CARNIVOROUS PLANTS.

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[PLATE CXXVI.]

OLD landmarks are fast being obliterated. In former times the mind even of the most scientific was trammeled by the idea that nature could be mapped out into districts, like squares upon a chess-board, each bordered by a well-marked line of circumvallation, and standing in a perfectly definite relation to the squares on either side. The objects of nature were supposed to be classified, not by man but by the Creator of all things, in accordance with a certain preconceived and often most fantastic ideal. It is only within a comparatively short time that our views on this head have undergone a radical change. The general acceptance of the theory of evolution has given a final blow to the old idea. Classification is now but a human contrivance for tabulating the links in the endless chain which connects together all living things. The lines on the chess-board have disappeared, and have given place to the imperceptible gradations of the colours of the rainbow. While we can still define red and yellow, and distinguish one from the other, we must admit a wide debatable border-land of orange.

This change affects not only the ultimate, but even the primary distinctions between organic beings. Even the division of animate nature into the two kingdoms of animal and vegetable is no longer unchallenged. No other naturalist of mark has, it is true, followed Haeckel in erecting a third kingdom out of the simplest forms of the other two. It is rather that not a single one of the characters which have formerly been relied on to distinguish animals from vegetables has passed unscathed through the crucible of modern research. The power of spontaneous, or at least of apparently spontaneous motion, which was formerly considered to belong exclusively to animals, is now known to be possessed in an equal degree by many of the most lowly vegetable organisms, and even to be apparently a universal property of living protoplasm, whether animal or vegetable. We were taught in our childhood that while animals inhale oxygen and exhale carbonic acid, the respiration of plants is of an exactly opposite character; vegetable physiologists now tell us that the true process of respiration which all plants perform consists, like that of animals, in an exhalation of carbonic acid gas. It was formerly believed that starch was never produced by animals, while it is always formed by plants at some period of their existence; we now know that fungi never produce starch, while on the other hand it has been found in the tunics of the Salpæ. Even the last refuge of those who still maintained the essential distinction of the two kingdoms—that the food of animals is organic while that of plants is inorganic—must now be abandoned.

This is, however, no recent discovery in particular cases. The plants known as parasites, whether phanerogamic or fungi, the mistletoe and dodder, or the potato-blight and mildew, live entirely on the already assimilated food-materials found in the tissues of the "hosts" on which they are parasitic. But in all these instances the nutritive material is absorbed by the plant in a manner similar to that in which the majority of vegetables derive their nourishment from the soil; in the case of flowering plants through root-like organs or "haustoria," and in the case of fungi through a mycelium, which penetrates deeply into the tissue of the host. The point of greatest interest to physiologists in the facts brought out in Dr. Hooker's inaugural address to Section D, at the meeting of the British Association at Belfast, in 1874, and more recently in Mr. Darwin's latest publication,* is that certain plants have the power of absorbing the material required for their food—not only through the root, but also through the tissue of the leaf by means of certain special organs, aided by most elaborate and beautiful mechanical contrivances. The first announcement of this fact was the more startling, inasmuch as the most recent experiments appear to have demonstrated that leaves are quite incapable, except under the most exceptional circumstances, of absorbing pure water, either in the liquid or gaseous condition.

The number of genera in which this power has been demonstrated with more or less certainty is about thirteen, ten of which are described more or less minutely in Mr. Darwin's work. Of these genera three only are British; two of these have species which are common and readily accessible, and to them we propose mainly to direct attention in the present paper.

Few lovers of plants have not gathered and admired the

* "Insectivorous Plants." By Charles Darwin, M.A., F.R.S., &c. London: J. Murray, 1875.

pretty little *Drosera*, or Sundew, a denizen of bogs, with its small red leaves clothed with glands which are apparently always wet with dew on the hottest summer day, and elegant scape of minute white flowers, opening only in the brightest sunshine. The commonest species *D. rotundifolia*, with round leaves, is found in sphagnum and peat-bogs throughout the country, and is especially common in all our sub-alpine districts. Two other species are British, *D. intermedia* and *anglica*, both with linear-oblong leaves, the latter much the larger plant, but are much scarcer; the former, however, grows as near London as close by the Burnham Beeches in Buckinghamshire, intermixed with *D. rotundifolia*, and is abundant in the New Forest. On closer examination it is seen that the minute drops which hang on the glands are not dew, but consist of a viscid fluid stretched in threads from one to another; and that numbers of minute insects are captured in it and firmly held down by the enfolding of the glands over them.

