Changes in Bark Thickness During Sap Flow in Sugar Maples[1]

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The phenomenon of sap flow in sugar maple, *Acer saccharophorum* Koch (*Acer saccharum* Marsh), and other species has been the subject of investigation for many years (*4, 7, 6, 3*). Burstrom and Krogh (*1*) have added valuable observations on *Carpinus.*

TABLE 1

Date	Time	Air temp. (°C)	Exp. 1 Changes in bark thickness (μ) Avg. 14 trees	Xylem temp. (°C)	Exp. 2 Changes in bark thickness (μ) Avg. 2 trees	Exp. 2 Changes in xylem diameter (μ) Avg. 2 trees	Exp. 2 Change in 10 mm of xylem diameter (μ) Avg. 2 trees
4/3	10 : 30 a.m.	− 3		+ 7			
					+ 30	− 64	− 1.39
	3 : 15 p.m.	− 3		+ 4			
			− 63		− 88	− 16	− .35
4/4	5 : 45 a.m.	− 6		− 1			
			+ 72		+ 82	+ 55	+ 1.20
	12 : 15 p.m.	+ 7		+ 1			
			− 3		+ 7	+ 11	+ .24
4/5	6 : 00 a.m.	+ 8		+ 2			
			− 9		− 6	+ 2	+ .04
	1 : 40 p.m.	+ 19		+ 6			
			+ 8		+ 6	− 37	− .80
4/6	4 : 45 p.m.	+ 12		+ 11			
			− 1		+ 5	− 7	− .15
4/7	6 : 00 a.m.	+ 2		+ 10			
			− 2		− 16	+ 36	+ .78
	3 : 45 p.m.	+ 15		+ 9			
			+ 4		+ 5	+ 1	+ .02
4/8	3 : 15 p.m.	+ 14		+ 11			
			+ 1		− 5	− 6	− .13
4/9	2 : 45 p.m.	− 2		+ 9			
			− 83		− 87	− 20	− .43
4/10	5 : 45 a.m.	− 8		+ 5			
			+ 80		+ 89	+ 36	+ .78
	2 : 45 p.m.	+ 2		+ 3			
			− 48		− 40	− 26	− .56
4/11	6 : 00 a.m.	− 2		+ 3			
			+ 48		+ 35	+ 31	+ .67
	12 : 00 noon	+ 4		+ 2			
			+ 25		+ 52	+ 5	+ .11
4/12	9 : 00 a.m.	+ 11		+ 5			
			± 0		− 21	− 16	− .35
	5 : 00 p m.	+ 12		+ 8			
			− 1		− 9	− 9	− .20
4/13	2 : 00 p.m.	+ 11		+ 7			

No completely satisfactory explanation of the mechanism responsible for the transitory xylem pressure and sap flow has been suggested. Stevens and Eggert show that excised red maple stems when supplied with water and allowed to freeze and thaw in nature produce a flow of sap, which demonstrates that roots are not essential for a xylem pressure. They also suggest that xylem pressures are the result of the change in state from ice to a liquid solution of the vessel sap. Johnson is of the opinion that respiration rate changes produce the pressure and that oxygen tension in the tissues is of great importance. Burstrom regards an osmotic mechanism involving the living cells in the xylem and the contents of the xylem vessels as the best explanation for bleeding in *Carpinus.* Wiegand, in a theoretical exposition three decades earlier, considered several possible mechanisms. He concluded that, as a result of temperature changes in the stem, an osmotic gradient occurred between the contents of the xylem vessels and the adjacent living cells. Thus, water or a solution moved into the vessels and created a pressure.

In experiments designed to study the tissues that are active in the flow mechanism, it was found that when the tissues exterior to the xylem were removed no flow occurred. To investigate the physical changes in the bark, further studies were made in the field on mature trees during the spring of 1948. The results of these field observations are reported here.

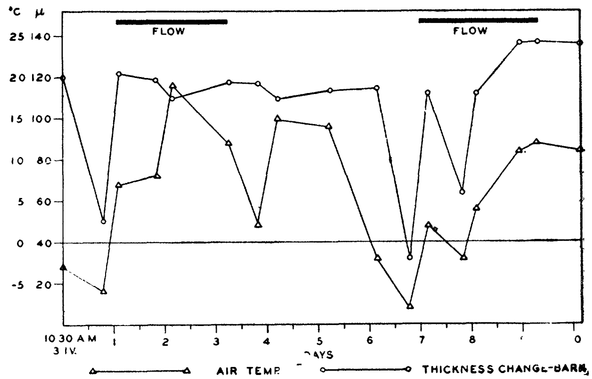

FIG. 1. Air temperatures and the changes in bark thickness. The changes are the average for the 14 trees measured.

