ART. III.—1. *Insectivorous Plants.* By Charles Darwin, M. A., F. R. S., &c. London: John Murray. 1875.

2. *Report of the British Association for the Advancement of Science,* 1874, p. 102. London: John Murray. 1875.

3. *Proceedings of the American Association for the Advancement of Science,* 1874, pp. 18, 64, 113. Salem, Mass.: Published by Permanent Secretary. 1875.

In the year 1768, Ellis, a well-known English naturalist, sent to Linnæus the drawing and description of a plant to which he gave the poetical name of *Dionœa.* This — one of the names of the goddess of beauty — has been very freely translated for popular service, into Venus' Fly-trap. Though this observation of Ellis is, so far as we know, the first ever made upon the insectivorous plants, the observer saw at once the significance of certain organic peculiarities, and has left to us a record of the fact. That which separates this class of plants from all others in the vegetable world is the wonderful power which they possess of capturing insects and feeding upon them, and this power Ellis mentions in the first description sent to Linnæus. The plant, he says, 'shows that Nature may have some views towards its nourishment, in forming the upper joint of its leaf like a machine to catch food; upon the middle of this lies the bait for the unhappy insect that becomes its prey; . . . and the instant the tender parts are irritated by its feet, the two lobes rise up, grasp it fast, lock the rows of spines together, and squeeze it to death; . . . nor do the lobes ever open again while the dead animal continues there'.

Linnæus did not accept this explanation of Ellis, but looked upon the movement of the leaves as an instance of extreme sensitiveness, and nothing more. In 1782 Dr. Roth published, in the *Beiträge zur Botanik,* some observations made by himself upon the *Drosera,* a plant belonging to the same family. For many years the subject seems to have lost its interest, and was at last taken up in a remote locality, and observations were made upon a distantly allied species. In 1816, Dr. McBride, a physician of South Carolina, published an account of *Sarracenia variolaris*, the American Pitcher-plant, or Side-saddle flower, as it is popularly called, which is now known as one of the insectivorous plants. These discoveries, though of great value, were completely forgotten, until revived by the close and careful observation of another physician of the same State — Dr. Mellichamp — who has recognized and confirmed the value of his predecessor's work.

Here and there, scattered throughout the pages of Scientific Transactions, or in some of the higher kinds of physiological botanies, notices are to be found of the curious habits of some varieties of these plants. But most of them, before the year 1860, were incomplete and lacking in general interest, unless we except an interesting though short account of the habits of *Drosera* which, Darwin tells us, was published in the *Botanisch Zeitung*, 1852, p. 540.

Country folk, whose observation is generally much keener than their reasoning powers, had long been aware of the fact that the leaves of *Drosera* are frequently covered with captured insects, without inquiring what relation these facts bore to the vital functions of the plant. In 1860 Mr. Darwin undertook to investigate this subject; and the results of his investigation we find in the volume under review. This book is devoted, almost exclusively, to the record of observed facts and to their immediate theoretical inferences; his peculiar views of evolution only occasionally cropping out. As an observer of facts Mr. Darwin has no superior, and his power of description is scarcely less remarkable than his power of observation. His style is simple, direct, and lucid; it is, in fact, so transparent a medium of his thought, that it requires an effort to withdraw the attention from the matter and fix it critically upon the manner of his work. He lacks the delicate play of fancy, the perpetual outflow of imagination, which inform Tyndall's style with such beauty, as well as the brilliant flashes of wit which illumine Huxley's dryest dissertations; but as a scientific style we feel inclined to award it the highest place.

The member of this curious family of carnivorous plants which has been most closely studied and most fully described, is the common Sundew, or *Drosera rotundifolia.* It is found in many parts of North America, and flourishes in damp, but poor and boggy soil. From the surface of the ground a single stem, or sometimes more than one stem, rises to about five or six inches in height, and bears upon its termination a cluster of delicate snow-white flowers: a varying number of leaf-stalks spread radially out and close to the ground; from the base of the flower-bearing axis a few tiny rootlets, not exceeding an inch in length, reach down and penetrate the damp and peaty soil.

It is the foliage-leaf of the Sundew, as it is of all the insectivorous plants, which makes it so remarkable. These are nearly circular and slightly concave disks, covered with delicate purple hairs, each terminated by a somewhat swollen gland. The glands continually secrete a viscid fluid, which surrounds each one like a drop of dew. This appearance, together with the fact that the secretion is most copious when the sun shines upon it most brightly, has given to the plant the popular and poetic name of Sundew; as though this dew, in contradistinction to the ordinary kind, were condensed by the sun instead of being dissipated by it.

In order to understand the peculiar mechanism of the insectivorous plants, it will be necessary to examine a little into the ordinary functions of leaves and of roots. Plants, as is very familiarly known, imbibe their nutriment in several different ways. They need oxygen, carbon, and nitrogen in order to the building-up of their tissues and the performance of their vital functions. The oxygen and carbon they receive directly from the air. Every plant-tissue, whether it be leaf, stem, root, or flower, is made up of a multitude of minute cells, each having a cellulose wall and protoplasmic contents. Associated with the protoplasm of many of the cells, is a substance known as *chlorophyll,* which is the green coloring-matter of plants; and by means of this many of the most important chemical combinations necessary to life are effected. Atmospheric air enters the plant tissues by means of the thousand little openings, called *stomates,* which occur upon the exposed surfaces. The air fills the intercellular cavities of the plant, and comes in contact with the cellulose walls of the cells themselves. Every one of these possesses a power akin to that of respiration, by which it absorbs oxygen, and liberates carbon-di-oxide (carbonic acid). It has long been believed that plants reverse the processes of respiration, by day and by night; that is, that they breathe in carbon-di-oxide by day, and liberate oxygen; while they breathe in oxygen by night, and liberate carbonic acid. As a mere matter of result, this is true; but the change is not an effect of mere respiration. Plants, like animals, constantly inhale oxygen, and exhale carbon-di-oxide. This is a process carried on by means of all their cells, colored and uncolored. In addition to this the chlorophyll-cells have the power, under the influence of sunlight, of taking in the carbon-di-oxide, of separating it into its constituent elements, of appropriating the carbon and of yielding up the oxygen. During the day this latter assimilating process goes on so much the more powerfully, and its products are so much in excess of those of respiration, that the constant, and gentler, process is completely masked. There is no reversal of the respiratory process in the darkness; it is only that the chemical action of the chlorophyll, under the controlling power of light, is necessarily suspended for the time, and the hitherto unperceived process of breathing may then be detected. These functions, both of breathing and assimilation, go on in the insectivorous as in the other plants.

This, however, is not all that has been found essential to plant life. Nitrogen, as well as oxygen and carbon, is essential to vegetable existence. In ordinary cases, the necessary nitrogen, which plants have no power to absorb from the air, is supplied to the roots in a state of solution and in chemical combination. This is the element which so largely enters into all composts, whether natural or artificial. As we have seen in the case of Drosera (and it is equally true of other insectivorous plants), the roots are extremely small; they are, in fact, totally incapable, from their size if from nothing else, of supplying the nitrogenous element needed. They have a use, and that one essential to the existence of the plant, for it is by them that the necessary water is imbibed. It has been found that some of these plants can be reared very successfully upon wet moss, with no soil whatever from which to draw supplies; and their habitat, where they grow wild, is in miserable, boggy ground, where only the mosses flourish; and these, as is well known, only drink by means of their root-hairs, true roots being wanting to them, while they receive their food entirely from the air.

Nitrogen must therefore be supplied to the insectivorous plant in some other way, and this is done by the absorption of organized animal or vegetable matter. Having a truly vegetable nature, and possessing the organs to perform all ordinary vegetable functions, these curious plants superadd to their vegetable powers one of the most marvellous of animal functions, that of a true digestion and assimilation. The transitions in Nature from form to form are never startlingly abrupt, and even this curious capacity has its representation in other forms of vegetable life. The embryo-plant within the seed lives upon and assimilates formed organic matter till it has sufficiently developed roots to take up its own nutriment, and in its tiny laboratory combine and recombine the inorganic elements of earth, air, and water into organic tissue. The Drosera and its compeers seem to carry on this embryonic life throughout their whole existence, aided by most wonderful functional adaptations to their modes of nutrition. But link them as we may to a higher or lower, to more or less perfect forms of existence, there seem to be nowhere in organic Nature so many sudden transitions and wonderful combinations as we find among the insectivorous plants.

In order to understand the wonderful powers of this plant we must look into the anatomy and physiology of the tiny disk, not over half an inch in diameter, in which such powers reside. The leaf is a slightly concave plate of cellular tissue; it possesses the usual systems of cells—the parenchymal, or ordinary internal cellular system of leaves, the fibro-vascular bundles or veins, and the upper and lower epidermal or skin-tissues. In all ordinary cases the vegetable hairs or trichomes, which give to many leaves and petals their soft and velvety look, are mere outgrowths of the upper or epidermal layer of cells. The tentacles of Drosera are, however, not mere superficial cells elongated by growth, and so are not strictly trichomes, but would seem rather to be peculiar prolongations of the leaf itself. It is found, by looking through a moderate magnifying power, that the fibro-vascular bundles run up into each gland a tentacle, as they are called, and quite a number of clearly marked spiral vessels occupy the terminal swelling. These spirally marked vessels, which present the appearance of closely coiled springs, long enough to form a cylindrical vessel, form one of the commonest characteristics of leaves, stems, and roots; but are nowhere seen in vegetable hairs. The spiral coils in the Drosera glands are surrounded with several series of elongated cells, which spread out radially where the tentacle springs from the leaf. The tentacles in the centre of the disk are short, and their pedicels or stems are green, as is the disk itself, while the terminal glands are purple. The tentacles are longer towards the edge of the disk, and the extreme marginal ones are greatly elongated and entirely purple; not only is this true of the pedicels, but of the glands as well. The purple fluid filling the cells of the glands must differ in some respect from that in the cells of the pedicel; for upon placing the leaf in hot water the glands become white and opaque, the cell-contents immediately beneath them assume a brighter green tint, while the pedicel-cells turn to a bright red color.

In addition to the tentacles the disk bears a number of minute papillæ and true vegetable hairs, which can absorb but not secrete. If a small object, either organic or inorganic, be placed upon the centre of the disk, the tentacles touched send out a mysterious impulse toward the marginal glands. The nearer ones are first affected and slowly bend toward the object; gradually those farther and farther off receive the impulse, and they also bend in the same way, till at the end of a few hours the object is closely clasped by the hundred or more tentacles growing upon the upper surface of the leaf. The time required for inflection varies, in consequence of a number of varying circumstances; it depends upon the size of the object, upon the nutritious qualities it possesses, upon the age and vigor of the leaf, and upon the temperature of the air. The movement is, however, quite different from the nocturnal movements, or sleep as it is called, of many plants, and it takes place as readily and promptly by night as by day. If any exciting fluid, such as milk, or an infusion of raw meat, be placed upon the disk, or if one or more glands be repeatedly touched, the tentacles bend over and close upon the disk; while a sudden blow, even though it be quite sharp, produces no effect whatever.

The marginal tentacles, in their normal position, bend back beyond the level of the disk, so that an inflection causes them in folding over to describe an arc of 180°, or sometimes even of 270°. The whole tentacle does not curve when it becomes inflected; the bending part being confined to a small portion just above the base. If the exciting substance be placed on the centre of the disk, the middle glands remain erect; but if it be placed between the centre and the margin, then they turn toward and clasp the object. The leaf in this case shows almost every tentacle in one half bent over, while those in the other half remain in their normal position.

The motion in many instances may be distinctly noted in half a minute after the object has been placed upon the disk. When drops of a nutritious or exciting fluid, such as infusion of raw meat, milk, or soda, are allowed to fall upon the middle of the leaf, the whole disk becomes incurved and forms a little cup, sometimes round, more frequently triangular in shape.

The secretion of the glands is very viscid, so that it may be drawn out into long threads; and the presence of any object placed upon one of them induces an increase in the quantity: if the object which excites secretion be one capable of affording nutriment to the plant, the secretion not only becomes greater, but it also changes its character. It possesses at all times an antiseptic quality; bits of meat and other substances were left side by side to test this point — the one upon the Drosera disk bathed in the secretion, and the other near it on pieces of wet moss. The former remained perfectly sweet till it was dissolved and absorbed; the other soon decayed and swarmed with infusoria. With substances that do not readily become decomposed the like experiment was tried; cubes of the white of hard-boiled egg were used, and when the portion upon the leaf had been dissolved and partially absorbed, that upon the moss was found to be mouldy.

The Drosera secures its prey by means of the viscid secretion of its glands. An insect as it alights is caught by the sticky drops; the pressure of its delicate feet (even in the case of the smallest gnat this is true) soon makes its presence known to the sensitive gland, and inflection takes place. The extreme minuteness of the object producing this effect is almost beyond belief; a bit of hair weighing only the $\frac{1}{85000}$ of a grain has been known to cause the inflection of the tentacle on which it was placed, while all the others about it remained motionless. This experiment has been repeated so often, and with such precautions, as to render the results absolutely certain.

When an insect alights upon the middle of the leaf, an impulse is sent out from there, and all the tentacles bend over and clasp it. If, however, it alights upon a marginal tentacle, that one bends over till it reaches the second row; the one of these touched takes up the little captive and carries it forward. In this way it is conveyed, by a sort of rolling motion, from margin to centre. As soon as the destination is reached, however, a radial impulse is sent out, and all the tentacles become inflected over their prey. It is not known whether the insects are attracted to these leaves, or whether they alight by chance. In the former case, Darwin says, the leaf may be compared to a baited trap; in the latter, to a trap laid in a run which is frequented by game, but which is not supplied with any bait.

The pressure which induces inflection, it has already been said, is almost infinitesimally small; but in every case which was critically examined, these minute particles which produced the inflection were seen to penetrate the viscid secretion and rest upon the gland itself. The reason for this peculiar kind of sensitiveness is very manifest; the most delicate insect which will serve for food causes inflection and the pouring forth of the digestive fluid, while no effect is produced by heavy falling drops of rain or the strongest current of air.

A very curious molecular motion accompanies the inflection, to which we have already referred as aggregation. When the glands of a young leaf which has never been inflected are examined under the microscope, every cell seems filled with a homogeneous purple fluid, and a constant current of colorless protoplasm is seen to be circulating around the interior surface of the cell-walls; this circulation, termed *cyclosis*, is a well-known and often observed phenomenon in cell-life. If, after the tentacles have been caused to bend by the presence of some exciting substance, the cells be again examined, a change which is apparent to the naked eye may be observed. The smooth purple color has now become flecked and mottled. Under a high power of the microscope the cause may be discovered, and the process in all its stages watched. When by any means a tentacle is caused to become inflected, whether directly or indirectly, the aggregation begins at the glands and travels downward. When the exciting substance is placed upon the gland itself, the motor impulse must, of course, travel down the pedicel to the bending portion; when the excitation comes from the centre of the disk, the motor impulse must travel up the pedicel to the bending portion. But, whichever way the motor is propagated, aggregation always begins at the gland and travels downward.

When subjected to a high magnifying power this process is seen to be in its various stages, first, in most of the cells, a separation of the purple protoplasm into small grains, which coalesce, in their turn, into minute spheres. These unite into one or more irregularly shaped masses of purple protoplasm, which undergo constant changes of form, uniting and dividing, and becoming contorted in various ways. Whenever the exciting cause is removed, the tentacles begin to reëxpand, and the minute masses of protoplasm suspended in their transparent fluid-medium to redissolve, and finally when the tentacle is fully opened the cells seem again filled with the homogeneous purple fluid. It is curious to observe the aggregation proceed from the gland downward; it flashes the length of a longitudinal cell, then seems obstructed by the end-wall of the cell; penetrates the barrier, flashes along the extent of the cell, again to be obstructed, and again to overcome the obstacle. The redissolution of the purple masses travels from the base of the pedicel up toward the gland, the reverse direction from aggregation, of which it is also the reverse process. In almost all cases inflection and aggregation are associated together, though it is not universally the case.

From the many experiments made by Mr. Darwin it is proved that the tentacles of Drosera remain much longer inflected over nitrogenous than over non-nitrogenous substances, fluid as well as solid; and he gives us also the reason for this fact. Plants, by means of their roots, can only take up such nitrogen as is presented to them in solution. Animals have the means of reducing to solution solid substances and assimilating them. The Drosera, it is found by careful observation, possesses this animal power which is one of the characteristics of true digestion. In the case of animals, the digestion of albuminous compounds is effected by means of pepsin, which is a ferment, and acts only in the presence of a weak acid; neither the pepsin nor the acid alone being possessed of any such power.

The secretion which stands always upon the glands of unexcited Drosera leaves is not at all acid; but when aggregation and inflection are caused by the presence of any exciting object, not only is the secretion greatly increased in quantity, but it is also changed in quality and becomes decidedly acid. Any artificial irritation of an animal's stomach induces, in the same way, an acid secretion. As soon, however, as a portion of the substance dissolved by this acid is secreted in the leaf-glands, the true gastric fluid is poured forth. This vegetable pepsin is capable of digesting the same substances which animal pepsin digests, and is equally powerless upon others.

The movement of the tentacles presents a very remarkable phenomenon, which finds its parallel in animal life. It might naturally be supposed that the motor impulse passed through the fibro-vascular bundles or veins of the leaf, as these anastomose and so form a connected system throughout the leaf; but experiment proves that it is not so. The impulse sent down from a tentacle moves outward, just as the aggregation is seen to advance, radially. It seems to run out more easily in the line of least resistance; and as the cells are ranged radially about the foot of the tentacle, and are longitudinal in form, there seems no subtler reason needed for the direction in which the impulse is propagated. When a tentacle is touched, itself, it always bends toward the centre; but when the impulse comes from without, the side turned toward the motor centre contracts, and bends the tentacles toward that centre. The highest powers of the microscope do not reveal the slightest wrinkle or fold in the contracted portion, even when a tentacle has been made to describe a whole circumference. There is manifestly, under such examination, a transference of some portion of the cell-contents from the concave to the convex portion of the bending segment. The motor impulse as it ascends the pedicels of adjacent tentacles acts directly upon the bending portion, without first ascending to the glands and then being transmitted downward. Some other impulse must, nevertheless, be transmitted to the glands, for they begin immediately secreting an acid substance, and the glands send backward to the base that mysterious force which causes aggregation. This is the only phenomenon in the vegetable world, so far as is now known, akin to the reflex nervous action of animals.

