On the rise of the sap in the spring / Edwin Sidney.

Ino and Bacchus — Little Nell — Psyche, in Cheverton's Machine Sculpture. [Exhibited by W. T. Copeland, Esq.]

Partridge and Woodcock, worked in Leather, in imitation of Wood-Carving, by Mr. W. Sanders.

Portraits of John Dalrymple, Esq., F.R.S. and of Dr. Holland, F.R.S., by J. Z. Bell, Esq.

Mr. C. Varley exhibited several interesting objects by the Microscope.

WEEKLY EVENING MEETING,

38.

Friday, May 14.

Sir Charles Fellows, Vice-President, in the Chair.

The Rev. Edwin Sidney,

On the Rise of the Sap in the Spring.

After a few prefatory observations, the speaker divided the subject into four parts which he proposed to consider in order. 1. A short description of certain physical phenomena to be regarded as preparatory. 2. Their application to the known organism of vegetable structures. 3. The circumstances under which these organisms will be called into that activity which may be regarded as the proximate cause of the rise of the sap in the spring. 4. The diffusion of the sap through the plant. The inquiry was limited of course to plants of our own climate.

1. In directing attention to the first part of the subject, it was observed that vitality must not be disregarded. The *most* chemical and physical forces fail to explain all. Vital force is mysterious, it is true, but so are all forces. If there were not a living formative force superadded above dead physical forces, all the varieties of organized substances could not originate as they do from a simple vesicle. The phenomena now to be considered were those of capillarity and endosmosis. The former is greatly affected by temperature, and the imbibition due to it differs much in different liquids and solutions. Endosmosis is known as the phenomenon of the mixture of two liquids of unequal density through a membrane, accompanied by a change of volume. It is called endosmosis when the volume increases, exosmosis when it diminishes. It is generally, but not always, found that when the heavier liquid is above the lighter, mixture is accelerated by the interposition of the membrane. Other things equal, the force of the current varies as the excess of the density of the interior liquid proportional to water. A current with a pressure of several

atmospheres is producible by albumen. — There are those who regard capillarity and endosmosis as modifications of the same attractive force existing beween solids and liquids. But different conditions are required. Capillarity is a statical effect, and so differs from the double current of endosmosis and exosmosis.

2. In applying these phenomena to the vegetable organism, it was noticed that plants have no particular vessels carrying nutrient fluids, but their open tubular structure is a condition favorable to capillarity. Plants have ducts, and so called vessels ; but the latter, except at certain times, contain air, and are not in connection with the stomata. The fulness of the ducts is due to capillarity. The structure of plants is favourable to endosmosis : the life of a cell involves an act of it. It is promoted by the thickening of the cell contents due to evaporation and other causes, and new materials are furnished by the lighter fluids surrounding the cells. The fine extremities of the roots are in the condition of the interposed membrane, and thus we have conditions of endosmosis — a vessel with organic sides, an exterior liquid capable of being imbibed by this tissue, and an internal liquid also capable of being imbibed by this tissue, of mixing with the exterior liquid, and permeating the tissues. The force detected at the root appears throughout the system ; and it is obvious that the contiguity of the cells to each other is promotive of an interchange of contents by endosmosis. Juices may be collected from plants by boring ; and while the sap movements are active, the higher the bore the thicker the juice : and albumen, the fluid most forcible in endosmosis, is closely connected with proteine compounds found in developing cells. The more active the development, the denser the fluid ; insoluble starch is found in the cells when store is required, and when nutrition is active it is changed into gum, dextrine, and sugar. The nature of the cells, vessels, &c. spoken of was illustrated by diagrams.

3. In proceeding to the third point it was observed that the movements under present consideration were not rotations or mere movements of cell contents, nor could they be regarded as having any analogy with the circulation of animal fluids through arteries and veins. They are the movements by which nutrient fluids are conveyed to the organs of development. To aid in this conveyance two agencies appear, endosmosis and capillarity. If at any one time all the cells of a tissue contain a fluid of equal density, endosmosis takes place in those which come into immediate proximity to water, which dilutes their fluids and sets up the conditions of endosmosis between them and the next cells. Where evaporation is most active, there is the greatest concentration of sap; therefore the stream is towards the green parts and buds. The rise of the sap, generally, may be regarded as effected by the increased density of the fluids as they approach the seat of the evaporating process. Curious experiments by Mr. Lawes, which were detailed by the aid of drawings,

