Amici's Microscopical Observations

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Professor Amici, of Modena, has published the results of his **microscopical observations on various plants,** in the *Proceedings of the Italian Society of Sciences at Modena*. We have only seen an account of these researches in the *Bibliothèque Universelle*, xxiii., and have made the following abstracts from it. The work of Amici is illustrated by several large plates, of the accuracy of which, and also of the descriptions, his abilities and means are securities.

Circulation of the Sap in Vegetables. *Caulinea fragilis*. - Corti first discovered the motion of the sap in plants, and among others in an aquatic plant of which he has not given the name, but only an imperfect figure; it proved to be that of which Wildenow made a genera under the name of *Caulinea*. Some time since Amici observed and described a similar phenomenon, in the *chara vulgaris*: the circulation was seen in the vessels of this plant, always in the same direction, and was supposed to be caused by small crowns of green particles lining the internal membrane of the tube.

A transverse section of the *Caulinea*, viewed by powers of 60 and 150, appeared as a polygon of 8 rays, each formed by a range of circular bodies; the centre was occupied by a large tube, surrounded by a bundle of smaller tubes parallel to each other, and in which were diaphragms at a considerable distance one from another. These vessels contained only air, which escaped in bubbles, when they were cut under water; all the other apertures in the section, are those of the vessels which conduct the sap, and which also have diaphragms, more or less distant from each other. No proper trachæ or porous tube was discovered.

Each cavity of the *Caulinea* formed a particular vessel, in which the liquid moved, independent of the circulation in the neighbouring vessel, and in a manner analogous to the movements before observed in the vessels of the *Chara*. The fluid contains visible concretions which moving with it indicate its course, and the velocity of its motion in different parts. These particles are globular, of the same size in the same vessel, but varying in different parts of the plant. The motion is as follows: - globules ascend on the one side of the tube containing them and the liquid until they reach a diaphragm, when they move horizontally to the opposite side, and descend, until coming to a diaphragm beneath, they move horizontally in the opposite direction to the first horizontal motion, and again ascend as before. This effect continues as long as the plant is alive. All the globules are not in contact with the surface of the tube; those which are at some little distance, circulate as well as the others, but less rapidly; and their motions were slower, as they were nearer to a plane, which may be supposed to pass through the tube, and separate the two currents. Sometimes the globules displaced each other, at other times they passed from the one side to the other, before they reached the diaphragm. The directions of the motion in two parallel and contiguous vessels appeared to have no relation to each other. The rapidity is variable, according to the size and length of the canal, and the degree of injury it may have suffered in preparing it, a complete circulation has been observed in a vessel ⅓ of a line, in length, in 30", this velocity is not more than a third of that observed in the *chara vulgaris*. It is to be remarked that when the plant is cut, to submit it to observation, the circulation is suspended for a time and requires some hours to be renewed.

The circulation of the sap takes place in the cellular tissue as well as in the vessels, the globules move along the surface of the cell, changing their direction when they arrive at the angles of the polygons. Sometimes a mass of globules collect in the centre and rotate with a motion common to

the whole. Observations on the leaves are more delicate, than those on the stalks of the plants, they require to be made whilst the leaf is attached to the plant, and the light must be thrown from above, as for opaque objects.

Thus each vessel presents two currents, one ascending, the other descending, which are not separated by any division: the interior is studded with small crowns, composed of particles which are very difficult to discover, because of their tenuity and transparency, and the nature of the motion shews it to arise from the surface of the tube, and precisely from those points occupied by the crowns, for there may be observed the maximum of the velocity with which the globules move.

M. Amici does not state that no liquid passes from one cavity to another, he is indeed convinced of the contrary; but the transfusion takes place through invisible apertures, through which the globules cannot pass. He has remarked two varieties of limpid fluid in the *Caulinea*, one white and one red, contained in different vessels, though of the same form. He attributes the distinct green colour of the plant, to globules very green themselves, floating in the fluid; they are greener towards the exterior of the plant, than in the interior. There is this difference between the *Chara* and the *Caulinea*, that in the first the globules are white, and the particles of the small crowns green, the latter colour the plant; but in the second, the globules are green, and the crowns yellow. Oil and alcohol do not alter the form of the globules of the *Caulinea* but discolour them entirely.

