DEMONSTRATION OF THE MOVEMENT OF THE WATER IN LEAVES.

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(Abstract.)

A brief statement of the present state of knowledge of transpiration in plants will furnish an appropriate setting for the demonstration of the moving stream of water as it traverses the veins of leaves. We have not seen a clearer statement than that of Dr. C. R. Barnes in his admirable "Physiology of Plants,"* from which we quote as follows:

"The ultimate cause of the ascent of sap is transpiration; but how it acts is entirely unknown."

"The evidence that the xylem is the path of the transpiration stream rests in part upon direct observation, but mainly upon inference from the effects of cutting the xylem strands or blocking the tracheae."

"It is fairly certain that the transpiration stream traverses the xylem strands and that it is the lumina of the tracheae that form the conduits for the water."

"The xylem strands form a connected series, extending from the root-hair region to the mesophyll of the leaves, among which they branch so extensively that there is scarcely a cell which is separated from a strand by more than a half dozen of its neighbors. Here the first branches end blindly or join their fellows."

It is my purpose to demonstrate briefly a method which I have recently developed for making visible to the eye, either without or with the aid of magnification, the actual movement of the transpiration stream along the xylem strands of live leaves. My investigation was undertaken in the hope that my students might see the movement of the sap when demonstrated with a projection microscope or by direct observation. The use of translucent plant stems and modified leaves gave negative or unsatisfactory

*Text Book of Botany, (Coulter, Barnes and Cowles) pp. 351, 347, 348, 342 and 343.

results, but led to experiments with normal green leaves in which the veins and veinlets appear white when seen by transmitted light. Positive results have been obtained with leaves of bean, corn, barley, turnip, lettuce, Easter lily, Chinese sacred lily, freesia, and lilac. Leaves of corn and barley grown in the laboratory are preferred for use by students in simple demonstrations and also for projection experiments. For study under the compound microscope leaves of the bean and lilac are preferred.

The rate of movement in the veins varies greatly, but, in general, appears to be more rapid than has been observed in stems. I have repeatedly noted a rate of 30 mm. in fifteen seconds, but the maximum rate observed by my students seems to be considerably faster. These measurements were made by direct observation. For observing the phenomenon as it is related to the lumen and walls of the tracheae it is necessary to use the compound microscope with a power as high, at least, as a quarter inch objective and one inch ocular. It is possible to identify the tracheae in the smaller xylem strands and note the normal conditions of the lumen and wall and a moment later observe the movement of the colored liquid through the lumen of the cell.

Troublesome conditions are met with in the manipulation of the leaves under the compound and projection microscopes. New forms of apparatus, devised by the author, for the control of these conditions are not yet sufficiently perfected for publication but will be included in a report of further researches.

The laboratory demonstration included, first, the methods of preparation of the leaves for direct observation with the eye alone or aided by a hand magnifier and, second, the exhibition and description of a special cell for use in projecting the moving stream, the method of mounting a leaf in this cell and the demonstration of the movement by projection on a screen.

The first method, as used by students in the biological laboratory of the Chicago Teachers' College was worked out and the specimens passed to members of the Academy. The leaves used were from barley plants from six to ten inches high, grown in the biological laboratory of the college. A few drops of a strong aqueous solution of eosin were placed in either a small homeopathic vial or in a watch glass. A leaf was cut, with a sharp knife, at a right angle to its length and at a half inch or more from its attachment to the stem. The cut end was immediately placed in the solution of eosin and the specimen held between the eye and any strong light. The upward movement of the red liquid began at once and continued until the veins were colored to their tips at the apex of the leaf.

In the second method of demonstration by projecting the prepared leaf on a screen a special glass and metal cell was used. This cell is so constructed that it does not interfere with the normal activity in the loaf, but keeps the leaf flattened under the objective, prevents the upward flow of the eosin solution on the surface of the leaf next to the glass, and permits any necessary movements for accurate adjustments on the stage of the projection microscope. As a large field and low magnification are desirable conditions in this demonstration, a regular lantern slide projection apparatus was used as a low power projection microscope.[1] A vertical glass plate was attached to the slide stage which was then moved away from the condenser lenses a few inches and the lamp was so adjusted that the light was focused on the vertical glass plate. The quarter size projection lens was moved to such a point that it projected on the screen a clear picture of an object held against the vertical glass plate which was, in effect, the stage of the projection microscope. A cooling tank of distilled water was placed between the condenser lenses and the glass stage to prevent undue heating of the leaf. A drop or two of water was then put into the special cell. A barley leaf, cut as described above, was placed in it, the cell placed on the glass plate and the transparent veins of the leaf sharply focused on the screen. The normal colors of the leaf having been seen, a few drops of strong eosin solution were added to the water in the cell and the movement of the colored liquid along the veins was immediately visible as far as to the rear of the room or forty feet from the screen.

[1]Cole's Manual of Biological Projection and Anasthesia of Animals, p. 38.