The leaf is indeed a veritable fly-trap. If a specimen is planted in a saucer in damp sand, and a minute insect placed on a leaf which was before quite free, the glands will be seen to bend over it, commencing with the ones nearest to those that actually touch it, until at length every gland on the leaf has become inflected, and the insect is hopelessly imprisoned. Long before this it has, however, probably almost ceased to move; and that the movement of the glands is not the result of mechanical irritation from the struggles of the insect—like that of the stamens of *Berberis*—is proved by the fact that the outermost marginal glands do not fold over until the struggles of the insect have ceased. Fig. 1, Plate CXXVI., shows a plant of *Drosera rotundifolia* about the natural size; fig. 2, one of the leaves magnified about twice; fig. 3, a leaf with an insect just captured; fig. 4, one in which nearly all the glands are folded over, both multiplied about four times; and fig. 5, one of the glands on a much larger scale.

The mechanism of the movement of the "tentacles," as Darwin terms these organs, has been closely investigated by him and others. Each tentacle consists of a stalk or pedicel, composed of several rows of elongated cells, with a roundish or ellipsoidal dark-red gland at its extremity. The gland is seen under a high magnifying power to be pitted or honeycombed; and the pedicels, as well as the upper surface of the leaf where not occupied by the tentacles, is provided with a number of minute papillæ, consisting of several cells. The morphological nature of the tentacles has been a subject of much discussion. Trécul, Warming, and other observers have clearly shown that, at least as regards some of them, especially those at or near the margin of the leaf, they are an integral part of the leaf itself, as is proved by their being traversed throughout their length by a fibro-vascular bundle containing spiral threads. Fig. 6 is copied from a drawing of Warming's, representing the internal structure of one of these organs. I am inclined to think, however, from an examination of a number of leaves in a very early stage of development, that this is not the history of all the tentacles; but that a number of them are true "trichomes," or epidermal structures. That organs which closely resemble one another outwardly and perform similar functions, should not all have the same morphological origin, is not without parallel in the vegetable kingdom. The terminal glands are seen, when the plant is in a healthy and vigorous condition, to exude a quantity of a viscid secretion which can be drawn out into long threads; and the quantity of this secretion is greatly increased by contact with organic matter.

If an object capable of exciting the motion is placed in the centre of a leaf, the whole of the tentacles of the leaf gradually converge towards it, and finally completely envelope it. If, on the contrary, the object is placed on one of the marginal glands, this tentacle only first of all bends over towards the centre of the leaf carrying the object with it; and then the same inflection occurs of the remaining leaves. The inflection takes place in the lowest portion of the pedicel only, the remaining part of the pedicel and the gland itself remaining perfectly straight. The exudation of the viscid secretion is however from the gland only; and Mr. Darwin records in his work some very remarkable facts connected with the change that takes place in the protoplasm contained in the various cells of the pedicel. In a leaf when in the normal condition, the cells of the pedicel are filled with a homogeneous purple fluid. This appearance undergoes a great change after the gland has been excited by repeated touches or by contact with an organic substance. The cells have then a mottled appearance even to the naked eye, owing to the colouring matter becoming aggregated into purple masses of various shapes, which now float in an almost colourless fluid. This aggregation of the purple matter commences in the cells immediately beneath the gland, whence it travels down to the base of the pedicel; the little coloured masses constantly changing their form, separating and reuniting with a motion similar to that of an Amœba or of the white corpuscles of the blood.

