INTERNATIONAL ASSOCIATION OF WOOD ANATOMISTS

Bulletin

ZÜRICH 1968/2

Editor: A. Frey-Wyssling, ETH Zürich

Semi-annually published by: I. A. W. A. Office
Mikrotechnologische Holzforschung ETH
Universitätstrasse 2
8006 Zürich / Switzerland

Subscription price for non-members: sFr. 15.— yearly

TIMBER APPRAISAL AT PRINCES RISBOROUGH

Observations on Some South-East Asian Timbers

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As part of the work of the United Kingdom Forest Products Research Laboratory, appraisals are made of the properties and potential use of overseas timbers. In some cases this information is required because shippers are offering a timber which is unfamiliar to the user and information is sought for its efficient handling and effective use. Outstanding examples of such timbers which, although now familiar names, were once unknown, are ramin (Gonystylus bancanus) from Sarawak and afrormosia or kokrodua (Pericopsis elata) from West Africa. For both timbers authoritative technical data, when they were first offered, did much to facilitate their successful exploitation and use. In other cases, the request for information comes from overseas when, for example, a Forest Service wants an appraisal of the economic potential of a species which enumerations have shown to be common and for which a decision has to be made on whether or not it should be favoured in forest management practices. Yet anouther source of query is the appraisal of plantation growth of exotic species, once again to determine their importance in forest development and also their potential use once the timber is cropped.

Thus such studies may be concerned with woods which are or soon become familiar, in other instances there may be a considerable time interval before exploitation is undertaken and, for yet others, their use may be confined to a local rather than an international market.

Timbers from many countries of the world have been the subject of examination and test at Princes Risborough but in recent years considerable attention has been given to the woods of Sabah (formerly North Borneo), part of the Federation of Malaysia. Sabah is a country of vast timber resources and rapidly expanding timber production. Many of its timber species are of considerable commercial importance and others are likely to become so. For the wood scientist and especially the wood anatomist there are aspects of the physical and anatomical characteristics of some of these woods which are of interest and some of these are discussed briefly here. For all the timbers mentioned, technical information reports have been issued and are obtainable free on request to the Forest Products Research Laboratory.

The outstanding tree and timber family in south-east Asia is the Dipterocarpaceae and 20 species representing a number of technical groups of timber have been examined. It is almost 30 years since DESCH (3), following a study of the systematic botany of the Dipterocarpaceae in Malaya by SYMINGTON (9), proposed a classification for the timbers of the family. This classification has stood the test of time and, although minor modifications have been made, it forms the basis for the Malaysian trade in the Dipterocarp woods. One of the outstanding genera is Shorea; its timbers are of great commercial importance and, with more than 150 species, the genus is of particular interest to the wood anatomist and plant systematist. It is characterised by timbers covering a range of technical properties and anatomical structure with, for the most part, a close agreement between the commercial and anatomical classifications. A recent botanical classification of Shorea (1) recognises nine sections; in some instances timber groups correspond with species of a single section, for example yellow meranti with the section Richetioides and white meranti with the Anthoshoreae. In other instances, commercial timbers include species of more than one section, thus balau, although produced mainly by the section Shorea, also includes S.isoptera of the section Neohopea, and the red meranti group of timbers include species of five botanical sections, Mutica, Rubella, Brachyptera, Ovalis and Pachycarpa.

Finally in this brief comment, reference must be made to the commercial nomenclature of the timbers which varies according to the country of origin. Thus balau in Malaya is equivalent to selangan batu in Sabah and yakal in the Philippines, and meranti in Malaya and Sarawak is broadly equivalent to seraya in Sabah and lauan in the Philippines. Further division of the light-weight, meranti type timbers is on colour, and the following are generally similar:

Light red meranti, light red seraya and white lauan (although white lauan also includes species of Parashorea and Pentacme).

Dark red meranti, dark red seraya and red lauan.

Yellow meranti, yellow seraya.

White meranti and Borneo melapi (it should be noted that Borneo white seraya is not equivalent to these timbers).

