichert's *Das diastatische Ferment der Pflanzen*. Quantitative observations, in which pure diastase was employed, have been conducted by Mr. J. H. Manley, of the Magdalen College Chemical Laboratory, Oxford; these, though not yet complete, confirm the rough observations.

It became essential to see next if this soluble oxalate had the same action on starch in the living leaf. For experiments I selected sub-

merged aquatic plants, in order that salt-solution should penetrate the living cells rapidly. After some rough preliminary experiments on *Vallisneria*, I selected *Elodea canadensis* and *Callitriche* sp.

Experiments with Elodea.

The leaves were placed in 50 cc. of solutions *A* to *L*, varying therefore from 0 per cent. up to .24 per cent. acid oxalate of potassium. When first put in the leaves contained starch. The leaves of *Callitriche* were only casually examined to see that there was in general the same distribution of starch. The following table represents under the general heading II, the amount of starch found in leaves kept darkened for 24, 72, and 96 hours, in solutions *A* to *L*.

Strength of solution of acid potassic oxalate.	II.			III.
	Amount of starch in leaf after darkening for 24 hours.	72 hours.	96 hours.	Amount of starch in leaves after several days' illumination. Examined sometimes between 10 a.m. and 1 p.m.
<i>A</i> 0	0	0	0	Starch present.
<i>B</i> .000065	0	0	0	"
<i>C</i> .00025	0	0	0	"
<i>D</i> .001	0	0	0	More starch than in <i>C, B</i> .
<i>E</i> .0025	0	0	0	Much starch: more than <i>B, C, D</i> .
<i>F</i> .005	Small amount	0	0	" "
<i>G</i> .01	"	Small amount	Minute amount	If anything had less starch than before illumination.
<i>H</i> .04	?	Considerable amount	Considerable amount	Considerable amount of starch.
<i>I</i> .08	Considerable amount	"	"	" "
<i>K</i> .16	"	"	"	" "
<i>L</i> .24	"	"	"	" "

These observations show that acid potassic oxalate retards the process of the change of starch into sugar in the living leaf.

It remained to be seen, if, under conditions of alternating light and darkness, an abnormal accumulation of starch could be induced, such as occurs when plants are cultivated in solutions devoid of calcium. To ascertain this I continued this second series of experiments, but placed the leaves, still lying in their respective solutions, in front of a window in the laboratory. They were allowed to remain thus for

two or three days¹. The last column (96 hours) under the heading II of the foregoing table, therefore represents the amount of starch contained by these leaves before illumination; and the details given under the heading III describe how much starch there was after two to three days and nights. In *A*, *B*, *C* there was some starch, showing that starch was being formed but was constantly being reconverted into sugar. In *D* there was more starch, and in *E* and *F* much more starch: thus showing that starch was being manufactured but that its reversion into sugar was slower than in *A*, *B*, *C*. In *G* to *L* there was no appreciable change in the amount of starch caused by illumination: thus demonstrating that not only was the change of starch into sugar retarded but that the manufacture of starch was almost or quite arrested.

Restoring all the leaves into tap-water showed that those which had been in *A-G* were still alive and could make starch, whereas those in *H-L* had been killed.

The difficulty at once presents itself as to how the change from starch to sugar is accomplished in leaves which normally contain a considerable amount of acid potassic oxalate in solution. I therefore made several series of experiments with leaves of *Oxalis floribunda*, in which there is a large amount of soluble oxalate. A description of one of these series will suffice to show the results obtained.

Experiments with Oxalis floribunda.

Leaves were picked which contained a considerable amount of starch. The leaflets were pulled from the petiole and then either cut transversely or longitudinally into two halves, or they were only wounded by three cuts extending from the margin of the distal or proximal part towards the centre of the leaflets. These leaflets were then dropped into solutions *A-L* identical with those used in the *Elodea*-experiments, and into an additional solution (*M*) of .5 per cent. acid potassic oxalate. The cuts were made in order to allow the solution to penetrate the leaves. The leaflets in the respective solutions were then kept in darkness for ninety-six hours, at the conclusion of which they were examined. Leaflets in *A-E*, cut in various ways, all showed starch only in the actually injured cells at the cut surface. Leaflet in *F* had starch only in a narrow band of cells bounding and running

¹ I unfortunately omitted to record the number of days.

parallel to the cut. Leaflets in *G-M*, cut in various ways, all possessed starch in a band of cells bounding and running parallel to the cut. In *G-M* the band was broader than in *F*. Elsewhere there was no starch excepting a small amount coating the vascular bundles for a short distance as they radiated from the cuts.

