PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

The Transpiration Stream: Introduction

T. A. Mansfield, W. J. Davies and R. A. Leigh

Phil. Trans. R. Soc. Lond. B 1993 **341**, 3-4
doi: 10.1098/rstb.1993.0085

The transpiration stream: introduction

T. A. MANSFIELD[1], W. J. DAVIES[1] AND R. A. LEIGH[2]

[1]*Institute of Environmental and Biological Sciences, Division of Biological Sciences, Lancaster University, Lancaster LA1 4YQ, U.K.*
[2]*Biochemistry and Physiology Department, AFRC Institute of Arable Crops Research, Rothamsted Experimental Station, Harpenden, Hertfordshire AL5 2JQ, U.K.*

An inevitable consequence of their assimilation of carbon dioxide is the loss of water from aerial parts of plants. Leaves have a very low water content compared with the rate at which water can be lost into dry air. If they are to avoid damaging water deficits, which can develop within a few minutes, they must not only have a way of controlling water loss, but also have a means of ensuring rapid replacement of any water that is lost. The existence of tall land plants became possible only after a vascular system evolved which permitted rapid conduction of sufficient water from roots to shoots.

Stephen Hales in *Essays in vegetable statics* in 1727 first proved experimentally that the ascending transpiration stream flows through the woody part of the stem. Figure 1 is a copy of Hales' own illustration for which Strasburger *et al.* (1903) offered this explanation:

> At *Z* in the branch *b* all the tissues external to the slender wood have been removed. Since the leaves of this branch remain as fresh as those of the branch *c*, it is evident that the transpiration current must pass through the wood and not through the cortical tissues. On the other hand, when a short length of the wood is removed from a stem, without at the same time unduly destroying the continuity of the bark, the leaves above the point of removal will droop as quickly as a twig cut off from the stem.

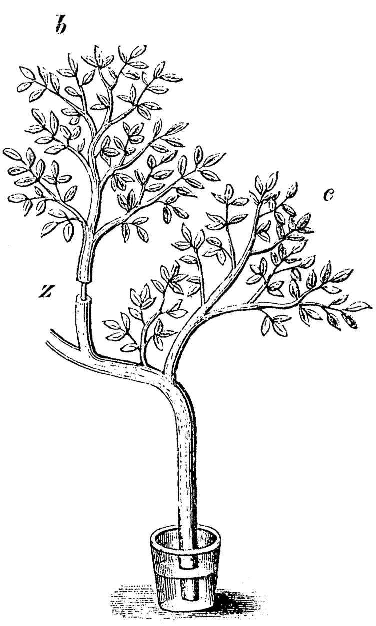

Figure 1. Hales' experiment (1727) showing that the ascent of sap occurs in the woody part of the stem. See text for explanation.

Almost a century ago, Dixon and Joly put forward the well-known and generally accepted Cohesion Theory, and illustrations like that in figure 2 became a familiar sight in textbooks of plant physiology. Since that time the upward movement of water in plants and the transport of inorganic and organic substances with that water have generally been regarded as relatively

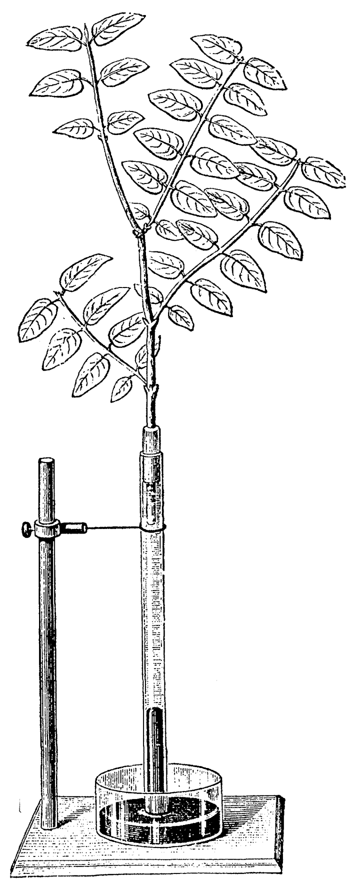

Figure 2. Demonstration of the suction created by a transpiring shoot. The shoot is fitted with an airtight seal in a glass tube filled with water, and the lower end of the tube is immersed in mercury, which is pulled up the tube when the shoot transpires. From Strasburger *et al.* (1903).

Phil. Trans. R. Soc. Lond. B (1993) **341,** 3–4
Printed in Great Britain

simple, uncomplicated processes and they have only received spasmodic attention by plant physiologists for most of the 20th century. In the past few years, however, new information has begun to emerge suggesting that the transpiration stream, and the dissolved substances distributed by it, are worthy of much more detailed consideration.

The rapid advances in molecular biology that have taken place recently have led to radical changes in experimental methods and have opened up many new areas of investigation. At the same time, however, a much quieter and little heralded, but equally important, revolution has been taking place in traditional areas of plant physiology. This has been fuelled in the main by the advent of new analytical and exploratory techniques.

The ten papers making up this collection demonstrate that our understanding of the transpiration stream is far from complete, and that some areas which have only rarely been reconsidered during many decades, because we thought our knowledge was secure, must now be examined again. Even the simplest version of the Cohesion Theory itself is under challenge in one contribution.

We have not hesitated to include controversial and iconoclastic material. The main objective has been to demonstrate that the availability of new techniques has reopened several areas of exploration for plant physiologists, and has exposed the weakness and insecurity of many of our cherished notions.

REFERENCE

Strasburger, E., Noll, F., Schenck, H. & Schimper, A.F.W. 1903 *A text-book of botany*, 2nd English edn. London: Macmillan.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES