forms will result, *with split faces turned away from the direction of the flow.* These split faces are exceedingly abundant in the granite region, from a few inches to over a thousand feet in height. If no cleavage planes are developed, *long ovals* will be formed, whose greatest diameters extend parallel with the denuding current.

In vertical erosion the general tendency is to make the valleys deeper and ridges relatively higher. The ice current being constantly attracted to the valleys, causing erosion to go on at an accelerated rate, and withdrawn from the more resisting ridges, until finally they emerge from the ice-sheet altogether.

Thus it appears that all the mountains of the range between lat. 36°, 30′ and 39°, whether the lofty Alps of the summit, the richly sculptured dome clusters of the flanks, or the burnished bosses and mountainets projecting from the sides of valleys—all owe their development to the ice-sheet of the great winter, which brooded them all, and flowed grandly above them like a wind.

In all these sublime chapters of Sierra history there has been no upbuilding, but a gradual dismantling, and of this, all its elevations and depressions are the records and monuments.

DARLINGTONIA CALIFORNICA, AN INSECTIVOROUS PLANT. By WM. M. CANBY, of Wilmington, Del.

THE Natural Order of Plants Sarraceniaceæ is composed of but three genera and eight species. The six species of Sarracenia are found native along the Atlantic slope of the United States and principally south of Virginia, one species only extending northward to Newfoundland and thence westward to Michigan. The single species of Heliamphora[1] has been found only on a mountain of British Guiana or Venezuela; while the remaining member of the family, the *Darlingtonia Californica* of Torrey,[2] inhabits a few

[1] Bentham in Trans. Linn. Soc. Vol. 18, p. 423, et seq.

[2] "On the *Darlingtonia Californica*, a new pitcher plant from Northern California. By John Torrey, F. L. S."—Smithsonian Contributions, April, 1853.

bogs at an elevation,[3] of 6000 to 7000 feet in the northern mountains of California beneath the snows of Mt. Shasta. The Sarraceniæ, having their home in a country long since brought under the dominion of civilized man, have been subject to the observations of naturalists for many years. Yet with perhaps a single exception, the *Sarracenia variolaris*, the peculiar adaptations and structural arrangements which so admirably serve their purpose as insect catchers have not been thoroughly studied. Indeed it was not until Dr. Mellichamp's most interesting and instructive observations on the above-mentioned species were made that its operations were fully understood; though Dr. Gray has shown us that many of the facts connected therewith had long ago been made public by Dr. McBride and Mr. Elliott.

Having been much interested in researches of this character, and fully cognizant of Dr. Mellichamp's experiments while they were being carried on, it was very natural that I should turn to the nearly related Californian plant, in order to ascertain if possible if it had similar insect-preying habits. It was first discovered in 1842 by Dr. Brackenridge of the Wilkes' Exploring Expedition.[4] But his specimens were too scanty and imperfect to warrant a description, and it was not until 1851 that the late Dr. Torrey received additional ones in a flowering state. Still two years elapsed before his excellent description and plate were published by the Smithsonian Institution. Even then ripe seeds had not been obtained, and some years still passed before Dr. Gray's description of them completed the systematic diagnosis.

A plant so rare, known only as inhabiting a few stations in a rugged, almost uninhabited and little visited region, while thus affording sufficient material for systematic description, has as yet given but slender opportunity for observation upon its physiological structure and habits. For while good seeds have been obtained and distributed, the plant has not yet, so far as I know, been cultivated with even moderate success. I have therefore had to rely upon an examination of dried specimens, and the descriptions of a single observer of the perfect living plant for an investigation of its insect-catching properties, and what is here offered is not so much to give a thorough description of its structure and func-

[3] *Fide* Lemmon in litt. Prof. Brewer says he has found it at an elevation of only 1000 feet.

[4] *Vide* Torrey *supra*.

tions, as to draw attention to it, in order that fuller knowledge of a very rare and curious plant may be obtained.

All the species mentioned in this paper are "pitcher-plants," so called from the very peculiar structure of the leaves; that part corresponding to the petiole or stem of the leaf being a more or less elongated and dilated tube, in growth erect or somewhat reclining, and capable of holding a considerable quantity of fluid. In Sarracenia this tubular portion is open at the summit, and is surmounted by a hood which corresponds to the usual lamina or blade of the leaf. This hood is erect in some species, leaving the orifice of the tube more or less exposed, while in others, as in *S. variolaris*, it is curved completely over the open tube, so much so, indeed, as to prevent rain from falling or even being blown into it. In Darlingtonia the structure of these organs is essentially different. Here we have indeed the elongated, nearly erect, but *twisted* tube; but its summit is vaulted and expanded, and so bent over in one direction that the orifice is brought directly underneath and covered over completely by it. It is therefore utterly impossible — the leaves being in their natural position — that any rain or bog-water could get into the tubes. Their summits are curiously mottled with green veins and semi-transparent yellowish spots in much the same manner as *Sarracenia variolaris*. The orifice in the largest leaves is a little over an inch in diameter. At the outermost point of this opening, an organ corresponding to the hood in Sarracenia but of a very different and peculiar shape is found, being narrow at its insertion but widening rapidly, and soon bifurcating into two divergent laminæ, the whole having a striking resemblance in shape to the tail of a fish. This appendage points downwards, — the extremities apparently curving somewhat inwards. It is somewhat mottled, the main color varying from the ordinary green of the other parts to a deep brown or red. The inner side has many short stiff bristles pointing towards the orifice. So far as I have been able to make out from the dried plant the upper edges of these laminæ are rolled inwards for nearly their whole length, to an extent ranging from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch, gradually widening from the outer extremities to the aperture of the tube, each thus forming a sort of groove enlarging towards, and leading directly into, the orifice. Here they join a similar turned-in process or fold which extends all around the inside edge of the orifice. The last however is wider, stouter and