The most curious fact of all in connection with these movements, is that made known by Dr. Burdon Sanderson, who has discovered that Drosera and Dionæa have a normal electric current, like that of animals, which is disturbed by the movement of their leaves as the current in animals is by their muscular contractions. Not only are these curious plants allied to animal life by their powers of digestion, but also, it would seem, by something even subtler than this, by muscular contraction and the transmission of a motive force.

The only sensitive portions of the Drosera-leaf seem to be the glands, or the cells immediately below the tentacles: the faculty of secretion is confined to the glands alone; but absorption takes place not only in the glands, but in the minute papillæ and vegetable hairs which cover the surface of the disk. When a nutritious substance is placed upon the disk, the folding-in of the tentacles and the incurvation of the disk itself forms a temporary stomach, which, like the stomach of an animal, pours forth at first an acid secretion, and afterwards, as an effect of absorption, a ferment which really enables the plant to take into its own tissues and assimilate this truly digested matter.

There are a number of other species of Drosera which have been examined. These differ more in appearance than in structure from *Drosera rotundifolia.* The leaves in most other species are long, instead of round. In the *Drosera longifolia* the apex of the leaf as well as the tentacles curls over the captured prey. *Drosera Capensis,* a native of the Cape of Good Hope, shows the peculiarity (which we shall see also characterizes Dionæa) of a petiole with broad leaf-like margins, which are longer than, and nearly as broad as, the gland-bearing leaf. It might be popularly described as a leaf of the ordinary kind with a gland-bearing leaf springing from its apex.' The petiole has the power possessed by other foliage-leaves, and draws a large part of its nutriment from the air, while the gland-bearing disk has fewer chlorophyll-cells.

One of the most remarkable facts recorded of the long-leaved Droseras, is that to be found in the *American Naturalist*, Dec. 1873. This was observed and recorded by Mrs. Mary Treat of New Jersey, of whom Darwin and other eminent naturalists speak with great respect. She says that when she pinned living flies at a short distance from the leaves, without touching them, the leaf actually bent toward and seized its prey. No mention is made in Darwin's book of this particular observation, though he quotes Mrs. Treat for other facts, and alludes to this very article on p. 278 in a foot-note.

The *Drosera binata* (or Dichotoma) is a gigantic Australian species, which is of great interest because it forms one of those wonderful connecting links in the series; possessing affinities with the preceding and succeeding form, and being, as it were, an interpreter between them. The footstalk of the leaf, which is somewhat like a rush, is sometimes twenty inches long; the leaf-blade, which is narrow, bifurcates once at its junction with the tip of the footstalk, and again two or three times, curling over in an irregular way. The blade being about seven inches long, the whole leaf, including footstalk, measures sometimes as much as twenty-seven inches. The peculiarity of the species is that it unites within itself the characteristics of Drosera, and its nearest of kin the Drosophyllum. Besides the usual tentacles, bearing glands and capable of inflection, which characterize the other Droseras, it has upon both its upper and lower surface sessile glands, consisting of four, eight, or twelve cells, which absorb powerfully; and, upon the backs of the leaves, near the edges, tentacles which secrete the usual viscid substance, but are incapable of bending. These we shall see hereafter are characteristic of Drosophyllum, where they have a marked significance. Like the wonderful mechanism which is bound together in the fins of the fish, or folded away beneath the horse's hoof, and which only finds its true significance when it reaches its perfect development in the marvellous adaptability of the human hand, like this shadowing forth of the higher life in the lower, we see the peculiar mechanism, which is perfected in the Drosophyllum, entering into the structure, apparently without purpose, in this species of Drosera. This gift of a mute but unerring prophecy which we find again and again in Nature, is no mean endowment, but serves to bind into a divine and exquisite harmony the facts of creation, and to make manifest the purpose which runs through them all.

The Drosophyllum is a rare plant, found only, so far as is now known, in Portugal and Morocco. It sends up long narrow leaves from a woody axis, which are concave above and convex beneath. Both surfaces, with the exception of a narrow central channel, are covered with two kinds of glands, corresponding with the dorsal immovable tentacles and the sessile glands of *Drosera binata.* The taller glands are raised upon pedicels, and are of a mushroom form, having convex umbrella-shaped caps. These tentacles are of many sizes, and are of a bright pink or purple color. Like the tentacles of Drosera, they are rather prolongations of the leaf than true vegetable hairs. These glands secrete copiously a substance more liquid than that of Drosera. Beneath them, upon the surface of the leaf, are multitudes of minute colorless glands, which show the same internal structure as the tentacles, but which never secrete spontaneously. There is a curious division of labor performed in the Drosophyllum by the two sets of different glands, as we shall soon see. The secretion of the taller glands, unlike that of the Drosera, is equally acid, whether normally at rest or excited by the presence of nutritious matter. When a bit of meat is placed upon one of the upper tentacles, or an insect alights there, the convex surface affords a very insecure resting-place, and the drop of secretion being very liquid, generally rolls off, carrying with it the intruder. Its feet, legs and wings are clogged by the liquid, and its struggles only serve to precipitate doom, in the form of other drops which are shaken from the neighboring tentacles; the trachæa of the insect being closed by the secretion, it soon succumbs and dies. The lower glands absorb powerfully, and are excited by so doing to pour forth their secretion, which is of the nature of the ferment given out by the glands of the Drosera. The secretion of the taller glands of Drosophyllum, whose function it is to catch the prey and supply the acid necessary for digestion, is not increased by the presence of nitrogenous matter. On the other hand, the lower sessile glands only secrete under the influence of the presence of such matter, and they alone possess any marked power of digestion. The marvellous adaptation of the organs to their function, shown by the various modes in which these plants capture and assimilate their prey, seems sometimes almost too wonderful for belief. Each variety has its peculiarity of organs, which are closely related to its peculiarity of function; the reason of each modification is, in almost every instance, perfectly clear, even with our imperfect knowledge of the subject. Drosophyllum, like Drosera, has very small roots, by which it imbibes water only.

Dionæa, or Venus' Fly-trap, grows principally in the eastern part of North Carolina. A central stalk, or stalks, rise from a radial cluster of leaves; each bears upon its summit a cluster of white-petalled flowers. The foliage-leaves possess a broad leaf-like petiole, the central vein of which — the mid-rib — grows beyond the termination of the petiole, and forms a two-lobed leaf of very peculiar shape and structure; the two lobes stand up from the mid-rib at a little less than a right angle, each being slightly curved on its upper side. It is fringed along the upper and outer edges by a row of spines, which are prolongations of the leaf. Upon the inner surface of each lobe there are placed triangularly three delicate filaments (sometimes, though very seldom, the number of these filaments is more or less than three). Under a power of about three hundred diameters, the smaller filament of a Dionæa lobe, which we have examined, measures about two inches; it is a sharply-pointed narrow cone formed of longitudinal cells, and has a clearly marked articulation, which answers as a joint, near the base. These are the only sensitive portions of the leaf; and they are so exquisitely sensitive that the lightest touch will cause — not the filaments themselves, but — both lobes to close instantly, the filaments folding flat, by means of the joint, against the leaf. If a touch, or the presence of some innutritious substance, be the exciting cause, the lobes become curved into a concave form, the terminal spines of their upper edges interlocking like the fingers of two clasped hands, and remain in this position. A concave chamber is thus formed; and just rapidly enough do the spines interlock to retain a large insect, and to allow a very small one to escape. If it be an insect or other nutritious substance which is caught, the leaves do not remain concave, but press against each other throughout their whole extent, so closely as to force out of shape cubes of the white of hard-boiled egg. The muscular contraction is forcible enough to resist any effort to open the lobes; they often tear rather than separate, and flap back with an audible sound when released from the hold, when the attempt to open them has been successful.

The purpose of each of these peculiarities of structure is very clear. Dionæa has no secretion by means of which it can catch its prey; if Drosera is a baited or unbaited trap laid in a run frequented by game, Dionæa is something with which we are even more familiar, a spring-trap, that closes upon the unwary intruder which touches some secret wire. This wire, however, is not baited; the little delicate filaments are only the sentinels stationed to give the signal when an unwary victim is within the power of its captor. Dionæa does not seem to possess anything like the recuperative power of the various Droseras, and the provisions which we find made against a useless expenditure of force are very remarkable. Dionæa, like Drosera, closes alike upon organic and inorganic substances. The Drosera, we have seen, pours out its acid secretion upon whatever inflects its tentacles (though pepsin is only secreted and exuded when the object is organic), and the tentacles soon unbend when the enclosed object yields no nutriment. There is not even so much loss of time and force as this in the Dionæa. We have already said that the lobes curve about an inorganic object, while they flatten themselves against an organic one. The sessile glands, which cover the surface of the lobes, like those of Drosophyllum, only secrete after the absorption of some nutritious substance, and then only such glands secrete as themselves absorb. When the lobes unclose after having held some inorganic object, it is found to be perfectly dry, no secretion having taken place. If, however, an insect or bit of meat be clasped between the lobes, they press against it, and each gland touching it is excited to secretion; this secretion, mingled with the dissolved food, flows by capillary attraction between the closely pressed lobes, and in this way every gland is induced to secrete.