The aggregation of the protoplasm and the inflection of the tentacles are independent of one another, and are both brought about by a variety of causes—concussion of the gland, the pressure of solid particles of any kind, absorption of solid substances, and by a certain degree of heat. Any solid particle allowed to rest on a gland or a number of glands will produce inflection; but if the particle is inorganic the effect is only slight, and the tentacles soon resume their normal position. With organic substances, and especially minute living animals, the case is very different; the embracing motion of the tentacle is compared by Darwin to that of the tentacles of a polyp when seizing its prey; and they do not again unfold until the substance is partially or entirely absorbed. The behaviour of the leaves with fluids is still more remarkable. Distilled water produces no effect whatever. This might be expected; but it is more noteworthy that the same is the case apparently with all organic but non-nitrogenous fluids. In sixty-one experiments recorded in Mr. Darwin's work, with gum-arabic, sugar, starch, dilute alcohol, olive oil, and a decoction of tea, the tentacles were not inflected in a single case. The case is very different with all nitrogenous fluids. Milk, albumen, infusion of meat, mucus, saliva, and isinglass, produced inflection in every instance, after a longer or shorter time. In fact the leaves of *Drosera* furnish a test for nitrogen in solutions, rivalling in delicacy any of the performances of the spectroscope. Experiments, which were repeated over and over again to ensure accuracy, and with the utmost care to eliminate every possible source of error, show that the $\frac{1}{14,400}$ of a grain (·00445 milligram) of carbonate of ammonia absorbed by a gland, is sufficient to induce inflection in the basal part of the same tentacle; and, if immersed in a solution of this substance for a few hours, the same effect is produced by the $\frac{1}{268,800}$ of a grain (·00024 mg.). Immersion in nitrate of ammonia of such strength that each gland can absorb only the $\frac{1}{691,200}$ of a grain (·0000937 mg.) excites movements in each tentacle. With phosphate of ammonia the result is still more extraordinary. A minute drop containing $\frac{1}{153,600}$ of a grain (·000423 mg.), if held for a few seconds in contact with a gland, causes the tentacle bearing this gland to be inflected. If a leaf is immersed for a few hours, and sometimes for a shorter time, in a solution so weak that each gland can absorb only the $\frac{1}{19,760,000}$ of a grain (·00000328 mg.), this is enough to excite the tentacle into movement, so that it becomes closely inflected.

The facts connected with the list of non-nitrogenous substances which cause and which do not cause inflection of the tentacles are very curious. Nine salts of soda with which Mr. Darwin experimented all caused inflection, while none of seven corresponding salts of potassa did so; the salts of metals as a rule caused inflection; as did nineteen out of twenty-four organic and inorganic acids, the exceptions being gallic, tannic, tartaric, citric, and uric, none of which acted as poisons. The action of alkaloids and organic poisons was very various; strychnine, digitaline, and nicotine are poisonous, and produce inflection, as does hydrocyanic acid very rapidly; while morphia, hyoscyamus, atropine, veratrine, colchicine, curare, and dilute alcohol are not poisonous, and have no power, or only a very slight one, of inducing inflection. The vapours of chloroform, and sulphuric and nitric ether, act in a singularly variable manner, sometimes producing extraordinarily rapid inflection; but further experiments on this point seem required.

The mode of transmission of the motor impulse from one gland to another is a very curious and intricate branch of the subject. From the facts already mentioned it would appear that the glands, together with the cells of the pedicel lying immediately beneath them, are the sole seat of the irritability or sensitiveness of the leaves; and the impulse has to be transmitted down nearly the whole length of the pedicel before inflection takes place. But this motor impulse is transmitted from the gland immediately excited to others which are not in contact with the exciting substance; and in the tentacles thus indirectly excited the aggregation of the protoplasm always commences also in the cells immediately beneath the gland. Mr. Darwin terms this process a reflex action, and compares it to the irritation of a sensory nerve, by which, when an impression is carried to a ganglion, some influence is sent back to a muscle or gland, causing movement or increased secretion. He believes that the motor impulse is not transmitted, at least exclusively, through the spiral vessels or the tissue immediately surrounding them, but through the cellular tissue, and more rapidly in a longitudinal than in a transverse direction. I am inclined to think, from experiments of my own, that it is possible that, at least in some instances, the impulse may be transmitted, not through the tissue of the leaf at all, but through the viscid secretion; as in some instances I have found tentacles on one leaf to be inflected by contact with excited tentacles belonging to another leaf, where there is nothing to cause inflection in the first. One of the most remarkable circumstances connected with these phenomena is the fact that after leaves have been detached from the plant, they do not in any degree lose the power of inflection and aggregation of the protoplasm inherent in the tentacles for many hours or even days; a strong indication that they possess some power of imbibing nutriment independent of the root.

