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ON THE DIGESTIVE FERMENT OF NEPENTHES.

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The publication of Dr Hooker's Address at the Belfast Meeting of the British Association for the Advancement of Science (August, 1874), and of Mr Darwin's book on *Insectivorous Plants*, has given rise to several investigations into the nature of the phenomena described in those works.

In the *Botanische Zeitung* for Oct. 29, 1875, Reess and Will of Erlangen published a series of experiments upon Drosera rotundifolia. They made a glycerin extract from the leaves, just in the same way as a glycerin extract is made from the glands of animals, and found that this extract, when acidified with very dilute hydrochloric acid, exercised a distinct digestive influence, causing complete solution of shreds of swollen-up fibrin within the space of eighteen hours. They found also that the filtrate from the fluid in which the fibrin had been dissolved gave the characteristic reaction of peptone when treated with caustic potash and copper sulphate (Biuret-reaction). They further found that the glycerine extract had naturally a feebly acid reaction, but that still no digestion of fibrin occurred when dilute hydrochloric acid was not added to the extract. By these experiments they clearly demonstrated the similarity, amounting to identity, of the phenomena which occur on the surface of the leaf of Drosera to those which take place in the digestive cavity of an animal. In both it appears that a ferment is secreted by the gland-cells, which is capable, in the presence of dilute acid, of converting proteids into peptones.

Similar experiments have been made by von Gorup-Besanez[1] with reference to Nepenthes. In this case, however, the secretion itself was the subject of experiment. Shreds of fibrin, prepared according to the method of Grünhagen, were rapidly attacked when exposed to the action of the secretion at a temperature of about 40° C., and the digestion was more

[1] *Berichte der deutsch-chem. Gesellschaft zu* Berlin. Jahrg. 9, No. 9. May 22, 1876.

rapid when dilute hydrochloric acid (0·2%) had been added. The filtered fluid gave the characteristic reaction of peptones, when treated with caustic potash and copper sulphate.

Contemporaneously with von Gorup-Besanez I had entered upon an investigation of the nature of the phenomena described by Dr Hooker as occurring in the pitchers of Nepenthes.

In my experiments upon Nepenthes (hybridus and gracilis) I followed the method pursued by Reess and Will in their experiments on Drosera, that is to say I made a glycerin extract of the pitchers. After having placed a shred of swollen-up fibrin in a small quantity of the extract, to which a few drops of dilute hydrochloric acid had been added, I found that, after eight hours at a temperature of 40° C. the filtrate gave a distinct peptone reaction, although the fibrin was not completely dissolved. I had also placed a similar shred of fibrin in a test-tube containing a small quantity of the dilute acid, and another in a test-tube containing a small quantity of the glycerin extract, which, I may add, was neutral in reaction. The filtrates from the fluids contained in these two tubes gave no trace of peptone when tested with caustic potash and copper sulphate.

These experiments show that in the gland-cells of the pitchers of Nepenthes, as in those of the leaves of Drosera, there is contained a digestive ferment which resembles that existing in the peptic glands of animals, in that it is soluble in glycerin, and in that it is capable of converting proteid into peptones in the presence of a sufficient quantity of acid.

In comparing the results of my experiments on the digestive power of a glycerine extract of Nepenthes pitchers, with those obtained by von Gorup-Besanez in his experiments with the secretion itself, I was struck by the great rapidity of the digestive process in the latter case, and I inferred that the quantity of ferment present in the glycerine extract must be very much smaller than that present in the secretion. Reference to similar experiments made upon the stomachs of animals shewed that Ebstein and Grützner[1] had found that a glycerin extract of much greater digestive power could be obtained from a gastric mucous membrane which had been previously treated with

[1] *Pflüger's Archiv*, Bd. VIII. p. 122—151. 1873.

dilute hydrochloric acid, than from a perfectly fresh one. The researches of Heidenhain[1] on the digestive ferment of the pancreas shew that from this organ also a more active glycerin extract could be obtained when it had been previously treated with a dilute acid. From his own experiments on the pancreas, and from those of Ebstein and Grützner on the stomach, he infers that these digestive ferments are not at first formed as such within the gland-cells. He regards the gland-cells as secreting an inert substance, which he terms zymogen, which may perhaps be a combination of the ferment with an albuminoid. It is only when this zymogen is decomposed, as a result of post-mortem change, or by the action of acids, that the ferment is liberated.

These investigations suggested that possibly the digestive ferment of Nepenthes might also be set free as a consequence of the decomposition of an inert body analogous to zymogen. Accordingly I treated some pitchers of Nepenthes hybridus and gracilis with dilute acetic acid (1%) for twenty-four hours previously to the preparation of the glycerin extract. On comparing the glycerin extract made from the pitchers so treated, with that made from fresh pitchers (gathered at the same time from the same plants), I found that the digestive power of the former greatly exceeded that of the latter. For instance, I placed a small pellet of swollen-up fibrin in a tube containing a small quantity of the acid extract, and a similar pellet in a tube containing a small quantity of the extract from the fresh pitchers. To each tube I added two cubic centimeters of dilute HCl. (·2%) and exposed them both to a temperature of 40°C. At the end of six hours the fibrin in the former tube had undergone complete solution, whereas that in the latter had decreased only slightly in size. The filtrates of both gave peptone reaction, though much more strongly in the first case than in the second.

Briefly summarising the results to which my experiments on Nepenthes lead, I find that in the first place, they confirm those of von Gorup-Besanez, and those of Reess and Will, in the demonstration of the fact that "carnivorous" plants are capable of digesting proteid matters by a process which is essentially

[1] *Pflüger's Archiv*, Bd. x. p. 581. 1875.

similar to that by which the gastric digestion of animals is performed; and that, in the second place, they point out that the mode of origin of the digestive ferment, in Nepenthes at least, is essentially similar to that indicated by Heidenhain with reference to the digestive ferment of the pancreas (pancreatin), and by Ebstein and Grützner as regards that of the stomach (pepsin).

The foregoing is an abstract of a paper read before the Linnæan Society of London on June 15, 1876. Since that time I have more than once repeated my experiments, always with the same results. I have also followed the same line of investigation with reference to Sarracenia (flava), but I have failed, as yet, to obtain any indication of the presence of a digestive ferment in the pitchers of that plant.

I have also endeavoured to find out whether any diastatic ferment is present in the glands of these plants. In the case of Nepenthes the glycerin extract had no action upon starch, a result which von Gorup-Besanez also obtained in his experiments with the secretion.

In the case of Sarracenia I was surprised to find that a mixture of the glycerin extract with starch gave a well-marked sugar reaction. This I found to be due to the presence of sugar in the extract.

The fact that sugar occurred in the extract of Sarracenia, from which the digestive ferment was absent, as well as the fact that no sugar was found in the Nepenthes extract, in which the presence of the ferment was detected, seems to indicate that the pitchers of Sarracenia were in a condition in which their digestive function was in abeyance. Further experiments with this plant, we may hope, will shew that under other conditions the gland-cells of the plant, like those of Nepenthes, give rise to a digestive ferment.