The Drosera remains closed over an organic body, which is not too large for it to digest, from forty-six hours to ten days, according to the digestibility of its prey; cubes of albumen and bits of roast meat requiring the shorter time. After the matter has been completely dissolved and absorbed, the tentacles open, and the disks are ready for another meal. The Dionæa, on the other hand, which remains closed not more than twenty-four hours over an inorganic substance, and suffers no exhaustion of the gastric fluid, remains closed for fifteen, twenty-four, or even as long as thirty-five days over an organic substance which it is digesting. When it reöpens its lobes, the leaf seems torpid, and usually no excitation of the sensitive filaments will cause it to shut again. Another very curious fact, closely related to the needs of this plant, is that inorganic matter placed anywhere upon the disk, if it do not touch the filaments, produces no effect; while organic, whether it touch the filaments or not, causes the lobes to close upon it; in the latter case, however, the movement is slow. It is easy to see how each one of the peculiarities of each plant is meant to subserve a definite purpose. A touch upon a Drosera-leaf produces no inflection; continued pressure, even the most exquisitely delicate pressure, produces the effect of finally bending all the tentacles. Drosera ensures, by its sticky secretion, the persistence of any pressure which will bring it advantage, and closes leisurely upon its victim. Dionæa needs but the lightest touch to induce prompt movement; any leisurely motion in this case would, of course, be fatal to its purpose.

The motor impulse in Dionæa, like that in Drosera, is not transmitted by the fibro-vascular bundles, but follows the line of least obstruction in the parenchymal cells. The mechanism of the movement and its transmission is very mysterious; the bending portion of the lobes lies near the mid-rib, and appears to be due to a contraction of the upper epidermal layer of cells.

The filaments, which are so intimately associated with the closing of the lobes, have, it is proved by experiment, nothing to do with its reëxpansion. It seems probable from this that the lower cells of the lobes are in a state of tension, which is overcome by a violent contraction, when the sensitive filaments are touched; and that as soon as this contraction is past, and the upper epidermal cells are permitted to expand, this tension allows the lobes to resume their normal position.

There is nothing especially interesting in the account given by Mr. Darwin of the *Pinguiculas*, except that they seem very remotely allied to the other insectivorous plants, that the two lateral edges of their leaves fold over their prey, and that in a natural state they seem to live almost as much on organized vegetable as animal matter. In many of the specimens examined, pollen-grains, seeds, bits of leaves, and minute seedling plants were found adherent to the plant and in course of digestion. This is, however, not an exceptional case, as certain vegetable infusions, such as infusions of raw and cooked cabbage, green peas, &c., caused inflection, aggregation, and digestion in all the plants of which we have already spoken. In their natural condition, however, the others do not seem to derive any substantial nourishment from vegetation as Pinguicula does.

There is a very remarkable genus of insectivorous plants found in the Asiatic Archipelago, from Borneo to Ceylon, in tropical Australia, and in the Seychelle Islands. Instead of securing their prey by a voluntary motion of any kind, the *Nepenthes* have a most curious contrivance for entrapping them. We have seen in Dionæa that a prolongation of the mid-rib, or middle vein of the footstalk, is developed into the two lobes which close upon their prey. The leaf of Nepenthes has also an excurrent mid-rib which bears upon its termination a vase-shaped growth, and this forms the pitfall by means of which its numerous victims are captured. The pitcher of Nepenthes is not, like the lobes of Dionæa, a modified leaf; but being carefully watched in its development, it is found to be an enormously developed gland, like those which, in a less conspicuous form, are found upon the tips of various leaves. During the earlier stages in the development of the plant, pitchers are produced in great abundance. In the different varieties (and as many as thirty are now known to science), they vary greatly in size, shape, and general appearance. In size they range from one inch to eighteen inches in height. Those pitchers which grow near the roots rest naturally upon the ground; sometimes, upon those species which do not leaf near the ground, the excurrent mid-rib of the leaf grows a yard long before the pitcher is fully developed so that it may reach and rest upon the ground. The pitchers are surprisingly like our familiar household vessels after which they are named; the termination of the mid-rib is just below what we should call the bottom of the pitcher; above this it bulges out, and after a graceful curve, it contracts and terminates in an oblique mouth, sloping downward from the handle-side to the spout-side. Just where the handle would be united with the rim, a cordate leaf springs up, and stands (at various angles, according to the variety) as a lid to the hollow vessel beneath. The young pitchers are smaller, bulge more, and have smaller and more erect lids than the older ones. Down the outside of the front, run two fringed longitudinal wings; these generally become less conspicuous as the pitcher grows older. The mouth is furnished with a thick corrugated brim covered with honey-glands; this serves to strengthen the mouth, to keep it open, and to lure insects into the pitcher. When the lids are inclined over the digestive cavity, the inner surface of the lid is also supplied with honey-secreting glands; but in *Nepenthes ampullaria* — which Hooker tells us is the only species having the lid thrown horizontally back — there are no honey-glands upon the lid. From its position we can readily understand that honey upon this widely opened lid would attract insects, and lead them away from, instead of into, the pitcher.

In almost every species the pitchers stand erect; in those which climb high, the excurrent mid-rib often performs the office of a tendril, wrapping one or more times about any suitable support. The internal development of the pitcher of Nepenthes is very remarkable. There are, from the mouth downward, three distinct surfaces: the lid and brim form the attractive surface, and are supplied with honey-secreting glands in great numbers.

These glands consist of an assemblage of cells, imbedded in a cavity of the tissue in which they occur, and are surrounded by a guard-ring of cellular tissue of a glassy appearance. The brim sometimes slopes so as to form a funnel-shaped opening to the cavity below, and sometimes the inner edge is developed into a row of incurved hooks, strong enough, in certain varieties, to hold securely any adventurous bird which had thrust its body sufficiently far into the cavity in search of food.

The second surface is below the mouth; inside this is a smooth opaque surface, which Hooker tells us 'is formed of a fine network of cells, covered with a glass-like cuticle, and studded with minute reniform transverse excrescences.' (Rep. Brit. Asso. p. 112.) The remainder of the interior of the pitcher is the secretive surface; it is a plate of cellular tissue covered with an enormous number of glands, which resemble the honey-glands of the lid, and are set in a depression of the tissue in the same way, only that they are semicircular, with the mouth turned downward, so that all the secreted fluid falls to the bottom of the pitcher. In one variety, *N. Rafflesiana*, three thousand such glands were found upon a single square inch. The fluid-secretion is always acid, of the same nature as the first secretion of Drosera after being excited, or the constant secretion upon the mushroom-like glands of Drosophyllum. The fluid fills only a small portion of the pitcher. In one not less than five inches in height, which we saw inverted yesterday, not half a teaspoonful of liquid poured out. When the liquid is emptied out of a pitcher which has never received animal food, it collects again, though slowly and scantily. After being separated from the plant the glands continue to secrete, though not vigorously; if, however, nitrogenous substances, such as meat and white of egg, be administered, the secretion is just double the normal amount. The experiments tried by Darwin upon the Drosera and Dionæa, were tried with equal success by Hooker upon Nepenthes. The results of these experiments show that Nepenthes digests animal matter, and secretes a ferment like pepsin. The disintegration of nutritious matter he also found to be three times as rapid in the pitchers as it was in distilled water at the same temperature.

When too large a meal is given to the pitcher, it digests what it can, and then the remainder, which is undigested, becomes putrid. It is of course difficult, in the depth of the pitchers, and beneath the secretion always present, to detect the processes with the same accuracy with which they were observed in the Drosera and Dionæa leaves. Aggregation, it is found, accompanies digestion, as in Drosera and Dionæa. The clear green of the cells gives way to a brown and speckled appearance, which under the microscope shows itself to be aggregation.

In some varieties, especially those which are natives of Borneo, the colors of the pitchers are most gorgeous, especially the lid and the border about the mouth. The same devices are thus used to attract insects to this foliage-leaf as are used in the case of flowers: brilliant color and the presence of honey. One variety has a pitcher with broad, fringed, longitudinal wings, and an exquisitely fluted border about the mouth of a deep rose color. These longitudinal wings, which generally touch the ground below and run up to the honeyed brim, serve as a guide to the ascending insects. The Nepenthes forms the last of the series of plants which are sustained by digestion. There are several other varieties of insectivorous plants mentioned by the authorities, but which have not been examined with sufficient exactness to render them very interesting, and throw no new light upon the subject. We will, therefore, not touch upon them.