All that we have related so far would by no means prove a true process of digestion on the part of the sundew. It might be possible—and indeed this has been maintained by some—that these arrangements were merely a contrivance for facilitating the decay of the living insects or other entrapped organic substances; and that the nutrient matter resulting from their decay, being carried to the ground, fed the plants through the ordinary medium of the rootlets. To Darwin must be assigned the merit of having for the first time clearly and unmistakably demonstated a true process of digestion carried on by the foliar organs of plants; although Dr. Hooker and others had earlier given good reason for a belief in its existence in the case of *Nepenthes* and other pitcher plants. The viscid secretion from the glands of *Drosera* is, in the normal condition, nearly or quite neutral to test-paper. But as soon as it is excited by contact with any inorganic or organic substance, it becomes distinctly acid, and more strongly so after the tentacles have remained for some time closely clasped over any object. A small quantity of the substance thus obtained was sent for analysis to Professor Frankland, who found no trace of hydrochloric, sulphuric, tartaric, oxalic, or formic acid; but, as far as could be determined from the very minute quantity submitted to analysis, distinct indications of an acid belonging to the acetic or fatty series, probably propionic, with a possible admixture of acetic and butyric. A still more interesting result of Mr. Darwin's experiments was the conclusion that in addition to the acid a substance analogous to pepsin, and acting as a ferment, is secreted by the glands, but only when excited by the presence of digestible, *i.e.* nitrogenous, matter. This singular result, affording so striking an analogy to the phenomena of digestion by the stomach of an animal, is in harmony with the observation of Dr. Hooker in the case of *Nepenthes*, that the fluid formed in the pitchers of that plant entirely loses its power of digestion when removed from the pitcher and placed in a glass vessel, although it is even then distinctly acid. The following substances were found to be completely dissolved in the secretion, viz., albumen, muscle, fibrin, areolar tissue, cartilage, the fibrous basis of bone, gelatin, chondrin, casein in the state in which it exists in milk, and gluten which has been subjected to the action of weak hydrochloric acid; while epidermic productions, fibro-elastic tissue, mucin, pepsin, urea, chitine, cellulose, gun-cotton, chlorophyll, starch, fat, and oil, are not acted on either by the secretion of *Drosera*, nor, as far as is known, by the gastric juice of animals.

The power possessed by *Drosera* of obtaining nourishment through the leaves receives confirmation from a valuable series of experiments by Dr. Lawson Tait,* who announced, inde-

* See "Nature," for July 29, 1875.

pendently of Mr. Darwin, the separation of a substance closely resembling pepsin from the viscid secretion of *Drosera dichotoma.* He placed side by side plants of the common *Drosera rotundifolia*, some in the normal state, others with the roots pinched off close to the rosette, and with the leaves all buried, only the budding flower-stalk appearing above the sand; others with the roots and flower-stalk left on, but all the leaves pinched of, the roots being buried in the sand; and others again with the roots left on but appearing above the sand, some of the leaves buried and others exposed. These plants were all carefully washed with distilled water, before being planted in silver sand which had deen deprived of all organic matter, carefully watched to prevent flies being caught; and were then fed, some with pure distilled water, others with a strong decoction of beef, and others with a very dilute solution of phosphate of ammonia. The conclusions arrived at from the series of experiments were that the plant can not only absorb nutriment by its leaves, but that it can actually live by their aid alone, and that it thrives better when supplied with nitrogenous material in small quantity. The nitrogenous matter is more readily absorbed by the leaves than by the roots, over-feeding killing the plant sooner through the leaves than through the roots alone; although the roots also certainly absorb nitrogenous matter. This absorption of nutrient material through the leaves is in harmony with the fact already mentioned, of the vitality of the leaves long after separation from the plant.