Air temperatures were recorded, and the changes in bark thickness measured with a micrometer during and between periods of flow after the technique of Reineke (*5*) and Daubenmire (*2*). Screws were inserted into the wood through holes in the bark and measurements were made between the heads of the screws and the surface of the bark; in this way changes in bark thickness rather than the bark thickness were recorded. These observations were made four feet above the ground on nearly mature trees. Changes in air temperature affected the micrometer and corrections were then made for these changes. Table 1 (experiment 1) and Fig. 1 show the changes in bark thickness which occurred between two successive measurements of 14 trees during two freezing periods and for the four-day period of high temperatures between freezes. During the cooling and freezing part of the diurnal temperature cycle as observed in the field, the bark decreased in thickness. A warm temperature fol-

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lowing the freeze was accompanied by a rapid increase in bark thickness of about the same magnitude as the previous decrease. For example, between 2: 45 p.m., April 9, and 5: 45 a.m., April 10, a freeze occurred, and the difference between the readings of the bark thickness for those two observations was $-83\,\mu$. Between 5: 45 a.m., and 2: 45 p.m. April 10 a thaw occurred, and the bark increased $+80\,\mu$. During the flow period there was some decrease in bark thickness. Changes also occurred during the period of elevated temperatures, but none of great magnitude occurred until the stem again froze.

To correlate changes in bark thickness with those in the xylem, changes in the diameter of the xylem cylinder were measured. A hole was drilled through the stem and

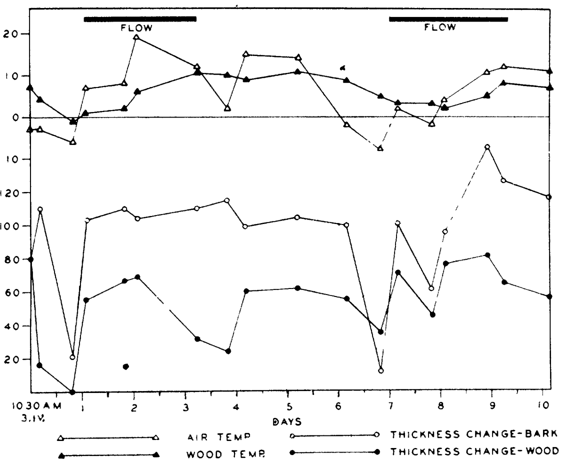

FIG. 2. The lower graph illustrates the changes in thickness of the bark and the xylem cylinder for the 2 trees measured. The upper graph illustrates air temperature and wood temperature for the same period.

an invar steel rod of a length equal to the tree's diameter was placed in the hole. The rod was fastened to the xylem on one side of the tree and the measurements were made between the end of the rod and the surface of the xylem cylinder on the other side of the tree. Corrections were made for thermal changes in the length of the rod. The observed changes in bark thickness, wood thickness, and wood temperature are illustrated in the table (experiment 2) Fig. 2. The changes observed are comparable to those found in experiment 1.

The xylem cylinder also changed in diameter at the time the changes occurred in the bark, and the change was in the same direction as that observed for the bark (see experiment 2). The magnitude of the change in the xylem is quite different from that of the bark. The bark changes were measured for a thickness of about 1 cm; the changes for the xylem, for a xylem cylinder 46 cm in diameter. Thus, the change recorded for the wood for any period should be multiplied by .022 to compare the two tissues on a unit of thickness basis. For example, between 5: 45 a.m. and 12: 15 p.m. on April 4 the bark increased 82 μ in diameter, and the xylem cylinder 55 μ in diameter. However, 1 cm of the xylem diameter increased only 1.20 μ; thus, the change recorded for the wood per unit of thickness was much less than that of the bark. A detailed analysis of the factors responsible for these changes is in progress.

The present observations which show that flow is preceded by a transient decrease in bark thickness induced by a transient freezing ambient temperature indicates that the bark must at least be considered in a discussion of the mechanism of sap flow.

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The Effect of Water Diuresis on Renal Plasma Flow[1]

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The effect of water diuresis on renal plasma flow in the human being has never been clearly defined. The subject has, however, been studied in various laboratory animals. Dicker and Heller (*3*), working with rats and rabbits, found that in the former species water diuresis had little or no effect on glomerular filtration rate or renal plasma flow; in the latter species both clearances rose as urine flow increased. The authors did not extend their studies to the human subject.

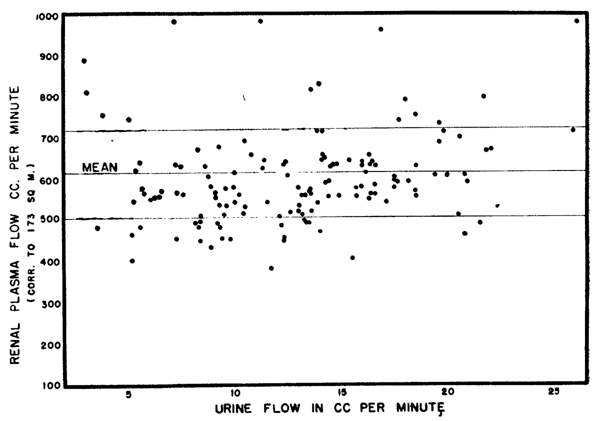

FIG. 1. Renal plasma flow at various rates of urine flow. Each dot represents a separate clearance period.

In devising a technique for the study of renal plasma flow in the human subject during exercise (*1*) we found it desirable to institute moderate water diuresis in order

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