more rolled in than the first. In this connection another organ is to be noticed; it is the wing more or less developed in all the species of this order, extending from the orifice of the tube to the ground. In the plant under notice it is narrow, perhaps never much over a quarter of an inch in width, and appears in fact to be two wings united for the greater part of their length, but separating within the orifice, where they form the folds already described, and also near the ground, where they become dilated and membranaceous, and assume their proper position on each side, of what is there an ordinary petiole springing from the rhizoma; so that in a morphological aspect, the whole structure is a singular modification of an ordinary winged petiole bearing at its extremity a deeply emarginate leaf! So far as the Sarraceniæ are concerned, much the same structure of the wing is discernible; and the view above taken receives additional confirmation from the structure of Heliamphora, the "pitchers" of which have each two separate yet contiguous wings running side by side from near the base to the orifice.[5]

Having given this brief sketch of the structure it now becomes necessary to show how it may be used for the trapping of, and preying upon, insects. From lack of information and experiment this cannot be done as yet very satisfactorily. In my inquiries on this point I have relied very much upon the evidence of Mr. J. G. Lemmon, who, living in Northern California, has, on several occasions, had an opportunity of seeing the plant in its native haunts, and who has most obligingly communicated recent specimens and given me all the information he could. That it is an insect-trapping plant to as great an extent as other and better known members of its family there can be no doubt. The dried

[5] Since this article was written I have had an opportunity to examine some leaves of *Sarracenia Psittacina* Michx. In their structure we may notice a near approach to those of Darlingtonia, the upper part of the pitcher being almost as in that plant. There is the same ventricose expanded summit which, if the leaves were erect, would bring the orifice underneath, and the fold within the orifice is not only present but proportionally many times larger. To be sure the "fishtail" appendage of Darlingtonia is not found here. But that admirable arrangement for attracting *flying* insects is not necessary in this plant, which has its leaves reclining in a rosulate cluster in such fashion, that the orifices are in a vertical instead of a horizontal position; thus presenting an open door for ambulatory insects, easy of entrance but extremely difficult of exit. As a consequence the prey corresponds to the structure, being composed principally of ants, with a proportion of the smaller spiders, beetles, etc. The hunter or fisher has often occasion to construct and use traps made on modifications of the same principle; but the arrangements of their mechanisms are poor and inefficient compared with those of these humble plants.

leaves received have in them, often to the height of several inches, the remains of captured insects. In letters received from Mr. Lemmon he says, "The plant I assure you is a flytrap 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 pendent like a swallow's tail from the outer edge of 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." Mr. Lemmon has kindly sent me an ounce phial completely filled with the fluid "from two petioles." Furthermore there is some evidence in the last number of the "Bulletin of the Torrey Botanical Club," that in one locality the leaves are employed as flytraps, just as those of *Sarracenia variolaris* have been. It is scarcely necessary to say, that as it is certain no water can get into the tube by any ordinary means, and as the fluid is always present in healthy leaves, it must be secreted by the plant as Mr. Lemmon says. I have quoted above what he says of a sweet secretion, exuded in the vaulted part of the tube, which is very attractive to insects. It is fair to say that in a recent visit to the growing plants he did not find it, but he adds that he "remembers distinctly that on former occasions it was quite apparent." I have no doubt that the plant has such a secretion which is used as a lure or bait in the same manner as in its allies the Sarraceniæ; for in some leaves long ago collected by Miss N. J. Davis, and which had been stuffed with cotton while in the fresh state, the cotton though easily removed from that part of the tube below the level of the aperture (where, it should be stated, for some distance there are neither bristles nor saccharine secretion) adhered with some tenacity to the upper part, and even to a portion of the appendage outside. The extent of this exudation is very plainly to be seen in many of the dried leaves which I have examined.

More to the point however than this is the fact that while the bristles of the vaulted part may not be secretive, the whole surface is sprinkled with minute glands which are doubtless organs of secretion. There is also some evidence of a secretion extending along the wing to the ground, though the weight of the testimony is against it. Mr. Lemmon thinks he has observed no instance of this. But it is fair to say that he has had no opportunity for observation since my letter containing specific inquiries on this and other points was received. There are along the edge of the wing, or rather along the hollow caused by the two wings not being completely united at their edges, minute brown glandular bristles, and sparingly intermixed, lighter-colored, nearly circular bodies which may be glands; one or both perhaps furnish a sparing secretion. Against this is the strong testimony of Prof. Riley, to whom the insects found in the leaves were submitted, that he finds no ambulatory ones among them, but that they are all such fliers as would be likely to be attracted towards, or arrested in, their course by the appendage.

