TREE PHYSIOLOGY

THE physiology of forest trees has long been a neglected subject, partly due, no doubt, to the special difficulties of size and slow development which trees present to the experimenter. Nevertheless, there is evidence that interest in this field is rapidly gaining momentum. What is believed to have been the first major symposium on tree physiology was held at Harvard Forest, Petersham, Massachusetts, during April 8–12, under the sponsorship of the Maria Moors Cabot Foundation. The meeting was attended by physiologists and research workers from the United States, various Commonwealth countries and Europe.

Much of the classical work on tree physiology was concerned with water relations, and it is clear from a number of the papers at the meeting that this is still an active field of work. Prof. P. F. Scholander, of the University of Oslo, critically examined the cohesion theory of the ascent of sap. In the past, one of the major difficulties for this theory has been the fact that water uptake continues even when the water columns in the wood are broken by air 'embolism'. Evidence was presented showing that, in the grape-vine, air entering severed vessels apparently does not spread beyond these vessels, and in the region of the cut sap flow is maintained in the interstices between the vessels. The patterns and rates of moisture movement in trees of various species were dealt with by Dr. K. N. H. Greenidge. A detailed study of seasonal changes in the water-contents of the wood and bark of a large number of species by Prof. R. D. Gibbs (McGill University, Montreal) showed that several distinct seasonal patterns may be recognized in hardwoods, and in many cases similarities in these patterns followed the taxonomic relationships of the species. The mechanism of maple sap flow has long puzzled plant physiologists, and a detailed re-assessment of this problem was given by Prof. J. W. Marvin (University of Vermont). Using an automatic recording device, he found that variations in the rate of flow in the spring appear to be related to temperature conditions *preceding* the time of flow. Yet another aspect of the water relations of trees was dealt with by Dr. E. C. Stone (University of California), who reported work on dew-absorption by seedlings of various species of conifer. It was shown that certain species are capable of surviving for long periods after the soil moisture has been reduced to the ultimate wilting point by the absorption of artificial dew applied to the leaves, suggesting that natural dew may be an important source of moisture for these species under desert conditions.

Problems of photosynthesis in trees were dealt with by three speakers. Prof. P. J. Kramer discussed the photosynthesis of trees in relation to various environmental factors, and indicated how a consideration of this problem is of value in determining why forest trees react to environmental factors as they do. Prof. B. Hüber (Forst botanisches Institut, Munich) described experiments to measure photosynthesis and respiration continuously in the field, using an infra-red recorder. In this way it was possible to study daily variations in the carbon dioxide content of air over a vegetation cover. Changes in photosynthetic efficiency of seedlings of *Pinus taeda* with increasing age were shown by Dr. F. H. Bormann (Dartmouth College, Hanover, N.H.) to be related to changes in the morphology of the primary and secondary leaves.

Several speakers dealt with the translocation of metabolites in trees, and a lively discussion on the possible validity of the 'mass-flow' hypothesis of Münch constituted an important part of the symposium. Prof. Hüber described observations on the daily variation in composition of phloem sap. These observations suggest that the entrance of food material into the sieve tubes is an active process, whereas its translocation appears to be essentially passive, since such different substances as fluorescein, sugars and radioactive isotopes move in the same direction and with similar velocities. Dr. M. H. Zimmermann (Harvard Forest) has examined the sieve-tube exudates of sixteen tree species. Observations on the diurnal and seasonal fluctuations in the gradient of sugars in the phloem are consistent with the 'mass-flow' theory. A novel way of obtaining samples of phloem sap, by cutting off the stylets of aphids, was described by Dr. T. E. Mittler (Unit of Insect Physiology, Cambridge). The method has also been used with isolated stem segments to investigate the possible mechanism of phloem transport.

The importance of the xylem sap in the transport of organic nitrogenous materials was dealt with by Dr. E. G. Bollard (Department of Scientific and Industrial Research, New Zealand). A survey of more than a hundred species showed that they can be divided into three groups, according to the type of organic nitrogenous compounds predominant in the xylem sap. In the majority glutamine or asparagine was the principal compound; in some species citrulline was predominant, while in a third group allantoin or allantoic acid was present in the greatest quantities. By injecting rubidium-86 and calcium-45 into the trunks of yellow birch and white pine, Dr. D. A. Fraser (Petawawa Forest Research Station, Chalk River, Ontario) was able to follow their upward movement in the xylem in the growing season, and the downward movement in the phloem in the autumn.

Two papers dealt with the distribution of chemical constituents in relation to taxonomic groups. The distribution of turpentines in a hundred species of the genus *Pinus* has been studied by Dr. N. T. Mirov (California Forest Experiment Station), who was able to relate similarities in the chemical constituents to taxonomic affinities. Prof. R. D. Gibbs described the results of the Mäule test (which indicates the presence of the syringyl group in the wood) with more than a thousand vascular plants. The taxonomic significance of the results was discussed.

The problem of frost-hardiness in *Robinia pseudo-acacia* has been studied by Dr. D. Simonovitch (Science Service, Ottawa). He found that seasonal changes in the frost-resistance of the living bark are closely associated with changes in the protein constituents, using electrophoretic methods.

Dr. L. Leyton (Department of Forestry, Oxford) described observations on the relationship between tree growth and the mineral composition of the foliage of conifers, as a basis for the foliar diagnosis of mineral deficiencies. He gave examples in which this approach has been successfully employed in the diagnosis of deficiencies.

