

Transport of Nitrogen in the Plant.

THE general question of translocation in plants demands attention, not only because of its practical importance in horticulture, but perhaps even more so because of its intensely controversial nature. Recent work on the translocation of carbohydrates in the cotton plant, by T. G. Mason and E. J. Maskell, has already been reviewed in NATURE (123, pp. 133-135; 1929). Maskell and Mason have extended their work to the translocation of nitrogen. This work, which appears as *Memoir 2, Series B* (1930), from the Cotton Research Station, Trinidad, is as valuable a contribution to the literature of nitrogen metabolism as to that of translocation.

The experimental technique is very similar to that adopted in the work on carbohydrates; indeed, in many cases, the nitrogen analyses were made on samples which had already yielded some of the data in the earlier papers. As before, the procedure involves various ingenious combinations of ringing, partial ringing, defoliation, etc., and a rather extensive statistical analysis of analytical data obtained for the various nitrogenous fractions. It is interesting to reflect that Malpighi ringed stems in the late seventeenth century, and at least so early as 1731 such practices as ringing, partial ringing, defoliation, etc., were the staple procedures in the attempt to elucidate the "circulation or non-circulation of the sap". Stephen Hales in his "Vegetable Staticks" describes experiments in which the experimental detail seems startlingly modern. However, in his preface he found it necessary to enlighten at length those of his readers "who complain that they do not understand the signification of those short signs or characters (+; -; ×; =) which are here made use of in many of the calculations, and which are usual in Algebra". Whilst two hundred years cannot be said to have produced very outstanding modifications in experimental technique, beyond the adoption of modern analytical methods instead of fragmentary observations on growth, leaf fall, colour, etc., one can see a vast change in the method of interpreting results. Maskell and Mason make very full use of statistical methods, and apparently place a greater confidence in their readers' mathematical comprehension.

Part 1 of the paper now before us, containing observations on the downward movement of nitrogen in the stem, consists of experiments designed to test the idea that the leaf is the principal seat of protein synthesis, and its greater claim than other organs for inorganic nitrogen rests on its 'transpiration pull'. Chibnall's contention that there are diurnal changes in nitrogen (total) content of the leaf is confirmed by Maskell and Mason for the cotton plant. They find the nitrogen content higher by day than by night. Though evidence for similar changes in the bark is not so conclusive, the tentative suggestion is made that the leaf changes lead to similar concentration changes in the bark which lag somewhat behind those of the leaf. The effects of ringing on nitrogen movements are interesting relative to Curtis's suggestion that nitrogen (organic and inorganic) moves not in the xylem but in the phloem. Maskell and Mason complete their experiment 24 hours after ringing. They find that the nitrogen content of the leaf samples (3 leaves from near the apex of each of 10 plants) from ringed and normal unringed groups show normal diurnal changes and are practically identical. It is concluded that ringing has not interrupted nitrate movement, which is therefore in the wood.

This view, however, assumes that a redistribution of nitrogen between the leaves above the ring may

be neglected. It is worthy of note that the sampled region is that most vigorously growing, and the possibility remains that it has drawn nitrogen, via the bark, from the lower leaves above the ring. This would be more possible in a short time experiment like the one described. Sampling of the entire leaf and stem above the ring clearly offers (in the cotton plant) considerable mechanical difficulties. The wood and bark of the ringed plants above the ring (seven inches sampled) show a significant increase in total nitrogen content, and similar samples below show a decrease. This is in harmony with the view that ringing prevents downward movement in the stem, though not that from leaf to bark. It does not necessarily indicate that there has been an upward movement of inorganic nitrogen in the wood past the ring. Curtis previously claimed (*Amer. Jour. Bot.*, 1923) that leaves of ringed twigs of lilac, privet, etc., increased in nitrogen content much less than corresponding ones of unringed plants. Maskell and Mason reinterpret one of Curtis's experiments to support the view that leaves above a ring import nitrate via the wood and export organic nitrogen via the bark. However, in the absence of data that an actual increase of total nitrogen had occurred above the ring, such an interpretation is inconclusive. Since it is known that transfer of nitrogen from one lateral branch to another does not readily take place (*Auchter Agric. Expt. Stat., Univ. of Maryland, Bull.* 257, 1923), it is improbable that the twigs in question imported organic nitrogen from the rest of the plant.