These results prove that in *Oxalis* a dilute solution of acid potassic oxalate in the assimilating cells will prevent the starch from being changed into sugar. Yet during the normal life of this *Oxalis* there is a large amount of the oxalate, still no such accumulation of starch ensues. For the explanation of the mystery we must look to the distribution of the acid oxalate in the normal leaves of *Oxalis*. Giessler (4) showed that the soluble oxalate is stored in the epidermis of the leaf, not in the assimilating tissue. The oxalate is stored in the epidermis because its presence in the mesophyll would derange the metabolic processes; and not because the plant needs to protect itself against snails, &c., as Giessler suggests. The protective significance of the superficial distribution of the oxalate is at most secondary.

To sum up:—

- (1) Acid potassic oxalate retards the action of diastase on starch.
- (2) In the living plant the first, and, at the commencement, the only visible effect of acid potassic oxalate on the assimilating organs is the accumulation of starch, owing to an arrest of the change of the starch into sugar.
- (3) The second effect, as the soluble oxalate accumulates, is a retardation of the manufacture of starch, and hence probably of the assimilation of carbon.
- (4) The last effect, with increased accumulation of the oxalate, is the death of the protoplasm.

These researches therefore confirm the discovery made by Schimper, that the evil effects of a lack of calcium are to be attributed to the accumulation of acid potassic oxalate in plants which normally contain calcic oxalate. They may be regarded as complementary in showing that, in the absence of calcium, there is a stoppage of the conduction of those carbohydrates only which have entered into the condition of starch. Schimper (5) showed that part of the carbon assimilated by a plant never enters into the starch-condition, and this has been confirmed by Brown and Morris (6). It is therefore clear why growth is not at once arrested in shoots or seedlings deprived of calcium.

LITERATURE.

- (1). J. BOEHM: Ueber der vegetabilischen Nährwerth der Kalksalze. Sitzber. d. Wiener Ak. d. W. Bd. 71, 1875.
- (2). A. F. W. SCHIMPER: Ueber Kalkoxalatbildung in den Laubblättern. Bot. Zeit. 1888 (Sep. Abd.).
- (3). A. F. W. SCHIMPER: Zur Frage der Assimilation der Mineralsalze durch die grüne Pflanze. Flora, 1890 (Sep. Abd.).
- (4). R. GIESSLER: Die Localization der Oxalsäure in der Pflanze. Bot. Zeitung, 1894, No. 2, p. 25.
- (5). A. F. W. SCHIMPER: Ueber Bildung und Wanderung der Kohlhydrate in den Laubblättern. Bot. Zeit. 1885 (Sep. Abd.).
- (6). HORACE T. BROWN & G. H. MORRIS: A Contribution to the Chemistry and Physiology of Foliage-leaves. Abstract in Annals of Botany, VII, 1893, p. 271.

PERCY GROOM.

OXFORD.

NOTE ON SACCORHIZA BULBOSA, J. G. AG., AND ALARIA ESCULENTA, GREV.—In his paper on the structure and development of the bulb in *Laminaria bulbosa*, Lam. in Vol. III of the Annals of Botany (pp. 41–64), Barber gives an interesting *résumé* of the literature dealing with this plant. From the references there given, it would not appear that the duration of the plant had, at that time, been satisfactorily settled. From observations made last year while collecting Algae on the coast of Anglesey, I have satisfied myself that the species is an annual, and in this respect contrasts sharply with the other British Laminariaceae.

During the spring tides of March, I had an opportunity of examining *Saccorhiza* growing, and at that time, I found it represented by specimens in two widely different conditions. First, there were large bulbs often more than a foot in diameter, from which the whole of the blade, and almost the whole of the stalk had disappeared through decay. The bulbs themselves were as yet sound, and required the exertion of considerable force to remove them. Among these blackish masses, bristling with ‘hapteres,’ were numerous young plants of a lighter colour, and exhibiting the various stages in the development of the bulb described by Barber; but in no case had the bulbous portion attained a diameter of more than four inches, or the whole plant a length of more than two feet. Upon visiting the same site during the spring tides of October, I could find no trace of exfoliated bulbs or of young imperfectly developed plants. All the specimens were now in the condition of the mature plant, with which we are made

Groom, Percy. 1896. "Preliminary note on the relation between calcium and the conduction of carbohydrates in plants." *Annals of botany* 10, 91–96.

<https://doi.org/10.1093/oxfordjournals.aob.a088602>.

View This Item Online: <https://www.biodiversitylibrary.org/item/235772>

DOI: <https://doi.org/10.1093/oxfordjournals.aob.a088602>

Permalink: <https://www.biodiversitylibrary.org/partpdf/318411>

Holding Institution

Smithsonian Libraries

Sponsored by

Biodiversity Heritage Library

Copyright & Reuse

Copyright Status: Not in copyright. The BHL knows of no copyright restrictions on this item.

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.