We are not acquainted with any special organ by which the processes of absorption and digestion are effected; indeed, almost everything connected with their *modus operandi* remains for the present in obscurity. It seems likely that the papillæ which abound on the upper surface of the leaf and on the pedicels of the tentacles have some share in them; and possibly also certain other bodies which are not described by Mr. Darwin, nor by any other observer as far as I am aware. These bodies, which I propose provisionally to call "ganglia," are represented in fig. 7, and are found, on making a careful dissection of the leaf, immediately beneath the epidermis of the upper surface, and on the pedicels of the tentacles. They consist of from two to four cells, much smaller than the ordinary cells of the mesophyll of the leaf, and have the appearance of centres from which the cell-walls radiate. They are filled with a brownish-green granular, presumably protoplasmic substance. I have not observed bodies of a similar character except in plants* whose foliar organs possess the power of digestion.

* With the exception of *Callitriche,* in which bodies of a similar character produce the so-called "rosulate" appearance of the leaves, and were long ago described as glands by the late Dr. E. Lankester.

The genus *Pinguicula* belongs to a natural order widely separated from *Drosera*. The Butterworts are all, like the sundews, natives of bogs, and are so called from the greasy texture of the thick leaves, caused by the viscid glands with which the upper side of the leaf is studded. The commonest species, *P. vulgaris*, fig. 8, is a very familiar plant by the side of streams and in other wet places in all the mountainous districts of our islands; but its deep blue flowers have passed away by the middle of summer. A second species or sub-species, *P. grandiflora*, with much larger blue flowers, is confined to the south-west of Ireland; and *P. alpina*, with nearly white flowers, to the most alpine parts of Scotland; while the fourth British species, *P. lusitanica*, with small lilac-yellow flowers, is abundant in the south-west of England, and the west of Scotland and Ireland.

The contrivance for capturing insects is very different in the case of *Pinguicula* to that which we have described in *Drosera*. The whole of the upper surface of the leaf is studded with a number of glands composed of a stalk or pedicel, which consists of a single cell, and of a flat capitate head, formed of a number of small cells, usually eight or sixteen; their mode of growth is represented in fig. 9, magnified; and a single one on a much larger scale in fig. 10. They are always secreting a large quantity of an extremely viscid fluid, neutral to test-paper; but have no power of motion when excited; the only movement in the leaf of the butterwort being a very slow incurving of the margin over any imprisoned object. The extreme viscidity of the secretion from the glands is the sole means by which the entrapped animals are detained. The incurving of the margin is caused either by the pressure of any solid particle, or by contact with a digestible substance, whether solid or in solution; but after a comparatively short time the margin again unfolds.

The general results of Mr. Darwin's observations on *Pinguicula vulgaris* amount to this:—Objects not containing soluble matter have little or no power of exciting the glands to increased secretion; while dense nitrogenous fluids cause the glands to pour forth a large supply of viscid fluid, which is still not acid. On the other hand the secretion from glands excited by contact with nitrogenous solids or liquids is not only very copious, but is invariably acid. The secretion in this state has the power of rapidly dissolving and digesting the tender part of the bodies of insects, meat, cartilage, albumen, fibrin, gelatine, and caseine. The secretion which has absorbed nitrogenous matter is quickly re-absorbed by the glands, which change their colour from green to brownish, and contain masses of aggregated granular, presumably protoplasmic matter, while no such effect is produced by the action of non-nitrogenous fluids.