The possibility remains, therefore, that the nitrogen entering the defoliated region of stem above a ring came from the young, active leaves above it (4 pairs), whilst that entering a similar region below a ring came only from the basal leaves on that same twig (probably not more than 4 or 5 pairs), which were older, less active in protein synthesis (August), and in competition with younger leaves on other shoots for the nitrate application to the soil. Hence the seeming inconsistency referred to by Maskell and Mason, that four pairs of leaves above a ring supply to a defoliated region of stem 70 per cent as much nitrogen as the rest of the plant to a similar region below a ring, may be more apparent than real. In view of their repetition of the criticism that Curtis's results were due to transpiration effects caused by blocking of the xylem, one is reminded of the claim (*Ann. Bot.*, 1925) that complete cutting of the xylem, leaving the phloem intact, has a smaller effect on upward translocation than the reverse procedure. In another connexion Mason and Maskell have suggested, whilst admitting the significance of some of these results, the contradictory view that the superiority of the cut xylem group may be due to a few xylem elements regenerated in six days on the inner bark, whilst the inferiority of the cut phloem group may be due to plugging of the xylem. Surely if a few regenerated xylem elements are adequate, the xylem of the cut phloem group would have to be plugged to an inconceivable degree.

All this indicates the difficulty of interpreting the apparently simple ringing experiments. Many will regard the upward path of inorganic nutrients as still open to question. If Maskell and Mason are right in their contention that inorganic nitrogen moves with the transpiration stream, one is left with the curious situation that one simple solute (cane sugar) moves upward and downward in the phloem and another (inorganic nitrate) moves apparently with the water. Experiments on downward movement of nitrogen in the bark with a restricted channel of transport show that the rate per unit area increases as the available

area decreases. As suggested in the case of sugars, this is suggestive of a movement analogous to diffusion.

Part 2 of Messrs. Maskell and Mason's paper consists of observations on concentration gradients in relation to nitrogen movement. The previous work on sugar movement in the bark by the same authors showed that it was always from a region of high to one of low concentration. No such relation could be found for downward movement of nitrogen in the bark, which proceeds against a well-defined negative gradient of total and crystalloid nitrogen. All attempts to distinguish between mobile and storage forms by fractionation of the total nitrogen fail to reveal a well-defined positive gradient of any nitrogen fraction in the direction of movement, unless this be the rather elusive residual or unfractionated nitrogen. Sub-division of the bark into inner and outer zones disproved the possibility that positive and negative gradients in the different regions mask each other.

Part 3 of the paper under notice consists of an attack on the problem of movement in relation to concentration gradients by determining the change in existing nitrogen gradients caused by stoppage and reversal of nitrogen movement. The desired conditions were obtained by suitable combinations

of ringing and defoliation. Unlike the situation in the case of the sugars, zero nitrogen movement is associated not with zero gradient but with a well-defined negative gradient of protein and crystalloid nitrogen. When downward movement of nitrogen is still proceeding, the negative gradient of total and crystalloid nitrogen is smaller than when movement has ceased: that is, the change from zero movement to downward movement is associated with the production of a positive gradient superimposed upon the existing negative gradient. This superimposed gradient is termed the dynamic gradient. An algebraical method of estimating the dynamic gradient, assuming a relatively constant storage gradient, is described. It is estimated that the degree of acceleration over diffusion previously found for sugars would suffice to account for the actual nitrogen movement with the observed concentration gradients (dynamic) of total nitrogen, protein nitrogen, and amino acid nitrogen. The localisation of the dynamic gradient largely in the inner bark suggests its association with the sieve tubes. It appears that the accelerating mechanism presumably associated with the sieve tubes acts impartially on sugar and nitrogen compounds.

