XXXVII. Memoir on the anatomy of vegetables. Read before the Physical Class of the Institute

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XXXVII. *Memoir on the Anatomy of Vegetables. Read before the Physical Class of the Institute by C. MIRBEL.*

[Concluded from p. 179.]

CHAP. VII.

Of the Pores.

THE pores are small apertures formed in the membranes; they favour evaporation, absorption, and the motion of the fluids. There are three kinds of them.

1st, *The insensible pores.*—These are apertures which cannot be perceived by the eye even when assisted by the most powerful microscopes. Effects, however, do not permit us to doubt of their existence. Every vegetable tissue is full of them, as is proved by insensible transpiration. What shows at the same time their extreme fineness is the phenomenon exhibited by an apple, or any other pulpy fruit, when placed below the receiver of an air-pump: the highly dilated air escapes only by bursting the skin.

2d, *The elongated pores.*—These have been observed by several naturalists, and particularly Decandolle, who gave them the name of cortical pores. I shall endeavour to complete his description, by uniting under the same point of view his observations and those which I have since made myself. For a knowledge of the principal facts I am indebted to his researches; but, as he considered this subject rather in a physical than an anatomical light, his labour does not supersede the necessity of publishing mine.

The elongated pores exist only in the epidermis of the herbaceous parts exposed to the air and the light. If the exterior membrane of the vegetable be skilfully removed, and if you then examine it with a microscope, you will see the interior sides of the epidermis still adhering, and which form as it were a hexagonal net-work; but here and there instead of a hexagon you will observe an ellipse, and the part of the epidermis circumscribed by that elliptical area is cleft in a longitudinal direction: the aperture is sometimes free, and sometimes obstructed: the latter case, in my opinion, arises from the lips of the pore, longer than is necessary to shut the aperture, being applied one to the other, and intercepting the light. The elongated pores are found commonly in the stems, the branches, the leaves, the bractæ, and even the herbaceous pericarpia. In herbaceous plants the two surfaces of the leaves are covered with pores; in the fat plants they are less numerous than in the other vegetables. In trees and shrubs the inferior surface only is in general pierced with these pores. The stems when they

they become ligneous are destitute of them. These pores serve for the sensible and insensible transpiration and for the absorption of the fluids. They each correspond to a small cell, which, according as the air is moister than the cellular tissue, or the cellular tissue than the air, absorbs the fluids dispersed throughout the atmosphere, or throws off those which the vegetable contains. When the parts become stiff, and the liquors contained in the vegetable have no longer the same fluidity, these cells become filled with thick gum and resin; which not being able to escape through the pores, nor to return into general circulation, become entirely hard; and are at length thrown out, when the state of the vegetable, by not permitting the epidermis to dilate itself further, forces it to burst.

3d, *The glandular pores.*—These are apertures bordered with thick opaque and unequal rolls. These pores serve for the movement and communication of the fluids in the interior of the vegetable. They are observed sometimes indeed in the epidermis, but this case is exceedingly rare. There are two kinds of glandular pores, the small and the large. The former are excessively small. To the most powerful microscopes they appear only like the small holes made in a sheet of paper with the point of a needle: sometimes they are scattered, and few in number; at other times they are very numerous, and disposed in regular series, always according to the breadth, and never according to the length of the tissue. The large glandular pores are only a modification of them: one might even suppose that the union of the small pores of one series produces the large ones, the direction of which is the same as that of the series. The reader must here call to mind what I have already said of the porous tubes, the false tracheæ, and even the tracheæ. There are some very striking relations between these different tubes, and the plan of nature is not equivocal.

CHAP. VIII.

Of the Epidermis.

This name is given to the exterior membrane formed by sides of the outer cells; or rather the epidermis is only the term of the cellular tissue itself.

To relate every thing that authors have said on this membrane, would fill a volume. No part in the organization of plants has given rise to more researches, nor perhaps has led into more errors. The first fault is, to have compared it without restriction to the epidermis of animals. When this idea was once adopted, every thing else was considered as analogous. The epidermis, said some writers, exists in all or-