Here then we seem to have a bait "that is very attractive to insects" leading directly to "a trap of the most successful kind." Mr. Lemmon further says, "I came upon a patch once in September and smelled it from afar so offensive was it. A portion of the leaves filled with insects to the depth of four to six inches, had fallen down apparently from the weight of the fluid and in sects."

But let us consider the probable uses of other organs. Dr. Mellichamp having shown the presence and use of the secretion on the edge of the wing in *Sarracenia variolaris*, a similar arrangement in Darlingtonia would infer a like use. But even if this be not verified, insects flying near the plants could hardly fail to be attracted by the peculiar bright colored appendages. Alighting upon either lamina of an appendage they would sooner or later crawl upwards, and would be inevitably directed towards the orifice by the rolls or grooves already described, aided by the thick set upward pointing bristles. Once persuaded inside by either route or attracted by the "honey pastures" (as Dr. Mellichamp well names those parts covered by the sweet secretions), there would be little chance of their escaping. For they would not be likely to fly downwards and so out of the orifice, while from but a small portion of the inside surface could they *drop* out; be-

cause if their hold was loosened while upon the sides of the vault over the orifice, the fold or rolled up portion upon the inside edge of it would retain them within, and I believe would also be sufficient to prevent them from attempting to crawl out. Here too would come in play the semi-transparent spots, if Dr. Mellichamp's ingenious surmise be correct, that by admitting light in another direction than from the orifice, they serve to attract and baffle the insect in his endeavor to escape. It is evident that these "areolæ," being successively in the line of the sun's rays, must admit more light and be more brilliant than the opening below; just as numerous windows in a roof would light an uppermost room very much more than a hatchway in the floor. It is to be noted too, that these light-admitting spaces extend some distance down the back of the tube and away from the orifice, and this I believe will be found to have its effect in luring the insects to destruction. As a further preventive of escape we find the inside of the vault clothed with innumerable bristles pointing backwards and downwards, as is the case with all the plants of the order. Thus we see how an insect might be attracted to the appendage, led along by the outside grooves to the orifice aided by the minute bristles which all point towards it, attracted inside from this or from the wing by the sweet secretions, prevented from falling or crawling out by the inside folds, baffled in any endeavor to escape by the bright areolæ and the retrorse bristles, and finally led to the ultimate and inevitable well of death. Surely there is enough in all this, to say nothing of other points yet unnoted, to tempt those who have the opportunity to make accurate observations of the functions and operations of this wonderful plant.

One other and a very curious characteristic of the leaves remains to be noticed. They are all twisted upon their axes about one-half a turn. So far as I have been able to observe, all the leaves of a plant twist in one direction. But leaves of different plants may be twisted in opposite directions, and if my specimens are any criterion, there are about as many winding from right to left as from left to right. I have not been able to divine the purpose of this twisting; but that it does subserve some useful purpose in the economy of the plant I have no doubt. Observation of the growing plant will probably furnish a solution.

Finally, I wish briefly to call attention to the floral organs. The flower is solitary and nodding upon a scape, which Mr. Lemmon

says is generally about one-third higher than the leaves. Beneath the five sepals and the five petals, the twelve to fifteen stamens are clustered around the uppermost and thinnest part of the almost exactly bell-shaped ovary. Under this and corresponding to the clapper of the bell, is found the five-parted style, with its divisions recurved and stigmatose at the extremity, and therefore pointing somewhat upwards under the ovary. Such an arrangement renders it as impossible for the granular pollen of the flower to drop upon its stigmas, as it would be for a marble dropped upon a bell to strike the clapper. Consequently the flowers are not self-fertilizing. Knowing that the flowers of all the species of Sarracenia must from their peculiar formation be cross-fertilized by the aid of insects, it is evident that this plant will be found to be another instance of the same fact; and it would not be at all wonderful if the only remaining plant of the order, the Heliamphora, should be found to correspond with its allies in this respect.

Having thus described, as well as I was able, with the means at hand, some of the functions of this most curious plant, I hope to draw such attention to it that its wonderful operations may soon be fully elucidated.

ORIGIN OF THE CASCADES AND OF THE SUBMERGED FOREST ON THE COLUMBIA RIVER, OREGON.[1] By WILLIAM P. BLAKE, of New Haven, Conn.

IT is generally known that the Columbia River has cut its way through the basaltic rocks of the Cascade Range, leaving cliffs on each side from 2500 to 3000 feet high, but it is not so generally understood that the stream at that point flows at a higher level than it formerly did owing to a partial filling up of the channel. The evidence that the river once flowed for a considerable period of time at a lower level is found in the submerged forests of fir trees extending for twenty-five miles or more along the valley

[1] The observations upon which this paper is based were made in the year 1867.