F. C. S.

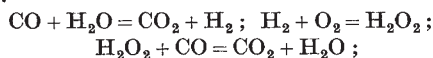
Influence of Steam on the Combustion of Carbonic Oxide.

PROF. W. A. BONE, who delivered the third Liversidge Lecture before the Chemical Society on Dec. 11, chose for his subject "Fifty Years' Experimental Research upon the Influence of Steam on the Combustion of Carbonic Oxide (1880-1930)". Commencing with the late Prof. H. B. Dixon's abandonment of classics for science in 1876, Prof. Bone referred to his repetition of Bunsen's work and his observation (communicated to the British Association at Swansea in 1880) that a mixture of carbon monoxide and oxygen, if dried at the ordinary pressure over phosphorus pentoxide, becomes non-explosive when sparked in the usual way. Examination of the effect of various third substances led him to adopt the view that the action of moisture is chemical and due to the hydrogen contained in it, the pure, dry reactants being mutually inert. Moreover, the speed of flame propagation had a minimum value in the dried mixture and a maximum value in the presence of nearly 6 per cent of moisture.

The investigation was extended in 1884 by Prof. H. B. Baker, who showed that, in dry oxygen, carbon burns essentially to carbon monoxide. Prof. Bone explained the precautions necessary in such experiments, and mentioned Morley's work in 1887 and 1904; long contact of a gas with phosphorus pentoxide is unnecessary, but there is considerable difficulty in drying the surface of the containing vessel. Continuing, he referred to Traube's observations (1885) that the flame of dry carbon monoxide is extinguished by plunging it into dry air, and that when the carbon monoxide flame is directed on to ice, hydrogen peroxide may be detected; hence the scheme



was proposed. Mendeléeff, however, preferred the series:



and Prof. H. E. Armstrong regarded the case as one of 'reversed electrolysis'. Lothar Meyer in 1886 showed that dry, 'non-explosive' carbon monoxide and oxygen could be caused to combine non-explosively by means of a powerful discharge, indicating that direct oxidation requires a higher temperature than indirect. Beketoff postulated the necessity for the presence of oxygen atoms, which were pro-

vided by steam more readily than by oxygen molecules themselves.

Dixon's experiments in 1886 showed that in the combustion of dry cyanogen with excess of oxygen, carbon dioxide is always formed to completion, the monoxide being produced intermediately. Smithells and Dent, using the flame separator, found that the outer cone of the dry cyanogen flame will burn in air dried by sulphuric acid only if the cones are not widely separated, showing that the length of life of the carbon monoxide is a determining factor. It was confirmed in 1896 by Dixon, Strange, and Graham that the carbon monoxide, freshly formed in a dry cyanogen explosion, will combine directly with excess of oxygen in the rear of the flame front.

Dixon discounted the conclusions of Mendeléeff and of Beketoff by showing that a dry mixture of carbon monoxide and nitrous oxide does not explode when sparked, and that dry mixtures of carbon monoxide and oxygen, whether exposed to X-rays or mixed with ozone or chlorine dioxide, are equally insensitive. In 1903 Girvan demonstrated that for a given sparking device a certain degree of desiccation is necessary to prevent explosion; while in 1914 Prof. W. M. Thornton found that for given sparking conditions the igniting current for a given medium has a minimum value.

Bone and Weston (1925) studied the minimum discharge necessary to ignite a mixture of two volumes of carbon monoxide and one volume of oxygen under different conditions of water content, and obtained a hyperbolic curve. Moreover, such a mixture, completely dried in 250 days, would withstand moderate, but not heavy, discharges. The influence of hydrogen on the carbon monoxide flame had also been examined. When much is added the characteristic appearance of the flame vanishes. In the ordinary flame of carbon monoxide in oxygen direct and indirect oxidation proceed simultaneously; so-called 'steam lines' in the spectrum may be eliminated by increasing the pressure as well as by drying. A dry carbon monoxide-oxygen mixture which failed to remain in combustion was reignited while a tension of 80,000 volts was maintained between two ring electrodes 30 cm. apart in the tube. The flame slowly reached the electrodes, suddenly accelerated, and became like that of an undried mixture.