Chara flexilis. The organization of this plant is exceedingly simple, a section of the root, the trunk, the branches, or the leaves, presents but a single circular aperture belonging to a tube transparent as glass, and furnished in the interior with small crowns of green particles as in the *Chara vulgaris*. This tube contains a colourless liquor and white globules of various dimensions, some of them far surpassing, in size, the green globules adhering to the surface. These appearances are easily perceived, without any preparation of the plant, and with a common microscope. This plant has flowers, in the organs of which the circulation of the sap may be perceived in all their stages. The regular order preserved in the tubes by the two series of crowns, those of the ascending, and those of the descending side, is very remarkable and evident. The circulations in the vessels are independent of each other, so that if one is injured, the others still preserve their functions.

Of the Pollen. The principal object of M. Amici, under this head, is to describe a phenomenon, which he is anxious should be verified by other naturalists, but he forewarns them that a linear power of 300 is necessary for its observation; the drawing he has himself given was from a specimen magnified 1000 times. The Pollen was from the *Portulaca oleracea*. The figure represents a globe, 2 ½ inches in diameter, attached laterally to a curved tube, which descends vertically; between the tube and the globe and in contact with both is the superior extremity of a hair of the stigma, which forms also a transparent tube, filled with small corpuscules circulating slowly in it. On first observing it the author remarked nothing particular, but on a sudden the globe opened, and a tubular tail extended from it, which passing above the extremity of the hair of the stigma returned beneath it, thus applying itself to it and doubling its diameter; the membrane forming this tube was very transparent. This tube was filled with globules, which after circulating through it, passed into the globe of pollen, which itself was full of corpuscules in motion, and fresh globules supplied their places from it. The same kind of motion was observed in the vessels of the stigma. This phenomenon continued for three hours, after which time the corpuscules disappeared from the tube. M. Amici could not decide whether they had returned to the globe, or entered the cells of the stigma, or been otherwise disposed of.

It is necessary to an observation of this kind, that the flower be gathered a short time before it fades, the interior pistil separated and placed under the microscope; the most favourable light is that of the sun: if then the globules of pollen already adhering to the extremities of the hairs of the stigma, be placed at the focus of distinct vision, and all humidity excluded, they will appear perfectly spherical, but shortly they will be seen to explode and develop the tube-like tail, and the phenomena will appear as above described. The effect takes place more readily as the weather is

warmer. The flower gathered about eight A.M., preserves for nearly three hours the power of exhibiting this phenomenon. - M. Amici considers the globules which he saw circulating in the tail, as the same as those which other observers have remarked as a little cloud, when a globe of pollen has been broken.

The pollen of the flower of the *cucurbita pepo*, are globes, which when moistened presented, at different points of their surface, very transparent vesicles, at the summit of which were adapted small opaque covers with a projecting spine in the middle; this cover appears to act as a valve whilst the vesicle is within the globules. If the pollen be dipped in alcohol, before being placed in water they do not break, and the phenomena of the vesicles are better observed.

The pollen of the *cichorium intybus* is of a regular dodecaëdral form, with pentagonal faces; put on to water it bursts at one of the faces and throws a liquid to a distance twice its own diameter, some of the other faces swell and produce vesicles, analogous to those before mentioned, but without the operculum.

On the Epidermis. The epidermis of the leaves of a great number of plants examined by M. Amici, is a tissue formed of a layer of cells, independent of those of the parenchyma which are covered by it. It is white, transparent, and may be removed without laceration of the subjacent parenchymatous layers, of which each has its particular membrane, which adheres only by contact to the epidermis.