Some observations made upon the glandular hairs of various plants, allied and unallied to the Droseraceæ, have proved that ordinary glandular hairs possess, in some species, the power of absorbing organic matter. Two species of *Saxifraga*, which are allies, and one each of *Primula* and Pelargonium, not allies of the Drosera, were found to absorb nutritious matter by means of their trichomes, and to become aggregated during the process. In the *Pinguicula* the secretive and absorptive glands are quite manifestly glandular hairs, and not prolongations of the leaf, which possess the power of digestion. The Pinguicula and Nepenthes are very remarkable members of the insectivorous tribe. They are not closely allied to the Droseraceæ, which includes in its family-circle Drosera, Dionæa, Drosophyllum, Roridula, Byblis, and Aldrovanda; and yet they possess in common with it the curious power of digestion.

In connection with this point, Darwin says:—'The embryos of some plants secrete a fluid which dissolves albuminous substances out of the endosperm [the stored-up food which is supplied to the sprouting embryo before it has burst the seed-coat]; although the endosperm is not actually united with, but only in contact with, the embryo. All plants, moreover, have the power of dissolving albuminous or proteid substances, such as protoplasm, chlorophyll, gluten, aleuronė, and of carrying them from one part to other parts of their tissues. This must be effected by a solvent, probably consisting of a ferment together with an acid' (p. 362). A foot-note supplies an interpolation:—'Since this sentence was written', he says, 'I have received a paper by Gorup-Besanez, who, with the aid of Dr. H. Will, has actually made the discovery that the seeds of the vetch contain a ferment, which, when extracted by glycerine, dissolves albuminous substances, such as fibrin, and converts them into true peptones'. (*Berichte der Deutschen Chem. Gesellschaft*, Berlin, 1874, p. 1478.) The presence therefore of acid, and even of a ferment akin to animal pepsin, it thus appears is not present alone in the insectivorous plants; though it nowhere else has received so great development, or performs so important a function.

Beside the plants already described, which receive nutriment from organic matter by a true digestion, there is another class (using the word class popularly, rather than botanically) which derive nourishment by the absorption of decomposed animal matter collected in their foliage-leaves. To this latter kind belongs the American Pitcher-plant, or Side-saddle flower, as it is indifferently called. Between the two general classes stands a wonderful little aquatic plant which partakes of the nature of both.

The *Aldrovanda*, Darwin says, 'may be called a miniature aquatic Dionæa. Stein discovered in 1873 that the bilobed leaves, which are generally found closed in Europe, open under a sufficiently high temperature, and when touched suddenly close'. This little plant is entirely destitute of roots, and floats freely in the water. The leaves are arranged in a whorl about the stem, and each one has a broad footstalk terminating in a bilobed leaf: from the termination of the petiole, just where the leaf is joined to it, four or five rigid projections spring, tipped each with a stiff bristle; these enclose between them the two-lobed leaf, the mid-rib of which is also tipped with a similar bristle. The lobes are formed of a very delicate translucent tissue, and open only about as wide as a living mussel-shell. Each lobe is in form rather more than a semicircle; and the edges of the outer surface of the lobes, which are furnished with points, are doubled inward. The lobe is composed of two very dissimilar portions. When the two lobes are laid flat open, the impression upon the eye is of two complete circles, intersecting each other in such a manner that the circumference of each touches the centre of the other. The illusion is increased by the fact that the apparently overlapping portion is darker than the others. The mid-rib, which divides the figure symmetrically, seems to be the common chord which subtends all the arcs — the two larger and two smaller ones. The lighter crescent-shaped outer portion of each circle is covered with small prominences, crowned with a quadrifid or four-rayed process, not unlike in appearance the stellate hairs which clothe many leaves and give to them their downy appearance; the inner curve encloses a space covered with simple colorless glands like those of Dionæa. Over this darker gland-bearing surface are found numerous delicate hairs, the sensitive filaments of our little aquatic Dionæa; they differ from those of Dionæa, however, in being colorless, and in having two joints instead of one. This inner, and darker, portion, which is composed of three layers of cells, represents the digestive and motive apparatus of the Dionæa; while the outer, and lighter, portion, composed of only two layers of cells, possesses the peculiar characteristic of at least some species of the second kind of insectivorous plants. The quadrifid processes do not digest as the glands do, but they possess the power of absorbing decomposed organic matter for the maintenance of the vegetable organism. It is certainly a most remarkable fact that a single insignificant plant should show, upon one tiny disk, the characteristic organic peculiarities of these two widely-separated classes of insectivorous plants, and that the one portion should be separated from the other by a defined boundary-line.

The Aldrovanda, though the notices of it are scant and imperfect, serves to introduce us to a new genus, upon which many observations have been made, namely, the *Utricularias.* These are aquatic plants, possessing an aërial portion which produces the flowers. A writer in the *Annales des Science Naturelle* gives the following rather fanciful description of one of these plants, as though it were two distinct organisms:—'The one is an aquatic plant, with horizontal leaves and no root; it can either raise itself to the surface of the water, or reach its depths; the other an aërial plant, turning toward the heavens, producing flowers on its summit, and planted upon the first, which serves it as soil, or rather as roots. Each of these beings not only accomplishes a special function in a particular mode, but each possesses an intimate structure appropriate to this function and to this mode; and the difference in this regard is so great between the two, that when one has submitted to him isolated fragments of the two axes, he does not hesitate to assign them to distinct and widely separated vegetable types'. (Fifth Series, vol. x. p. 59.) Most of the writers upon the insectivorous plants confine themselves closely to the leaves, their organic structure and functions. Any idea of the plants themselves has, therefore, to be gathered from various sources; and some of these descriptions must stand upon their own merits, having received neither the disapproval nor sanction of the latest and most accurate observers. Darwin merely says:—'The plants float near the surface of the water, and are quite destitute of roots, even during the earliest period of their growth. They commonly inhabit, as more than one observer has remarked to me, remarkably foul ditches' (p. 397). 'The leaves' of *U. neglecta*, he goes on to say, 'continually bifurcate, so that a full-grown one terminates in from twenty to thirty points. Each point is tipped by a short, sharp bristle; and slight notches on the sides of the leaves bear similar bristles. On both surfaces there are many small papillæ, crowned with two hemispherical cells in close contact' (pp. 396–7). On the same divided leaf there are frequently two or three of the *utricles* or bladders which give to the plant its name, as well as its chief interest. These are oval sacs, supported on the side by a short pedicel; when mature, they measure about one-tenth inch in length. At the smaller end of the egg-shaped sac there is an opening, guarded by two prolongations of the cellular tissue of the sac; the one called the collar, is a thick cellular growth which dips deeply into the cavity of the sac; the other, the valve, forms one side of the slit-like orifice which leads into the bladder; it becomes, at its margin, sharp, thin, and smooth, and rests upon the edge of the collar. Above the orifice, as if to guard it, there are two prolongations of the cellular tissue of the sac, bearing six or seven long, pointed bristles; these are quite enough like the antennæ of some of the lower crustacea to justify the name which Darwin has bestowed upon them. On the two sides of the entrance, beside the antennæ, are from three to seven long multicellular bristles. The valve can only open inwards, as both collar and valve dip into the cavity of the bladder. There is, of course, a hollow or depression, at the bottom of which lies the slit-like opening. On the lower side are both the stalk-like pedicel, toward the larger end of the oval, and the opening, toward the smaller, guarded by its bristles and antennæ; this lower side, which is flatter than the upper, faces the stem during the early stages of its development; later, however, it is generally found turned either horizontally, or obliquely downward. The bladders, with their bristles and valves, form the trap into which unwary crustaceans and other aquatic small-fry are ensnared.

The valve, which is colorless, transparent, flexible and elastic, is formed of two layers of small cells; two pairs of transparent, pointed bristles arise near the free portion and point obliquely outward; there are also upon its surface numerous glands, which have the power of absorption. These are of three kinds, which seem to graduate into one another. They are filled with protoplasm, and the usual tests determine those which have captured insects to contain matter in solution. The bladder itself, within, is covered with crowded masses of four-rayed processes, like those found on the outer crescent-shaped portion of the Aldrovanda lobe. At the junction of the larger, polygonal cells which form the tissue of the utricle, small angular cells are placed, and from these arise the quadrifid processes.

The bladders have been supposed to serve as floats to the plant; but this cannot be the office which they are intended to perform, for branches bearing none, and those from which the utricles had been removed, floated quite as well as those still retaining them were found to do. The real function of the bladders is to catch minute water animals, and insects, which serve as nutriment to the plant. Darwin, principally on the evidence supplied him by Mrs. Mary Treat, concludes that the bladders are not sensitive, and that insects force their way into the cavity through the valve-guarded slit, which permits ingress, but not egress. In an article published by Mrs. Treat (*Harper's Monthly Magazine*, Feb. 1876) since the appearance of Darwin's book, she brings forward the latest results of her investigations, and there states her belief in some sort of sensitiveness in the utricles. Darwin mentions the fact, that more than once objects placed near the orifice of the utricles suddenly disappeared; but finding that he could not cause any perceptible movement in the valve by touching or brushing it (in imitation of a crawling insect), he concluded the valves to be lacking in sensitiveness. Mrs. Treat says:—'After careful and repeated experiments, I find that the larva has nothing to do with effecting an entrance; if it is caught in the valve, the part that is within the utricle seems perfectly powerless to move, but the part that is outside can move and wriggle. And it would seem that when a larva as strong as a mosquito was caught, with its head and the first joint of its body sticking out of the utricle, it might escape; but as far as I have observed it never does. The chironomous larva, with its more slender body, was not often caught and held in the valve, but occasionally one was caught so. Usually they were carried bodily into the utricle with a sudden quick movement, and they were as often taken in tail first as head first. I have found as many as thirteen chironomous larvæ in a single utricle, and all caught within forty-eight hours of each other. There could be no mistake here, for the larvæ and plant were introduced forty-eight hours before. Upon two occasions I have found a dead chironomous larva held fast in the valve, and while I was looking, the valve suddenly opened and engulfed the larva with sufficient force to send it to the opposite side of the utricle'. The peculiar kind of sensitiveness possessed by the bladders, the point where it resides, and the mechanism of the motion, are still unsolved mysteries. The antennæ and bristles are manifestly useful in guiding insects toward the orifice, for they spread out, forming a funnel-shaped entrance, at the bottom of which is the opening.