ganised beings; it covers the nascent embryo, and the individual which has arrived at the state of decrepitude; it follows all the sinuosities of bodies, penetrates into their cavities, and protects the most delicate parts: thus in animals, after enveloping all the external parts, comprehending even the globe of the eye, it is seen falling back on the lips, penetrating into the intestinal canal, into the nostrils, and the auditory passage; and in plants, it covers the stems, branches, leaves, flowers and fruits. The epidermis (add they) is not similar in every part of the same being: sometimes it is exceedingly fine, and sometimes it assumes more consistence; but in all cases it is colourless and transparent. If it appears white on the trunk of the birch-tree, and brown on the young branches, ash-gray on the plum-tree, red and argenteous on the cherry-tree, green on the young shoots of the almond-tree, and ash-coloured on the old ones; this difference depends merely on the colour of the substances it covers, in the same manner as the white, black, and copper colour of the white, negro or caffè depend on the colour of the mucous body. By following this comparison, a new point of similitude is thought to be observed in the dilatability of the epidermis of animals and plants: it yields to all development, and extends in proportion as the being grows: it embraces only a small surface in the fœtus of the animal, but it dilates insensibly and covers a much greater surface when the animal attains to its utmost growth. It is thus that the epidermis which covers the seeds of plants dilates and yields to the increase of the fruit, and that the epidermis which covers the embryo yields also to the increase of trees. The extension of this membrane will be found to be prodigious, when we consider what the gourd was before its flower withered, and what the oak was when concealed in the acorn. But, as there are certain animals the old epidermis of which detaches itself, and at the end of a certain time gives place to another; in the same manner there are certain vegetables which throw off their epidermis in order to assume a new one. It is observed that the epidermis of the trunk and branches of the plane-tree detaches itself in scrolls like that of oviparous quadrupeds.

These comparisons, no doubt ingenious, are far from being exact in every point. It may even be said that they are founded on imperfect observations. To be convinced of this, it will be sufficient to reflect on the definition we have given of the epidermis of vegetables. This membrane is nothing but the exterior union of the cells of the circumference, and differs from the membranes which form the other sides only by the changes occasioned by its position. If it is less trans-

parent, drier and firmer, it is because it is continually exposed to the influence of the light and the air, and to the contact of all those bodies which float in the atmosphere: but it is not in reality a distinct part; and it may be said, strictly speaking, that vegetables have no organ analogous to the epidermis of animals. When vegetables grow large, the exterior membrane seems to dilate; but if this membrane becomes extended, it is because the number of the cells is multiplied at the circumference as at the exterior, and that consequently the sides which compose it are multiplied in proportion, and increase its capacity.

One objection remains to be combated. It may here be said, Why is it so easy in the spring time to detach the epidermis from the young branches, if it does not really form a distinct organ? This may be explained in the following manner:—All causes which have an external action on the vegetable alter its surface, and detach from it the interior parts: but this separation becomes more apparent when the vegetation is more vigorous, and when the fluids moisten the cellular tissue, and fill the tubes; for, as the disorganized surface cannot then develop itself with the rest, it ceases to adhere, and often comes off in fragments, or is insensibly destroyed. This is exactly what takes place in the spring.

In a word, this exterior stratum, which so many circumstances tend to destroy, and which almost always exhibits traces of its disorganization, is not composed of the last membrane only: the interior part of the cellular tissue is found in it, as is evident in the plane tree, and still more in the green oak, which produces cork. What has been here said is applicable only to the stems and branches, which do not die in the course of the year; for in herbs, and the annual parts of ligneous plants, such as the leaves, flowers, bractææ, &c. the surface does not detach itself from the rest of the tissue.

But the epidermis of vegetables has no resemblance to that of animals; and, though it is certainly formed by the exterior part of the cellular tissue, it is no less true that its nature is modified by secondary causes, and that it in fact becomes an organ, the functions of which are very distinct, and highly important. In the infancy of the vegetable, when all the parts are soft and mucilaginous, it opposes at the same time the disunion of the nascent organs, and the too strong action of the fluids. At a more advanced age, when the juices are less abundant, it prevents their too speedy evaporation, and maintains a just equilibrium between the solids and the fluids. At all times it secures the vegetable
from

from the deleterious influence of meteors, and shelters it from excessive heat, cold, moisture, and drought. In a word, it protects it against all external causes which might hurt it. Besides this, it serves for sensible and insensible transpiration, and the absorption of gas, and of those fluids dispersed throughout the atmosphere. For this reason it is often pierced with very visible pores: I say often, because it is not indeed a general law; and the epidermis of pulpy fruits, for example, has no apparent pores. I must add, also, that these fruits transpire very little, as Dr. Hales has shown in his *Vegetable Statics*.

CHAPTER IX.