M. Amici refutes the opinion of those who affirm the common nature of these two substances, by pointing out that in many cases (*dianthus caryophyllus* for one) the cells of the epidermis are quadrilateral, whilst those of the parenchyma are cylindrical tubes, of various lengths, perpendicular to the plan of the epidermis. But these vary in different plants, and are sometimes very singular. The difference in the figures of these cells may readily be seen without removing the epidermis, by only changing the focus of the microscope by a quantity equal to the thickness of the epidermis; they are thus presented alternately to the eye, and their want of correspondence made evident. The spaces which the varied dispositions of the parenchyma produces are filled with air; and they correspond with areas of an oval form in the epidermis, in the centre of which may be observed apertures, sometimes open and sometimes closed. In leaves of the *ranunculus repens* and *ruta graveolens*, the organ terminated by these orifices is a small bag or purse, which is opened or closed by a sphincter according to circumstances, not merely spontaneously in the living plant, but at the will of the observer. They are generally open in sun light, closed in darkness; large when the leaf is dry, narrow when it is moistened. In the *ruta graveolens*, when the pores are open, the parenchyma composed of a small green tubes may be seen, when closed the green disappears, and the orifices take an ash colour.

With regard to the functions of these pores, it is concluded, that they are not intended for absorption of water, because they close when moistened, and open to light and dry air; because roots and plants living under water have them not, floating leaves have them only on their upper surface; and because (with reference to rain and dew) they are more abundant on the under surface of leaves, than on the upper. That they are not intended for evaporation is assumed, because the plant being separated from the root they close, although evaporation still goes on. That they are not excretory organs, appears from their corresponding with cavities containing neither fluid nor solid matter. It is therefore concluded that they are intended for the passage of air, but whether for its entrance or exit is difficult to determine. At night when the large pores of the epidermis are closed, the leaves absorb the carbonic acid dissolved in the dew, whilst by day when they are open, the same leaves decompose the gas; hence, perhaps, they may be destined, M. Amici thinks, to the emission of the oxygen gas resulting from this decomposition; an opinion favoured by the remark of M. De Candolle, that the corolla which has no pores produces no oxygen.

Mode of Union in the vegetable Structure. - It has been a question whether the vessels of plants are all constructed of one continuous and single membrane, or whether each vessel has a complete

membrane of its own. M. Amici in examining this point has not only ascertained the latter to be the case, and shewn that the membrane between two vessels is in consequence always double, as well at the diaphragms as at the sides; but has shewn that they frequently are really separated, having curved surfaces and spaces between them: these intervals never contain any thing but air, and they put the existence of the *vasa revehentia* of Hedwig, and the *meatus intercellulares* of Link beyond doubt.

On the Air Vessels of Plants. - M. Amici considers every vessel or vacuity whatever may be its form, tubular or cellular, in which the microscope discovers orifices, or openings more or less long, as air vessels. This class comprehends the spiral vessels, the false trachæ, the porous tubes, the vessels with false partitions, those with small crowns, those with false cells, and a great variety of others. A recent section of a plant shews these vessels empty and dry, and very distinct from the fibrous vessels, and the cells containing their respective juices; and if the section be put under water, air is seen to issue from them.

There are cases when the elastic fluid in these vessels cannot have been obtained from the atmosphere, as in the *caulinea fragilis*, which grows under water. The author thinks it possible that the small crowns discovered in the interior of the sap vessels, may, perhaps, be the organs by which the air is in these cases separated from the water.

It is a constant law in the general system of vessels, that those which are fibrous surround those which are aëriform. In ligneous plants nature has substituted other channels for the intercellular passages found in the herbaceous plants, these are the medullary rays of which an example is offered by the hemp, which may be seen by three sections, one transverse, one down the axis of the plant, and a third parallel to it, but on one side. The *asclapias syriaca* offers a similar structure.

M. Amici believes that in all vegetables, water and their own fluids pass into the vessels through pores in their respective membranes, which the eye cannot discover, but which many facts prove to exist. He affirms the integrity of the vessels during the whole existence of the plant, and denies any change in their nature. As to the question whether the spirals of trachæ are themselves tubular, and conduct sap, he thinks it undeterminable until the optical means we possess, are such as to develop the structure of the vegetable membrane, for the dimensions of the spiral of the trachæ does not exceed the thickness of the membrane of the other tubes, in which as yet no one has found vessels containing fluids.