The process by means of which the utricles take advantage of the presence of their captured prey, it is proved by repeated experiment, is probably in no sense a process of digestion. The captured animals are generally found as a pulpy mass of decayed matter, through which the jaws and limbs, and sometimes the horny integuments of certain insects, are intermingled. There is reason to think that some substance is secreted which hastens the decomposition. Darwin quotes a statement from the *Natural History of Jamaica*, by Browne, to show that there is no inherent improbability in his supposition; the milky juice of the papaw, he tells us, causes meat which has been soaked in it to become quite tender in ten minutes, and soon after to become putrid.

However this may be, the decomposed matter contained in the utricles is absorbed by the quadrifid processes which line its interior. A change, hardly less marked than that caused by digestion in the Drosera-tentacles, shows itself in the quadrifid processes, after having been in contact with the decomposed mass. The absorption in this way of matter in solution and decomposed, is much less remarkable in the vegetable world than the digestion of the Droseraceæ. It seems to be in this case a transference of the functions of ordinary vegetable roots, to other and special organs provided for such plants as have no roots. The aquatic Utricularias of course have their bladders usually filled with water; a small quantity of air is however found in them in most cases. In the older utricles, containing dead and captured animals, air is almost always found; but this cannot be entirely due to decomposition, because it has also been found in young and perfectly empty utricles.

The *Utricularia montana* lives in the tropical regions of South America, and is generally counted among the air-plants; but there is some reason to suppose that it sometimes grows in the crevices of rocks. In hothouses it is grown in peaty soil. The leaves of this species, instead of bifurcating as in the aquatic varieties, are entire, and grow to about one inch and a-half in length. It produces numerous rhizomes, or creeping underground branches, which are not, strictly speaking, roots; these thread-like, colorless rhizomes bear small bladders; they also occasionally swell into tubers. Both of these developments are apparently destined to supply water to the plant, as no stored-up starch or other solid matter is found in them. The bladders grow in great numbers, sometimes as many as three or four hundred upon a single plant, and are generally found filled with water; though they are subterranean, many insects are captured by them, which undoubtedly afford nourishment to the plant. The shape of the utricles is greatly modified for its underground work; instead of the projecting antennæ armed with bristles, they possess unarmed antennæ which curve completely around, resting on either side of the bladder, and forming a roof over the depression where the orifice lies, which protects it from being clogged up by the earth, but which still leaves a free passage for the entrance of insects. Within the bladders are a multitude of quadrifid processes, which perform for the plant the necessary absorption of organic matter. The modes of nutrition, beginning with that closely allied to animal digestion, have approached by a descending series to true vegetable nutrition by means of roots, *Utricularia montana* forming the last of the series.

We now come to a genus of insectivorous plants which differ very widely from any that we have yet examined, though touching one or another at certain points. This is the *Sarracenia:* there are eight species of this genus, all similar in habits, and all natives of our Eastern States. Their habitat is in boggy ground, and even in places covered with shallow water; and they are found as far north as Newfoundland, and as far south as Florida. Some years ago its root was proposed as a remedy for small-pox, and it in this way 'enjoyed an evanescent notoriety'. It is known by several popular names, Trumpet-leaf, Side-saddle flower, Pitcher-plant, Fly-trap, &c.; but by its botanical name of *Sarracenia* it is perhaps better known than by any of the local appellations: the name was given to it from the fact that Dr. Sarrazen sent the first specimen from Quebec to Paris. The plant, as figured by Prof. Riley, is a cluster of leaves, springing directly from the ground. Some of these are ordinary-looking leaves, the others are long trumpet-shaped tubes covered with an arched hood; the tube is a transformed petiole, the hood a modified leaf. Hooker describes them as having two, or even three varieties of pitcher; but we gather from the descriptions of those familiar with them in their native soil, that these are, in some species at all events, only different stages in the development of similar pitchers. There are eight known species belonging to the genus. Four of these, *S. purpurea*, *S. flava*, *S. rubra*, and *S. Drummondii*, have, in their young state, pitchers with the hoods arched down over the mouth; in a more mature state the hood stands up nearly erect, with its sides so deflected as to shed all the rain-water which it catches, though the rain falling directly into the open receptacle is retained. *S. psittacina* and *S. variolaris* have permanently closed lids, into which no water can fall, though there is an aperture for the entrance of insects.

Dr. Mellichamp, who has perhaps made the closest observations upon *Sarracenia variolaris*, says:—'It is found mostly in our damp pine-lands, occasionally in wet bogs, but it flourishes best on slight elevations on the edges of "pine-barren ponds."

'In such situations, with an open grassy pine-land surrounding them, with an abundance of sunlight, and a sufficiency of moisture, these plants are found in large clusters or patches, their yellow flowers and curiously spotted leaves of green or purple presenting an appearance as singular as beautiful. The leaves, which vary in length from one foot to eighteen inches, have certain peculiarities of conformation, the throat being covered by an "arched or vaulted appendage", a sort of upper lid or hood, which extends forward and downward, overhanging the orifice and thus preventing the admission of rain-water; . . . the inner surface of the hood, or upper lid, is marked on its posterior portion by white translucent spots and purple reticulations, which last extend forward and upward, and again downward, on each side of the rim, for a half an inch, or sometimes an inch'.

The interior of the pitcher is very wonderful and beautiful, and may be divided into four surfaces, for the sake of description. The first portion — of translucent spots and purple reticulations, just described — Hooker calls the attractive surface; it occupies the inner surface of the lid, and that part of the pitcher just below the rim; it possesses many stomates, and, in common with the mouth of the pitcher, is covered with honey-secreting glands. The second surface, just below the first, called the conductive surface, is opaque, formed of glassy cells elongated into short conical processes which overlap each other like shingles upon a roof, and turn downward. This surface forms a peculiarly insecure foothold even to insects. The third, or glandular surface, occupies a considerable portion of that part of the cavity of the pitcher which is beneath the conductive surface; this also affords no foothold for insects, and is thickly studded with glands. Below this is the fourth or detentive surface: this portion of the cavity possesses no cuticle, and is studded with innumerable deflexed hairs, which are rigid and glass-like, and converge toward the axis of the lessening cavity, so that an insect which is once caught cannot effect its escape, and by its efforts after freedom only wedges itself more and more firmly in the pitcher.

It is a curious and suggestive fact that *Sarracenia purpurea*, which has an opened-mouthed rain-receiving pitcher, seems to secrete no honey or other fluid. It is also the only species which has a special glandular surface, and has no glands, as the other species have, upon its detentive portion. Such a concurrence of facts suggests the probability that this variety of Sarracenia either has no proper secretion of its own, or else that it gives it out only after the pitcher has been filled with rain-water. (Rep. Brit. Asso. p. 110.) Sir Joseph Hooker expresses the opinion that pitchers so differently constructed, and with such different tissues as those described above, do not, in all probability, act in the same way. Some of the pitchers appear to serve the purpose of retaining water for the use of the plant; but those with the closed lids have manifestly a different function. The fact that insects are caught, and become decomposed in an abnormally rapid manner, suggests that these plants feed upon the results of decomposition; but the subject has never received the close observation necessary to the determination of all these points. It is therefore impossible to tell whether the glands both secrete and absorb, like the Droseraceæ; whether they only absorb, like the quadrifid processes of Utricularia; and finally, what it is that they do secrete, whether a solvent or a ferment. The observations made by Hooker were upon cultivated plants, in a climate unlike their native climate, and this fact always somewhat complicates matters.

Dr. Mellichamp supplies us with some very curious facts, which we will now give. On the 22d of April, he tells us, the plants are blooming freely; the pitchers are, however, at this season, still tender and immature, and show no signs of honey. Many leaves were examined by him which had not yet lifted their lids, and into which, of course, no water could have penetrated; a small amount of fluid, varying from five to fifteen drops, was found in each. This liquid to the taste 'was bland and somewhat mucilaginous', says Dr. Mellichamp, 'yet eventually leaving in the mouth a peculiar astringency, recalling very accurately the taste of the root, with which I am familiar'. (Proc. Am. Asso. p. 115.) This is not a little curious, that the pitchers, which to a certain extent perform the functions of roots, should secrete a juice closely resembling that found in the root itself.