The phenomena exhibited by the butterwort have not, however, received nearly so much attention as in the case of the sundew; although the larger size and more transparent nature of the glands, and the firmer and thicker tissue of the leaves rendering it easier to obtain thin transparent sections, make it in some respects more favourable for observation. A section which exposes the epidermis of the upper surface of the leaf, reveals bodies of a similar nature, and possibly with a similar function to those which I have described as "ganglia" in the case of *Drosera.* Two of these bodies are represented in fig. 11. They are circular, and are divided by septa radiating from the centre usually into four, less often into six or eight cells, filled with protoplasm, and containing a few grains of chlorophyll. They closely resemble the heads of the glands, and, like the corresponding bodies in *Drosera,* may possibly be glands arrested in their development. *Pinguicula lusitanica,* which is more easily obtained in the south of England, exhibits the same phenomena as *P. vulgaris,* but rather more strongly.

Having now described somewhat in detail the phenomena presented by our most familiar British species of carnivorous plants, we will refer more briefly to those which are less known, or are natives of other countries. The species which can at present certainly be ranked under this category, are comprised in four natural orders—widely separated from one another in other points of structure, viz., Droseraceæ, Lentibulariaceæ, Nepenthaceæ, and Sarraceniaceæ.

Among Droseraceæ, the genus *Drosera* includes, besides the British species already described, a considerable number distributed over the greater part of the surface of the globe. All of these which have been examined in the fresh state display peculiarities similar to those of our country, some of them apparently with a greater intensity. A North American species, *D. filiformis,* is described by a careful observer, Mrs. Treat,* as growing in such abundance in parts of New Jersey as almost to cover the ground, and the detaining power of the leaves as being sufficient to entrap even moths and butterflies. An Australian species, *D. dichotoma,* has leaves, including the footstalk, 27 in. in length.

Another plant of very great interest belonging to this order is the well-known Venus's fly-trap, *Dionæa muscipula,* not unfrequently seen in cultivation in this country, though growing wild in a very limited area on boggy ground in the eastern part of the state of North Carolina. The arrangements for capturing insects are here altogether different from those found in the allied genus. The secreting glands are extremely minute, and exude the viscid fluid only after being excited by the presence

* "American Naturalist," Dec. 1873.

of a digestible substance, and have no power of motion. The faculty of detention lies in the elasticity of the tissue of the leaf itself. On the upper surface are six strong hairs or bristles which display extraordinary sensitiveness, conveying to the rest of the leaf an irritation when touched, which causes the leaf suddenly to fold up, the sharp serrations or spikes with which the margin is covered closing upon one another, and interlocking like the teeth of a rat-trap. The glands, which are in this instance true epidermal structures, secrete an almost colourless, slightly mucilaginous, strongly acid fluid, but only when excited by the presence of nitrogenous matter, which they have the power of absorbing. This secretion, the formation of which is seen, from what has been said, to be altogether independent of the mechanical irritation of the leaves, appears, from Mr. Darwin's experiments, to have a distinct power of digestion. The most remarkable fact connected with *Dionæa* is in the difference in the behaviour of the leaves after closing, according to whether a digestible substance, an indigestible substance, or nothing at all, has been captured. In the two latter cases the leaves reopen in less than twenty-four hours, and are then again at once sensitive to renewed impact. In the first case, on the contrary, they remain closely shut up for many days, and after re-expanding are torpid, and never act again, or only after a very considerable interval of time. Moreover, when the leaf is made to close over an insect or other body containing soluble nitrogenous matter, the two lobes, instead of remaining concave, as they otherwise do, enclosing a small cavity, slowly press close together throughout the whole of the blade with very considerable force, and offer very great resistance to any attempt to force them apart. Mr. Darwin draws some very interesting conclusions from these facts; showing how this arrangement allows small insects to escape before they are crushed and thus yield up their nutrient juices, while larger insects are hopelessly entrapped; the digestive process being therefore only brought into play when a considerable quantity of nutriment is at the command of the leaf. Dr. Burdon Sanderson has made the additional extremely curious observation * on the Venus's fly-trap, that a normal electrical current traverses the blade and the foot-stalk of the leaf, while the current is reversed when the leaves are irritated or the foot-stalk cut. The phenomena therefore present a most remarkable analogy to those which occur in the muscles of animals when contracted; although there does not appear to be anything whatever in the *Dionæa* which can in any way be compared to the nervous tissue of animals.

