It may be further pointed out that the dorsal position of the sporangia is not quite universal in the Filicinae. Thus, it has been ascertained[1] that ventral, as well as dorsal, sporangia are normally borne by the sporophyll of *Acrostichum* (*Olfersia*) *cervinum*, and the same thing has been observed as an abnormality in various other Ferns, such as *Scolopendrium vulgare*, *Polypodium anomalum*, &c. It appears also from Goebel's researches[2] that the sporangia of *Marsilia* and *Pilularia* are ventral.

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ON THE OCCURRENCE OF STARCH IN THE ONION.—The leaves of the onion are known to be somewhat exceptional in that they do not form starch in the process of assimilation, glucose, which is present in large quantities in the mesophyll-cells, apparently taking its place. Many other plants behave in a similar way, the chlorophyll-corpuscles of their leaves forming no starch in the normal process of assimilation, but by placing the plant or its leaves under unusual conditions in connection with its nutrition, starch may, in almost every case, be made to appear in larger or smaller quantities. Thus in the Musaceae, where oil might seem to take the place of starch as a product of assimilation in the mesophyll-cells, Godlewski[3] has shown that by isolating small pieces of healthy young leaves for a few hours in an atmosphere containing from six to eight per cent. of carbon dioxide, the mesophyll-cells become crowded with starch. Böhm[4] by laying the leaves in twenty per cent. sugar solution succeeded in bringing about formation of starch in a number of Monocotyledons, *Galanthus*, *Hyacinthus*, &c., in the leaves of which starch does not normally occur, but which, like the onion, contain a great deal of glucose.

He was, however, unsuccessful with the onion, both when he used a twenty per cent. sugar-solution, and in an atmosphere containing five per cent. of CO_2. Schimper[5], in his account of the formation and travelling of the carbohydrate in foliage-leaves, concludes that in some

[1] See Kunze, in Bot. Zeit. 1848; Moore, On some Suprasoriferous Ferns, in Journ. Linn. Soc. II, 1858; Braun, Die Frage nach der Gymnospermie der Cycadeen, in Monatsber. d. k. Akad. d. Wiss. Berlin, 1875, p. 352.

[2] Goebel, Entwicklungsgeschichte der Sporangien, in Bot. Zeitg., 1882, p. 776.

[3] Flora, 1877, p. 215. [4] Bot. Zeit. 1883. [5] Bot. Zeit. 1885.

species of *Euphorbia* glucose is first formed and then starch from it, just as can be effected by experiment in many Liliaceae and Orchidaceae, and in the *Iris*, and he suggests that glucose is always first produced and then starch from this when the quantity of it in the cell exceeds a certain maximum, varying according to the place. He did not succeed in making the onion form starch, and says this may be due to one of two things, either,

(1) the necessary strength of glucose was not reached; or

(2) as he thinks more probable, the chlorophyll-grains of the onion have entirely lost the power of forming starch.

I have found, however, that starch can not unfrequently be detected in the elongated parenchymatous cells bordering on the vascular bundle, which, in the green part of the leaf, always contain chlorophyll-corpuscles, in fact the layer known as the 'leitscheide,' or conducting-sheath.

Thus in a seedling about six-and-a-half inches long, picked at 2 P.M. on a warm sunny day, this layer contained starch, in small quantities, but at once noticeable when treated with dilute iodine solution after potash; it was found through the whole length of the leaf right down to the base, where the leaf had already begun to swell to form the future succulent leaf-scale. The green leaf of a seedling similar to the above, picked at the same time on a cold damp day, contained no starch at all. I have very rarely found small quantities in the same layer of cells in the green tubular leaf of older onions, e.g. the ordinary spring-onion whose largest leaf reaches a diameter of about a third of an inch, when the leaf has stood several hours in water after being picked. The chance of finding starch diminishes therefore as the leaf grows older. It is usually to be found in larger or smaller quantity, often in fair-sized grains in the parenchymatous cells round the vascular bundles in succulent leaf-scales of all ages, as also in the general parenchyma of the stem where the primary root and leaves come off.

In testing for starch, I followed Sachs' method of warming the sections in potash, neutralising with very dilute acetic acid, and then mounting in very dilute iodine. If this was carefully done it was seen, at any rate on the side of the bundle towards the epidermis, that the starch was contained in the chlorophyll-corpuscles.