In the unopened and immature pitchers there was no trace of insect-life to be found, no appearance of eggs, larvæ, or animal *débris*. In the mature leaf, on the contrary, in almost every one of the many hundreds subjected to examination, dead and decaying insects were found packed into the bottom of the tube. In the younger leaves there was only 'a small wad of macerated insects, chiefly ants . . . . over which floated the still, clear, and almost tasteless liquor' (Proc. Am. Asso. p. 110). In the more mature leaves a considerable mass of decaying insects, with the chitinous coats of others, are to be found, reaching to the height of from one to six inches in the tube. In the midst of all this decay and death there are several forms of living insects which are found in the Sarracenia tubes. Of these we shall speak hereafter.

The mode of capture in these trumpet-leaves is very like that in Nepenthes. Down the front exterior wall of the pitcher runs a broad, longitudinal wing, reaching from the honey-bearing rim to the ground. In favorable ground, and with the necessary moisture and sunlight, it is found that honey is secreted, not only about the rim and within the mouth of the pitcher, but down the whole length of the wing. On one occasion Dr. Mellichamp found the border of the wing—'the honey trail'—streaming with honey. This was, however, an exceptionally copious secretion. The honey has been supposed to possess some intoxicating quality, in order to account for the capture of such a number of insects. Dr. Mellichamp's observations do not sustain this assumption. Insects are lured on by the honeyed path from the ground to the brim of the pitcher, and from there to its interior honey-secreting portion. Just below this, as we have said, is the surface covered with soft, downward-pointing hairs. The weight of the insect's body probably presses down the further end of the hairs, as they invariably slip *backward* when the tube is in a horizontal position; when it is erect, of course the tendency toward the bottom of the tube is even greater. The popular belief—which seems to be entirely unfounded—is that flies walk upon the ceiling or walls by means of a sucker in each foot; what they really possess is a pad covered with many short hairs, which constantly exude a somewhat sticky moisture. This materially assists them in walking upon smooth surfaces; on rougher ground they are aided by their claws. The pubescent surface of Sarracenia offers neither a smooth surface for the adhesion of the pads, nor anything solid on which to fasten their claws. The delicate growth of elongated cells is too deep for their claws to penetrate and take firm hold of the epidermal layer beneath; and this is equally true of many other insects.

A fly, therefore, which has tempted fate so far as to venture inside the pitcher, has small chance of escape; the manner in which he slips and tumbles about in his struggles to save himself, naturally led to the supposition that the honey, or the fumes from the pool below, had produced a sort of intoxication. Dr. Mellichamp made many experiments to determine this point, as a result of which he found that the liquor in a vial, over which flies are suspended in a gauze net, produces no effect, neither does the honey, on which they are allowed to feed outside the tube; we may therefore infer that it is unsteadiness of the feet, rather than of the head, which causes the destruction, in the Sarracenia pitcher, of so many unwary insects. There seems to be, without question, some anæsthetic quality in the liquor itself which mercifully stupefies the victims soon after they are immersed. The drooping hood, and aperture at right angles with the direction of the tube, makes escape by flight a difficult matter, even to the nimble fly. Dr. Mellichamp hazards the conjecture that the white translucent spots upon the rim and lid of the pitchers are blinds to mislead the insects; he says:—'Doubtless this may be esteemed a "vain imagination", yet while watching the motions of flies in my first experiments, I have seen them strike against these "sky-lights" over and over'. (Proc. Am. Asso. p. 126.) It is a rather remarkable fact that the honey-loving bee very seldom frequents these tubes; only one humble-bee and one hive-bee have been found among the myriads of insects taken from the Sarracenia tubes, and examined by Dr. Mellichamp.

The insects which live in this miniature charnel-house are of several kinds. The first is a small and glossy moth, the *Xanthoptera semicrocea*, which is marked with black and pale yellow in rather a striking manner. This little moth possesses the power of walking securely over the treacherous ground which betrays so many of its fellows to their destruction. It is often found in pairs within the pitcher. About the end of April the female deposits her eggs near the mouth, soon after the pitcher has opened; and when the larva hatches, it spins over the slippery pubescence a web, which enables it to move securely over the surface; the larva then frets the leaf from within, the feeding beginning about a month after the pitcher is matured. When small, the larvæ 'begin to nip a little,' says Dr. Mellichamp, 'generally about the honey-pastures, or a little lower; but after gaining a little in size and strength, they spin a very fine gossamer-like web just at the mouth of the tube, thus connecting the hood and lower lip, and by which they effectually bar the outlet against all intruders from the outer world. They then go to work in earnest, eating both the anterior and posterior portions of the upper third of the leaf, through the parenchyma, and leaving only the thin epidermis — perhaps the closest cropping in Nature. The smaller leaves will sometimes be almost entirely devoured, but in the large ones only the upper third, and in some of these only small patches, chiefly the sugary portions. A cluster of these plants at this season, formerly so erect, and fresh and green, now looks burnt and blasted, the upper portions of the leaves frequently collapsing and falling down, while all that seems to support them is the excrementitious deposit of the larvæ'. (Proc. Am. Asso. p. 129.) Prof. C. V. Riley tells us that there are two broods of Xanthoptera every year. (*Ibid.* p. 21.)

The second species of living inhabitants is still more frequently found in the pitchers, and has received the name *Sarcophaga Sarraceniæ*, or Sarracenia Flesh-fly. 'By the time', says Prof. Riley, 'the whitish efflorescence shows about the mouth of the pitcher, the moist and macerated insect-remains at the bottom will be found to contain almost invariably a single whitish, legless grub or "gentile" . . . This worm riots in the putrid insect-remains, and when fed upon them to repletion, bores through the leaf just above the petiole, and burrows into the ground. Here it contracts to the pupa-state, and in a few days issues as a large two-winged fly'. (Proc. Am. Asso. p. 24.) This fly is viviparous, and it deposits its young upon tainted meat or other strong-smelling substances. It is possibly the odious smell of the Sarracenia which attracts it to the pitchers for this purpose. 'These two insects', Prof. Riley goes on to say, 'are the only species of any size that can invade the death-dealing trap with impunity while the leaf is in full vigor; and the only other species which seems at home in the leaf is a minute, pale mite belonging apparently to *Holothyrus* in the *Gamasidæ*, and which may quite commonly be found crawling within the pitcher; and a small lepidopterous leaf-miner, which I have not succeeded in rearing. There must, however, be a fifth species, which effectually braves the dangers of the bottom of the pit; for the pupa of Sarcophaga is sometimes crowded with a little chalcid parasite, the parent of which must have sought her victim while it was rioting there as larva'. (*Ibid.* pp. 22–3.)

The physical peculiarities which enable these insects to escape the destruction which seems almost inevitable to others, are partially known. The flesh-fly has a very large pad on each foot, and claws long enough to penetrate the pubescence and fasten on the solid cellular tissue below. The moth possesses long spines and spurs, which enable it to sustain itself in the same way. The larvæ have the power, in common with other varieties, of withstanding the solvent power of a fluid which is capable of destroying and decomposing other forms of life; this is not an exceptional power, but is found in numbers of other forms of *Muscidœ* and *Œstridœ*. It has been suggested that some of the insects thus reared in the trumpet-leaves may return the favor by fertilizing the flower, as Sarracenia is not a self-fertilizer; but this is not sustained by observation. Prof. Riley's conclusion is, briefly summed up, first, that Sarracenia is an insectivorous plant; second, that the insects most easily digested and most useful to the plant are ants and small flies, which are lured on by the honey-path, while the larger insects are entrapped by accident, and then fall victims to the mechanism of the pitchers; third, that the only benefit derived by the plants from the capture of their prey, is the liquid manure which is the result of the decay; fourth, that Sarcophaga is a mere intruder and sponges upon its unwilling host; fifth, that Xanthoptera has no function to perform which benefits the plant, but is the peculiar insect-enemy of Sarracenia; sixth, and finally, that neither moth nor fly has any exceptional structure not possessed by some allied species, which enables it to brave the dangers of the pitchers.

Hooker suggests it as probable, that 'just as the saccharine exudation only makes its appearance during one particular period in the life of the pitcher, so the digestive functions may also be only of short duration'. (Rep. Brit. Asso. p. 110.) The notion that birds resort to these pitchers in dry seasons for their water-supplies, seems to be due to the fact that they do often tear open the tubes in order to devour their contents. The office of the pitchers, it would seem, is not quite fulfilled in life, for after they wither and fall, the collected nitrogenous matter within them serves to enrich the soil, like ordinary manures.