* "Proceedings Royal Society," vol. xxi. p. 495; and "Nature," 1874, pp. 105 and 127.

Besides *Drosera* and *Dionæa*, there are four other genera included in the order Droseraceæ, viz., *Aldrovanda*, *Drosophyllum*, *Byblis*, and *Roridula*, all of which capture insects; and in all of them the phenomena of absorption and digestion have either been observed or may be fairly inferred. The first of these genera includes only a single species, *A. vesiculosa*, occurring in three somewhat distinct forms in Europe, India, and Australia. It is a small water-plant, with two-lobed leaves, having the peculiarity of suddenly closing on irritation similar to that of *Dionæa*, and furnished with long jointed hairs, which are apparently sensitive. Of the remaining three genera, one is European, another South African, and the third Australian. The first only has yet been examined in the growing state, and bears a strong resemblance to *Drosera*, except that the tentacles have no power of movement.

To the order Lentibulariaceæ belong the four genera, *Pinguicula*, *Utricularia*, *Polypompholyx*, and *Genlisea*, all carnivorous. The genus *Utricularia*, or Bladderwort, is a very interesting one, and includes three or four British species, plants found in ditches, often of fetid water, with elegant yellow flowers on slender stalks, and floating deeply-divided leaves furnished with little bladders, from whence the plant derives its name. These bladders have been recognised by several observers, Mr. R. Holland in this country and Mrs. Treat in the United States, as fly-traps, and their structure has been closely investigated by Mr. Darwin in the case of the commonest British species, *U. vulgaris*, and its variety or sub-species *U. neglecta*. The bladders are about one-tenth of an inch in diameter, are provided with a number of long bristles or "antennæ," and are closed by a valve which is attached on all sides to the bladder, except by its posterior margin, which is free, and forms one side of the slit-like orifice which leads into the bladder. The valve is covered on the inner surface with a number of glands which secrete, but apparently have no power of absorption. The margin of the valve rests on the edge of a rim or collar, which allows the valve to open inwards only. By this contrivance a large number of aquatic animals are entrapped—insects, Entomostraca, and even worms, as well as innumerable Algæ and Infusoria; and obviously, when once captured, cannot again escape. Mr. Darwin's observations serve to show beyond doubt that the bladders have the power of absorbing nitrogenous substances, which they doubtless derive from the decay of the imprisoned animalcules; but he does not consider that they have any power of digesting animal matter analogous to that possessed by the plants already described. This absorption he believes to be effected by certain peculiar bodies described by him as "bifids" and "quadrifids." These bodies line the whole of the inner surface of the bladders, and consist of four, less often of two, divergent arms or cells. The mode in which they act is not clear; but it is demonstrated that they possess the faculty of absorbing nitrogenous matter, salts of ammonia, or infusion of meat. Bodies of a somewhat similar character were observed by Mr. Darwin in the case of *Aldrovanda*, where he at one time conjectured that they performed the function of absorbing the indigestible portion of the food. I can scarcely doubt that they are homologous with the bodies described by me as "ganglia" in *Drosera*, and especially in *Pinguicula*, the function of which is at present unknown. May they not be rudimentary "quadrifids"?

A very remarkable species of bladderwort, *U. montana*, a native of tropical South America, is not aquatic, but is said to be epiphytic. The bladders, which are extremely minute, are borne on the underground thread-like rhizomes, and are produced in extraordinary numbers. They are closed by a valve on which are a number of minute glands, and bear internally rows of short, thick, quadrifid processes; and apparently capture and detain a number of minute insects, on which the plant feeds. This is the only species of *Utricularia* which is not aquatic or a native of marshes. *U. nelumbifolia* has the very singular habit of growing in the water which collects in the bottom of the leaves of a large *Tillandsia*, inhabiting an arid rocky part of the Organ Mountains, Brazil, at an elevation of 5,000 ft. above the sea. It propagates itself by runners, which direct themselves towards the nearest plant of *Tillandsia*.