*On the Organizing Substance, or Cambium of Dubamel.
Hypothesis on the Formation and Development of the Cellular Tissue and the Tubular Tissue.*

All the parts of the vegetable have, at first, been mucilaginous and fluid; and it is only in the succession of time that the tissue becomes firm and solid. This state of feebleness is visible in the seed. The embryo at first is but a drop of mucilage, in which the most powerful microscopes discover no organ. This substance has a vitreous appearance. It is speedily dried and destroyed by the contact of the air. Properly speaking, it is not a fluid; it is an organized substance, similar to the white of an egg. The organizing substance is formed during the whole time of the increase, and it deposits itself in that part of the tissue where the vegetable ought to acquire the greatest vigour. In the monocotyledons it is placed around each ligneous filament; in dicotyledons it is at the surface of the soft part of the wood and the medullary canal. Every day, therefore, the ligneous filaments of the cotyledons are seen to assume more volume, and the concentric strata of the dicotyledons to be multiplied, and their pith to be converted into wood. The organizing substance is the more abundant, and is renewed with more facility as the individual is younger and sounder; as it is in a more favourable situation, and as the season is better fitted for vegetation. This substance insensibly assumes determinate forms, whether the fluids develop in it, by their impulse, the cells and the tubes, or whether an unknown power acts in it alone, and determines these developments; or whether, as is probable, these two causes, united and combined, act in concert to change into membranous tissue the organizing substance, it is certain that the vegetable acquires a more considerable volume, and that it daily lengthens, and becomes

thicker. To explain the two phenomena of lengthening and becoming thicker, the action of which is simultaneous, we must acknowledge that the expansive force acting in the membranous tissue newly created is modified by the nature of the tissue itself. It is composed, as we have already seen, of two organic elements, one of which is cellular tissue, formed of the cells, whose diameter is nearly equal in every direction; the other is the tubular tissue, formed of the small and large tubes contiguous to each other. Let us suppose, for a moment, that the fluids imbibed by the vegetable are the cause of this dissimilarity in the tissue. We may do so the more, as this system is not void of probability. By way of example, let us employ the embryo: let us take the seed before fecundation: it is attached to the mother plant by the umbilical cord, the organization of which no doubt varies according to the species. By the help of the vessels which unite this organ to the seed, the fluids penetrate into the organizing substance; and their impulse being determined by the canals which afford them a passage, they then trace out the route which the fluids will afterwards pursue, and determine the order of the future developments. Being vigorously pushed in different points, which vary according to the species, they open the longitudinal tubes, and then filter slowly through their sides, deposit themselves in the organizing substance, and favour the development of the cells. In the first case, the fluids are pushed by the force which gives motion to the sap; in the second case, they issue forth and penetrate the organizing substance only, because they tend to assume an equilibrium. These two forces, balanced by each other, produce a multitude of intermediate shades between the longitudinal tubes and the perfect cellular tissue. But this theory is still far from explaining the phenomena of vegetable organization. There doubtless exist a thousand other physical causes, the influence of which cannot be calculated; and above all these causes ought to be placed the organizing power, the principle of which is totally unknown to us.

However, the cells and tubes being once formed, they increase till the inspissation and induration of the membranes present an obstacle to their development. During the growth of the membranous tissue, the fluids carried into the tubes, by several forces combined, determine the direction of the elongation by the impulse which they give to the organic molecule. But the cells suffer themselves to be penetrated by the fluids only in a slow manner; and, being subjected to no force which determines their development in one direction rather than in another, they grow and dilate themselves

selves in every direction. It would thence follow, if the cells grew equal in number to the tubes, that the cells ought to serve more for extending the thickness than the length of the vegetable, and that the inverse would be the case with the tubes; but when the latter are greatly multiplied, their number compensates for the small thickness which each has, and they then contribute no less than the cells to the sensible thickening of the vegetable. Nay more, the mass of the tubes is continually increased in trees, while the cells are not multiplied in the same proportion. In a word, several other causes, which I shall explain hereafter, contribute to disorganize them, and even to transform them into tubes, so that at the end of a certain time the mass of the latter is far superior to that of the cells.

XXXVIII. *Experiments on Electricity excited by Evaporation.* By a Correspondent.

SIR,

To Mr. Tillock.

I TAKE the liberty of communicating to you the following experiments on obtaining electricity by evaporation: and if you think them worthy of a place in your Philosophical Magazine, by inserting them therein you will very much oblige

June 9th, 1802.

Your humble servant,

W. W.

THE apparatus I used for this purpose consisted of a gold leaf electrometer (hung in a phial, which had had the bottom cut off, that a conducting communication might be made between two slips of tinfoil, which were stuck on the inside of the phial, and the earth,) and a tin dish made in the form of the frustum of a cone. The top diameter of it is about 2 inches; the bottom diameter is about 1 $\frac{1}{2}$ inch, and its depth is about $\frac{1}{2}$ inch. This dish, about half full of water, is placed on the electrometer, and the red-hot substances dropped into it from a pair of tongs, at 3 or 4 inches above it. (See Fig. 2. Pl. V.) In relating the experiments I shall put P. and N. to denote the two states, commonly denominated *positive* and *negative*.

1. Cinder of pit-coal about the size of a walnut, dropped into the water, made the electrometer diverge N. This was repeated five times with the same result. Sometimes the gold leaf would beat against the side of the bottle four or five

Q 3

times.