There is a short and unsatisfactory notice in the *Linnœan Society Transactions* (vol. xviii. p. 429) of another genus in the family *Sarraceniaceœ*, the *Heliamphora*. The tube of this plant is in its internal structure like the Sarracenia; it has never, so far as we know, been studied functionally. The chief interest which attaches to it, is the fact that it supplies to the eye at once the link which makes clear the morphology of the modified leaf. Botanists tell us that tubes of the pitcher-plants are metamorphosed petioles, bearing upon their tips leaves, which are the lids. To the uninitiated this is not altogether satisfactory; we want to know just how they know this, whether it is a fact reached after close and careful study, or merely a guess. When, however, we find a form like that of Heliamphora, our faith is wonderfully assisted, and we begin to think that botanists are remarkably good guessers. Here we see a broad-winged petiole, or footstalk, with its lateral portions curved round till they meet and form a tube, and with the extreme edges turned back again, making the longitudinal exterior wings or honey-path. From the tip of the petiole springs upright a small, deeply concave leaf, which suggests the lid of the Sarracenia-pitcher, or the still more remarkable hood of the Darlingtonia, the last insectivorous plant of which we shall speak. The Heliamphora, like Darlingtonia, might be called an 'insignificant geographical outlier' of the Sarracenia family, for only one species has yet been found, and that in British Guiana, at a height of six thousand feet above the sea-level.

The *Darlingtonia Californica* is found in an equally remote locality: it grows in the spongy sphagnum bogs of the Sierra Nevada, at a height of from five thousand to seven thousand feet above the level of the sea; 'in the northern mountains of California', Mr. Canby tells us, 'beneath the snows of Mount Shasta'. The Sarracenias, we have seen, are found only upon the Atlantic slope of North America, with the exception of one species, which, on the authority of Mr. Canby, is found as far west as Michigan. The Darlingtonia was first discovered by Dr. Brackenridge, of the Wilkes Exploring Expedition, in the year 1842; but the description of it was not considered accurate enough for publication until several years later. The first published description is to be found in the *Smithsonian Contributions* for the year 1854. The plant, Mr. Canby tells us, has not, so far as he knows, been cultivated with even moderate success. A few months ago there was a fine specimen in the greenhouses of the Agricultural Department at Washington, but a visit there a few days ago, for the purpose of examining it, educed only the discouraging information that it was dead.

The tubes of Darlingtonia, though like those of Sarracenia in some respects, show a marked difference in others. The leaves of this plant, like those of Sarracenia, are radical — that is, they spring directly from the ground. Every description and figure of the plant which we have been able to find, shows all the leaves to be pitcher-shaped. Each tube is twisted upon its axis about half a turn. On a single plant all the pitchers are twisted in one direction; but some plants show a uniform twist of all the leaves to the right, and others of all to the left. Instead of a lid like that of Sarracenia, the upper portion of the tubular petiole itself curves over, forming a dome which arches over the cavity of the pitcher, and so much beyond it that the apex of the dome stands above the inner wall of the tube. It continues to curve around and inward till only a small orifice is left between the lower edges of the curved dome and the inner wall of the tube. From this point, the upper edge of the orifice, springs the leaf. It is narrow at its junction with the petiole, but diverges rapidly, and soon bifurcates into two long, pointed wings. This appendage hangs downward, partially guarding the entrance to the tube. The tube itself is of a green color, which gradually melts into a yellowish tint as the arched hood is reached. Examined closely, it is found that the change of color is due to the presence, in the upper part of the pitcher which forms its dome, of large numbers of translucent yellowish spots, lying between the green veins of the petiole, just as we have already found the white diaphanous spots on Sarracenia lying amid the purple veins. The wings which flare out from the mouth of the orifice are brilliantly colored, of a red tint; on the inner surface they are covered with short, stiff bristles pointing toward the orifice. Down the outside of the curved tube, opposite the mid-rib, is a longitudinal wing like that in Nepenthes and Sarracenia. Evidently it is morphologically the doubling back of the two adjacent edges of the petiole, as in Heliamphora. This longitudinal projection does not probably serve as a lure, because, in the first place, there is no adequate evidence to prove that it possesses honey-glands, and in the second place, the insects found by Prof. Riley in the tube are flying insects, to which a honey-path, from the ground to the orifice, would be useless.

The swallow-tailed appendage, however, gives traces of honey, and the vaulted roof beneath the dome has distinctly observed honey-glands. This appendage is in every way fitted to attract the peculiar prey of Darlingtonia, and to decoy them into the pitcher, where escape is next to impossible.

The pitchers are found, like those of the other genera belonging to this family, packed with insect-remains, which are covered with a clear fluid secreted by the glands. Descriptions of new and strange forms, with which no analogy can be found, are very puzzling; we will therefore risk a tedious repetition, in order to make clear the form and mode of capture of the Darlingtonia pitchers. Mr. Lemmon, as quoted by Mr. Canby, says:—'The plant, I assure you, is a fly-trap of the most successful kind. The petioles are often thirty inches high, inflated and growing larger at the apex, where they swell into a thin, bladdery, transparent hood, projecting out over the wing of the petiole, and pierced by a round orifice beneath, and the true leaf pendant, like a swallow's tail, from the outer edge of the hood. Within this hood is secreted a saccharine fluid, which is very attractive to insects. The inner side of the inflated petiole is clothed with long, stiff hairs, pointing downwards. Several inches of the bottom of the tube are filled with a clear fluid (secreted by the leaves, it must be), and I have always found any leaf of age to contain a large quantity of insects or their remains in it. While bringing home plants in my buggy to see if I could cultivate them, the "Jack Hornets" crowded into them so that I had often to slit the leaves with a knife, or turn them over, to let those escape that were above the water'. (Proc. Am. Asso. p. 68.) Like the Sarracenia, the odor of this plant is very offensive.

The most remarkable fact in Darlingtonia, Hooker tells us, is, that it shows in its own person a curious combination of the two pitcher-forms found in the different species of Sarracenia. In its infant form, he says, 'it has narrow, twisted, trumpet-shaped pitchers, with very oblique open mouths, the dorsal tip of which is drawn out into a long, slender, arching scarlet hood that hardly closes the mouth'. (Rep. Brit. Asso. p. 111.) The slight twist in the tube causes them to turn in every direction; these capture only very small insects, and correspond to the tubes in the first class of Sarracenia. Before maturing, however, the plant bears much larger sub-erect pitchers, also twisted, with the lip produced into a large inflated hood—and so on, giving a full description of the tube, which has already been given here; these, he says, correspond with the pitchers in the last-mentioned species of Sarracenia.

The flower of the Darlingtonia is solitary, growing upon a tall stem, having a general, external look, in the uncolored plates, like a double daffodil, and growing to a height of three or four feet. There are five long overhanging green sepals, and five brightly colored petals, each of which has a notch upon either side. In the centre of from twelve to fifteen stamens hangs the ovary, which is bell-shaped; occupying the position of clapper to this bell, is the style, which parts into five curved stigmatic surfaces. From the relative position of the stigmas and anthers of the flower, it cannot be self-fertilizing; the pollen developed in the stamens could not possibly fall upon its own stigmatic surfaces, and fertilization by insect agency is therefore necessary. The following quotation from Hooker suggests a close connection between the floral and foliar arrangements of this curious plant:—

'Looking at a flowering specimen of Darlingtonia', he says, 'I was struck with a remarkable analogy between the arrangements and coloring of the parts of the leaf and of the flower. The petals are as highly colored as the flap of the pitcher, and between each pair of petals is a hole (formed by a notch in the opposite margins of each) leading to the stamens and stigma. Turning to the pitcher, the relation of its flap to its entrance is somewhat similar. Now, we know that colored petals are especially attractive organs, and that the object of their color is to bring insects to feed on their pollen or nectar, and, in this case, by means of the hole to fertilize the flower; that the object of the flap and its sugar is also to attract insects, but with a very different result, cannot be doubted. It is hence conceivable that this marvellous plant lures insects to its flowers for one object, and feeds them while it uses them to fertilize itself; and that when this is accomplished, some of its benefactors are thereafter lured to its pitchers, for the sake of feeding itself'. (Rep. Brit. Asso. p. 111.)

Wonderful and interesting as these plants in themselves are, possessing, as they do, the most varied and delicate and ingenious contrivances for the capture of their prey, and the most complex organs for digesting it; yet they derive their chief interest from the relation in which they stand to other organisms. They seem to form a connecting link between the two great organic kingdoms of Nature. Belonging truly to the vegetable world, they are yet in many points allied to the animal creation. Each new fact, or class of facts, which is added to the scanty sum of human knowledge, possesses an intrinsic worth which justifies the search for it; but besides this, it has been the incentive and the reward of that intellectual striving which is in itself so good and noble a thing.

Beyond all this, every fragment of truth has another and an added value; it is one of the stones needed for the uprearing of that mighty temple which, in its unfinished state, may be, perhaps, the abode of the moles and the bats, but which in its completeness shall be the temple of the Lord our God. Each new physical fact adds another note to the grand choral symphony of praise in which the works of God are forever sounding forth the glory of their Creator. The old Pythagorean fable of the 'harmony of the spheres', which only the ears of their master could hear, shadows forth a divine truth, but shadows it forth faintly and partially. The old exclusive philosophies, thank God! have passed away; it is not the Master alone who hears the divine truth, but all who are his. The ears which shall hear the full chorus when

'Earth, with her thousand voices, praises God',

are not alone those of the wise and the mighty, but those which have drunk in the heavenly wisdom, which have been purified from their earthliness by the touch of our loving Lord.