As seedlings are evidently more in the habit of forming starch than older plants, I thought they perhaps might be induced to make a

still larger amount, but experiments, though many times repeated, gave an almost uniformly negative result.

Thus seedlings vigorously growing in a pot were kept for several days in the sun, in a dry atmosphere (to increase transpiration) containing a much larger quantity of carbonic acid gas than normally, but only a very little starch was found in the green leaves, and that was close to the vascular bundles. A similar result was obtained in a moist atmosphere containing eight per cent. of CO_2 in the sun.

Leaves, both young and older, whole and cut up into small pieces, were fixed in damp sawdust, and placed in the sun, in an atmosphere containing about eight per cent. of CO_2, the amount found by Godlewski[1] to be most favourable to the formation of starch in leaves. These experiments lasted from several hours to several days, but the only result was, that sometimes rather more starch than usual was found in the cells adjoining the bundle on both sides; in one experiment with the first leaf of the seedling this layer was crowded with starch-grains. In the last case it might be said that the starch was simply formed from the reserve-material in the seed (which contains a good deal of oil but no starch) and was not therefore a product of assimilation, but this will not apply to the other cases mentioned, as in the majority of these the seed had been used up weeks before.

I also tried feeding with glucose and cane-sugar, both with whole plants and picked leaves,—whole and cut up in pieces—the strength of sugar-solution varying from twenty per cent. of glucose up to the syrupy glucose itself, but the result was always negative. The same was the case when the two modes of experiment were combined, i.e. feeding with sugar in an atmosphere containing eight per cent. of CO_2 in the sun. I never found any more starch than has been described above.

From the papers of Böhm, Schimper[2], A. Meyer, and others, it would appear that the green leaf of the onion does not form starch at all. Schimper gives a series of *Euphorbia*-species, showing all grades between a copious formation of starch and a very scanty one (as e.g. in *E. lathyris*, where it is present almost exclusively near the vascular bundle and at the base of the leaves), and then cites as the extreme case the onion which makes no starch at all. From the above, however, it is evident that the onion is rather to be considered as an

[1] Flora, 1873, p. 378.

[2] Bot. Zeit. 1885, pp. 453, 456, 504.

extreme instance of a plant like *Euphorbia Lathyris*, since, at any rate in seedlings, starch occurs under natural conditions in the same position as in this plant. Why more copious formation of starch cannot be induced under circumstances which succeed in other cases is not evident. One of Schimper's alternative explanations, viz. that the chlorophyll-corpuscles cannot form starch, must be rejected after what has just been described, as some of them evidently can and do form starch. It is however quite consistent with the present state of our knowledge to say that the chlorophyll-corpuscles of the assimilating tissue proper of the green leaves cannot or do not form starch.

The other alternative, that it is because the solution of glucose in the cell-sap is never sufficiently concentrated, seems rather doubtful, since, in the first place, from the quantity of glucose contained in the leaves the solution is probably at least as concentrated as almost anywhere in any plant; and secondly, because in isolated leaves and pieces of leaves placed under the various conditions mentioned above, as e.g. in highly concentrated glucose solution in a warm moist atmosphere, one would imagine the cell-sap to contain a sufficiently concentrated solution of glucose, if such were the necessary condition for formation of starch.

We can only say that for some reason or reasons unknown the onion almost invariably stores up the excess of carbohydrate formed as glucose instead of in the more usual form of starch. The habit of forming starch may have been for some purpose abandoned in the course of evolution, in which case it is interesting to note that it is in the seedlings that we get an intimation of the more general process of assimilation in which starch plays so conspicuous a part.

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A MODIFICATION OF PAGAN'S 'GROWING SLIDE.'—In the Journal of the Quekett Microscopical Club of last year[1] Mr. Spencer Smithson described an arrangement designed by the Rev. A. Pagan for growing on microscopical slides small organisms, such as Rotifers, Algae, &c., which live in water and require a frequent change of the medium. The results obtained with it were very remarkable; but in the original design the slide had always to be removed from the microscope and kept on a specially-constructed stage, and although in

[1] Ser. II. Vol. III. No. 18.