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SCIENCE AND SOCIAL PIONEERING[1]

By Dr. ISAIAH BOWMAN

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THE classic tale has man witless until he receives the Promethean gift of fire. Light and fire are the age-old symbols of the mystery of the creative force in man or of what some would call the divine beginnings of man's discovery of a forward way. We talk less of mystery to-day for, if the source of the light of understanding is still unknown, man himself has successfully trimmed the wick. Reflected, dispersed and recombined from thousands of mental and spiritual facets, the light reveals ever-new possibilities of adventure, experiment and stimulating insight for the self-conscious creature, half angel, half brute, who talks endlessly about his elusive destiny. Whatever their own genius may be, all thoughtful persons borrow or reflect enlightening fact wherever they find it, and observe with alternating hope and anxiety the endless search by other men for that object of faith and labor called progress.

[1] The first British and American Association Lecture, Dundee meeting, 1939.

Reflecting in this fashion, it seemed to me presumptuous to express only my limited individual opinion in this opening address in an annual exchange between the British and the American Associations for the Advancement of Science. It seemed better to inquire of others what they would choose to say. Because scientists are apt to praise the children of their brains, the views of non-scientists were sought on the contribution of science to social welfare and to that uniquely human process of consciously planned advance across the threshold of experience which we may call social pioneering.

To that end I invited one hundred men who are not engaged in either physical or biological research or teaching to express their opinions. For special reaor structure of plant cells but upon the properties of water.

In the dissection experiments made by the author, both intact and cut stems of plants growing in soil tubes were studied under the dissecting binocular. When a stem with tensile sap columns is cut, air immediately enters all the severed vessels, and the liquid columns recede from the cut end. However, if the deficit is not excessive, menisci in the smaller vessels soon reverse their movement, and these tubes are refilled. Meanwhile liquid in the large vessels continues to recede, supplying water for the refilling ones as well as that lost by transpiration. As expected from laws of capillarity, competition for water by various-sized tubes results in readjustment, the larger vessels losing and the smaller gaining. As the larger ones become depleted, successively smaller elements lose their contents until finally all conductors are sucked dry. During the various stages of readjustment, and particularly immediately following cutting, columns of sap, water vapor and air may be seen moving in opposite directions in the xylem—a fact that seems clear in terms of capillary action, yet one that has confused many students of translocation.

As might further be predicted, when tensile sap columns in intact xylem vessels are jarred or deformed by flattening the elements with a rounded instrument, they break and the vapor columns expand until they reach the limits of the elements in which they are formed, or until the pressure rises somewhat above the zero point. This proves the tensile state of the water columns, for the vapor phase would not continue to expand if the pressure was above that of saturated water vapor at the temperature of the experiment. As in the cut stem, if vapor is formed in several vessels and the stem is not further disturbed readjustment follows with the vapor columns in the smaller elements contracting and those in the larger continuing to expand. That the columns are water vapor and not air is proved by their rapid collapse under increased pressure. The forcing of air into solution by the surface forces of the bubble would require much more time, as is proved by similar tests with the Askenasy apparatus.

Though the above experiments provide satisfactory evidence of the existence and characteristics of tensile sap columns in plants, the old experiment on subaqueous transpiration performed by Dixon in 1897 has never been explained on a purely physical basis. As recently reported,[5] Smith, Dustman and Shull[6] failed to account for this phenomenon, for Dixon was able to obtain a rise of eosin after saturating his test shoots by immersion for twenty-four hours.

[5] H. H. Dixon, *Bot. School of Trinity Coll., Dublin, Notes*, 4: 319, 1938.

[6] F. Smith, R. B. Dustman and C. A. Shull, *Bot. Gaz.*, 91: 395, 1931.

The fact, recently confirmed by the writer, that subaqueous transpiration occurs only in the light suggested the following explanation: The pressure flow mechanism of solute transport in the phloem requires the osmotic absorption of water from the xylem in regions of active synthesis. Assimilates in solution move to regions of utilization where water is lost to the xylem or to expanding tissues.

Though a recirculation of water in the xylem will not explain the rise of eosin in subaqueous water movements, there are other places that the water might go. All growing cells of the cambium or expanding leaves of the shoot tips require water. Some liquid might also be lost to the intercellular spaces of leaves which often show a partial flooding. Uptake of water from the xylem would in all cases be a function of phloem activity rather than a secretory process of mesophyl cells as originally suggested by Dixon.

To substantiate these deductions, the writer has recently shown that when experiments on subaqueous water movement are set up using forked branches of *Syringa vulgaris,* ringing one of the branches will favor eosin movement up the unringed branch, especially if there is an appreciable portion of bare stem below the fork to provide an adequate differential of living tissue to consume the moving assimilates. These results indicate that the rise of sap in the non-living conduits of the xylem can be accounted for on purely physical grounds, and they explain the single exception made by Dixon to this assumption. On the other hand, they reemphasize the complexity of the over-all processes of translocation and point out the essential part played by living cells and tissues.

A. S. CRAFTS

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BOOKS RECEIVED

ADRIANCE, GUY W. and FRED R. BRISON. *Propagation of Horticultural Plants.* Pp. ix + 314. 182 figures. McGraw-Hill. $3.00.

ENGELDER, CARL J. *Calculations of Quantitative Analysis.* Pp. viii + 174. Wiley. $2.00.

HALL, WILBUR, Editor. *Partner of Nature.* By LUTHER BURBANK. Pp. xi + 315. Illustrated. Appleton-Century. $3.00.

KAGAN, SOLOMON R. *Life and Letters of Fielding H. Garrison.* Pp. xvi + 287. Illustrated. Medico-Historical Press, Boston.

LEVY, HYMAN. *Modern Science; A Study of Physical Science in the World To-day.* Pp. x + 736. 160 figures. Knopf. $5.00.

METCALF, C. L. and W. P. FLINT. *Destructive and Useful Insects; Their Habits and Control.* Second edition. Pp. xvi + 981. 584 figures. McGraw-Hill. $7.50.

PELTIER, GEORGE L., CARL E. GEORGI and LAWRENCE F. LINDGREN. *Laboratory Manual for General Bacteriology.* Second edition. Pp. viii + 275. Illustrated. Wiley.

TUCKER, S. MARION. *Public Speaking for Technical Men.* Pp. xv + 397. McGraw-Hill. $3.00.

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