Several sessions were devoted to various aspects of growth physiology in trees. Four papers dealt with problems of root-growth. Dr. S. D. Richardson (University of Aberdeen) described experiments dealing with the interaction between shoot- and root-growth in sycamore (*Acer pseudoplatanus*), especially

during the period of shoot dormancy. Disbudding experiments suggest that even in apparently dormant seedlings, root development is dependent upon physiological activity of the buds, and the possibility that auxin produced by the bud stimulates lateral-root initiation was suggested. The possible role of auxin secreted by the fungal symbiont in the formation of mycorrhizal roots of pine was discussed by Dr. V. Slankis (Laboratory of Forest Pathology, Maple, Ontario). It has proved possible to reproduce mycorrhiza-like root morphology by applying synthetic auxins in the absence of the fungus. Dr. S. Shapiro (Brookhaven National Laboratory) described the effect of light on the emergence of roots on stem cuttings of Lombardy poplar. A few minutes of exposure to low-intensity illumination is sufficient to inhibit the emergence of the roots. The most active region of the spectrum lies in the red (6800 A.), the effect of which is partially reversible by far-red radiation. Polarity phenomena in the regeneration of buds by Lombardy poplar were also described.

The effect of aeration in root growth of trees was dealt with by Dr. Leyton. In the absence of oxygen, root-growth ceased in jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), whereas willow (*Salix atrocinerca*) is able to continue root-growth without any apparent deleterious effect on the shoot.

Various other aspects of growth were covered by several speakers. The rate of cytoplasmic streaming in the cambial initials of *Pinus strobus* was studied by Prof. K. V. Thimann (Harvard University). The effect of indolyl acetic acid, enzyme inhibitors and oxygen tension was described. Cytoplasmic streaming shows marked seasonal variations. Dr. P. White (Jackson Memorial Laboratory, Bar Harbor) described tumours occurring on white spruce (*Picea glauca*), which arise as sectorial chimæras originating from single cells. In tissue culture, the tumour tissue shows characteristic metabolic differences from normal tissue. Variations in the amount of extractable auxin, in relation to developmental changes of longleaf pine (*Pinus palustris*), were described by Dr. C. L. Brown (Texas Forest Service), and seed dormancy in various species of pine was discussed by Prof. E. C. Stone.

A further session was devoted to photoperiodism in trees. Dr. R. T. Downes (U.S. Department of Agriculture, Beltsville) indicated the broad range of photoperiodic phenomena in tree seedlings. Dr. P. F. Wareing (University of Manchester) gave a comparative study of photoperiodism in seeds, buds and seedlings of a single species, *Betula pubescens*. The possible role of growth inhibitors in both seeds and buds was considered. Prof. S. S. Pauley (University of Minnesota) emphasized the importance of photoperiodism in forest tree breeding.

The importance of 'thermoperiodism' in loblolly pine (*P. taeda*) was demonstrated by Prof. Kramer. Best growth was made with the greatest difference in day and night temperatures. Species of oak show similar effects. It was suggested that 'thermoperiodism' may be important in limiting the range of some species.

The increasing importance of forest genetics has emphasized the need for a greater knowledge of the physiology of reproduction in trees, and there are signs that this subject is beginning to arouse widespread interest. Dr. K. Sax (Arnold Arboretum) described experiments designed to elucidate the physiological basis of several methods long used by horticulturalists to induce earlier flowering in trees, namely, the use of dwarfing rootstocks, bark inversion and knotting of the stem. A study of flower initiation in spruce in relation to various external conditions was described by Dr. D. A. Fraser.

Reproduction in pine was the subject of two papers. Dr. R. G. Stanley (California Forest Experiment Station) is carrying out a biochemical study of male, female and vegetative structures of pine, and attempting to identify differences in metabolites and enzyme patterns. Dr. Wareing outlined observations on the reproductive development of Scots pine and attempted to relate this development to the 'ageing' of the tree as a whole and of the individual branches.

There can be no doubt that the meeting was an outstanding success and will constitute a landmark in the development of this field of study. Tree physiologists are indebted to the Cabot Foundation, and especially to Prof. Thimann and Dr. Zimmerman as organizers of the meeting, for bringing them together to their mutual benefit. The proceedings of the symposium are to be published in full.

P. F. Wareing

NEW NATURE RESERVES IN BRITAIN

THE Nature Conservancy has announced the establishment of the following new nature reserves in England and Wales: Rodney Stoke Woods, Somersetshire; Coed Tremadoc, Caernarvonshire; Craig Cerrig Gleisiad, Breconshire; and the existing reserve at Coed Rheidol in Cardiganshire has been extended.

Rodney Stoke Woods—on the southern escarpment of the Mendip Hills—are the best example of a Mendip ash wood existing to-day. These Mendip woods are a scientifically interesting variant of the ash woods found throughout Britain on carboniferous limestone, which here underlies most of the reserve and in parts is exposed. The Reserve consists of an ash wood together with some rough grazing and covers an area of 65 acres: the highest part is 750 ft. above sea-level and the lowest about 200 ft. In these woods ash is the dominant tree and associated with it are the wych elm and field maple: the shrub and herb layers are very well developed. The whitebeam is common and the autumn crocus is locally abundant, while the blue gromwell is found in suitable habitats. Other characteristic plants of these woods are *Campanula trachelium*, *Daphne laureola* and the small-leaved lime. Rock rose is common in the old pasture and ferns such as hart's tongue, and *Asplenium trichomanes* occur in the rock crevices. The fauna is typical of the dryer Mendip woods, including badger, buzzard and many species of mollusc.

Access to this reserve, which will be used for research on ash wood and its ecology, will be by permit only. Applications for such permits and for authority to collect specimens of animals and plants should be sent to the Regional Officer for the South West, Nature Conservancy, Furzebrook Research Station, Wareham, Dorset.

The woods at Coed Tremadoc clothe precipitous cliff faces and the screes below them, and are a good