Polypompholyx is a native of Western Australia, and *Genlisea* of Brazil. In this last genus some of the leaves are elongated into a very narrow cylinder, half an inch to an inch in length, in the middle of which is a minute swelling or tubercle, in which organic matter is found. The neck of the cylinder is furnished with rows of bristles attached to ridges and pointing downwards, which would effectually prevent the escape of any insect that may descend the neck into the utricle, and with a number of quadrifid cells or processes, very closely resembling those already described in *Pinguicula*, the function of which can only be conjectured.

The order Nepenthaceæ comprises the single genus *Nepenthes*, which includes a considerable number of species, mostly natives of the East Indies and Australasia, and well known in hot-houses in this country as "Pitcher-plants." The pitcher consists partly of the leaf-stalk and partly of the blade of the leaf, and contains in its lower portion, to the depth of an inch or more, a fluid which was formerly believed to be nearly pure and potable water; but analysis shows it to contain in solution a considerable proportion of mineral salts. Buried in this fluid is frequently found a great mass of dead flies and other insects, which have been apparently lured into the pitcher by the secreted fluid; and, their escape being prevented by a rim furnished with bristles pointing downwards below its mouth, have there miserably perished. It was determined by Dr. Hooker that the fluid is distinctly acid, and that it possesses the power, not merely of hastening the decay, but of actually digesting the bodies of the insects drowned in it. He also made the additional remarkable observation that when removed from the pitcher and placed in a glass vessel, although still acid, it has entirely lost its power of digestion. This singular fact is interpreted by Mr. Darwin—and with great probability—to indicate that the actual agent in the digestion is a ferment of a nature similar to pepsin, which is secreted only during the absorption of some digestible nitrogenous substance. In the walls of the pitchers of *Nepenthes* are minute bodies resembling and possibly homologous to the "quadrifids," or rudimentary papillæ of *Genlisea* or *Pinguicula.*

To the last order, Sarraceniaceæ, belong the three genera *Sarracenia*, *Darlingtonia*, and *Heliamphora*, natives of America, also cultivated in this country under the name of "Side-saddle plants." The pitchers in this instance consist of the convoluted stalk of the leaf only, the blade forming the lid. They have not at present been subjected to the same careful examination as *Nepenthes*; but, from the observations of Dr. Hooker, Dr. Canby, and others, there is little doubt that they will be found to present very similar phenomena.

From the fact that the plants we have now passed under review belong to families very widely separated from one another on any system of classification, it is highly probable that phenomena of a similar character still remain to be discovered in other groups of the vegetable kingdom. Although, as we said at the outset, the assimilation of animal food by plants is no newly discovered fact, it must still be admitted that the series of observations here recorded—and especially the apparent production by vegetables of a digestive ferment performing all the functions of pepsin in the animal economy—form one of the most important and interesting additions to our knowledge of vegetable physiology that have been made for many years.

EXPLANATION OF PLATE CXXVI.

FIG. 1. *Drosera rotundifolia*; natural size.

FIG. 2. A leaf, × 2.

FIG. 3. A leaf, with imprisoned insect; the tentacles partially inflected, × 4.

Fig. 4. A leaf, with nearly all the tentacles closely inflected, × 4.
Fig. 5. A tentacle, greatly magnified.
Fig. 6. Internal structure of tentacle, showing spiral vessels.
Fig. 7. Section exposing under surface of epidermis of upper side of leaf; *a*, stomata; *b*, "ganglia," or arrested papillæ.
Fig. 8. *Pinguicula vulgaris*; natural size.
Fig. 9. Portion of upper surface of leaf, with two glands, magnified.
Fig. 10. Gland, greatly magnified.
Fig. 11. Section exposing under surface of epidermis of upper side of leaf; *a*, stomata; *b*, "ganglia," or arrested papillæ.
Fig. 6 after Warming, the rest from nature.