taught that for every grain of solid matter fixed in the plants tried when healthy, two hundred grains of water passed through by evaporation. Capillarity due to the ducts must also be taken into account in the rise of the sap. As regarded its rise in the spring, when the vigorous movement so well known takes place, a distinct explanation could be given. Here several experiments of Hales were mentioned as examples of ingenious method, but the true inferences could not be made at that time for want of knowledge. The quiescence in winter is due to the way in which evaporating surfaces are closed, and even sealed up, so that capillarity, which does not take place in sealed tubes, cannot act. The cells of buds are then filled with thin fluids. As spring advances, the thickening takes place under the influences of heat and moisture. Now we have the conditions of strong endosmosis. Development takes place, next comes evaporation, and capillarity acts. These two forces are therefore brought into full play, and the whole cellular chain is put into action from root to bud. In monocotyledons the upward course is through the most newly formed tissues, which are in the interior of the stem. In dicotyledons it passes along the last formed tissues of the wood, forming a pabulum for the cambium. All young tissues are permeable to the absorbed fluid, and whatever is formed of a soluble nature in one part of the plant, is conveyable to another. Thus a compound formed in the leaf may find its way to the stem and even the roots, which latter is most likely to take place in the autumn, and indeed goes to explain what is called root-action at that season.

4. The last point was the diffusion of the sap. This subject is at present by no means in a settled condition by reason of differences of opinion, and the influence which the long received views of a regular descent of sap, after elaboration in the leaves, still has upon many persons. There is, however, no proof whatever of the formation of ligneous tissues in the leaves, and the old theories of Duhamel and others are not to be maintained. Still it is not to be forgotten that it has already been shewn that compounds formed in the leaves may pass downwards, therefore the possibility of a descending sap remains, while there is no general demonstration of the fact. Ascent and diffusion may be regarded as sufficient to account for all the phenomena of growth. The old arguments in favour of a descending liber current in exogens, such as ringing the bark and grafting, are capable of other interpretations than those which they have received. A remarkable specimen of stock and graft was shewn, to prove that their growths were perfectly distinct, though nourished by a common food. If there were a descending bark sap, could this be so? The fact is, the new annual rings are formed out of a cell development of the cambium. To shew that the proper expression for the distribution of the sap is *diffusion*, an account was given, and drawings shewn, of some very remarkable experiments on a horse-chesnut, at Glassnevin near Dublin. They tended to prove that when the sap-flow from cell to cell was interrupted by the al-

burnum and cambium being cut across, it at once diverged laterally. There was nothing to indicate a vertical descent, but, on the contrary the current by endosmose took the directions indicated by circumstances. When also we consider the phenomena exhibited by cuttings of plants turned upside downwards, they indicate diffusion, according to the physical laws which have been considered, rather than such movements as have been so long attributed to currents of sap. If these facts be coupled with the proofs that may be given that the upward and downward channels so often taken for granted by vegetable physiologists have no ostensible existence, it must be allowed that the old theories, however fascinating, must give way, and the movements of the nutrient fluids be interpreted on sound principles. We shall be safe in speaking of the diffusion of these fluids as taking place according to the laws which have been demonstrated, and which must be considered as prevailing, not only as we know they do, in amorphous cellular masses, but in regularly organized structures.

The speaker concluded by apologizing for bringing this subject forward before such an audience, but his design was to excite to inquiry into the phenomena alluded to as amongst the most interesting that could occupy the attention. In the course of the evening there were also cited some experiments by the speaker on parts of plants in active growth with ozonometric tests, which manifested such actions as would consist with the idea that either ozone, or oxygen tending to act like ozone, was in some manner present at the places tested. If so, these phenomena might tend to throw new and important light on the chemistry of vegetable life.

[E. S.]

In the Library were exhibited: —

Casts of the Venus de Medicis, Venus of Melos, Apollo Belvedere, Laocoon, Dying Gladiator, Head of Jupiter, (reduced by Machinery). [Exhibited by R. Westmacott, Esq.]

The Theseus and Ilyssus, — Machine Sculpture, by Mr. Cheverton.

Bourdon's Metallic Barometer and Steam-Gauge, with enlarged models. [Exhibited by Mr. Dewrance.]

Model of Appold's Self-regulating Friction-break,— Labour-Machine for Prisons. [Exhibited by J. G. Appold, Esq., M.R.I.]

A New Instrument for Drawing Ellipses, by Dr. Roxburgh, M.R.I.

Crystals of Sulphate of Quinidin; and Specimens of Cast Iron, Ancient and Modern. [Exhibited by T. N. R. Morson, Esq., M.R.I.]

Photograph Portrait of Biot by M. Regnault. [Exhibited by Mr. Faraday.]