Anatomical differences between the timber groups are given by DESCH (3) and a study of the anatomy in relation to the taxonomy of the family has recently been made by GOTTWALD and PARAMESWARAN (4). Species representing each of the commercial timber groups of Shorea have been tested as follows:

Shorea superba. A species of the section Shorea, producing timber known in Sabah as selangan batu. The timber under test, which represented five trees,

was of particular interest for the considerable difference in weight that occurred between different logs. Timber from three of the logs was very similar in weight and averaged 900 kg/m^3 at 12 per cent moisture content whereas the timber from the other two logs was very much lighter at 700 kg/m^3; no consistent difference was observed in the herbarium material of the two groups and anatomically the only structural difference between their timbers was in fibre wall thickness.

Variation in timber of the selangan batu type is recognised in Sabah and harder, heavier wood is classed as selangan batu No.1 and lighter weight timber, less than 880 kg/m^3, as selangan batu No.2 (2).

Some timber of S.superba is acceptable commercially as selangan batu No.1 but, for the most part, it is a selangan batu No.2, and is believed to be the principal source of this timber. Anatomically the two types of selangan batu cannot be distinguished but if the end-grain is trimmed with a sharp knife the heavier timber gives a shiny or wax-like cut in contrast to the somewhat dull appearance of the selangan batu No.2 but, inevitably, this basis of separation is not always satisfactory in classifying pieces near the boundary weight for the two timbers.

Shorea guiso, another species of the section Shorea, is of interest because of its common occurrence and wide geographical distribution, from Malaya to the Philippine Islands. It is unusual, although not distinct, among species of the section Shorea in having a red wood, and this, in combination with its somewhat light weight for the group (850 kg/m^3), requires its separation from the heavier and more usually brown balau and selangan batu. It is known as red balau in Malaya, red selangan batu in Sabah and guijo in the Philippines, but the Malaysian names are also used for other species of Shorea especially S.kunstleri (section Brachyptera), which have timbers too hard and heavy for commercial acceptance as dark red meranti, etc. These woods which have a good combination of strength properties and are rated durable under temperate conditions offer an attractive commercial proposition for purposes where up to now keruing (Dipterocarpus spp.) has been used. They are marginally heavier than keruing but, unlike that timber, they do not exude resin and being non-siliceous do not cause excessive wear on cutting tools.

The commercial distinction between the red balau or red selangan batu on the one hand and the red meranti/seraya/lauan on the other is one of weight. The heavier, generally darker timbers of the red meranti group are known by distinctive names, dark red meranti, dark red seraya and red lauan. Philippine red lauan is produced mainly by Shorea negrosensis and S.polysperma, species with timbers having an average weight of about 625 kg/m^3. The dark red timber in Malaya, Sarawak and Sabah is produced mainly by a number of species but outstanding is Shorea pauciflora, known as nemesu in Malaya and obah suluk in Sabah.

Shorea pauciflora (section Brachyptera) is a moderately heavy red meranti; like many species of Shorea, it is somewhat variable in weight from tree to tree but averages about 640 kg/m^3 when dry, although some Malayan data (3) are somewhat higher. The upper weight range is of the order of 770 kg/m^3 and this represents about the maximum density acceptable as dark red meranti or dark red seraya. The dark red timbers are the heaviest and strongest woods acceptable commercially as meranti and with a considerable, although not outstanding resistance to wood-destroying fungi, they have found wide acceptance in the countries of continental Europe, especially France and Belgium.

They contrast in both colour and weight with light red meranti and light red seraya. These timbers are produced by a very large number, probably more than 30 species, and commercial shipments vary according to the composition of the forest being worked. Four Sabah species have been the subject of test viz. S.smithiana, S.leptoclados and S.waltoni of the section Brachyptera and S.parvifolia of section Mutica. Their timbers are typically light in weight, variable from log to log, but averaging from 420 kg/m^3 for S.waltoni to 500 kg/m^3 for S.smithiana. A noteworthy feature was the somewhat lighter weight of the Sabah timber of S.leptoclados and S.parvifolia, in both cases based on at least 60 specimens representative of five logs, compared with the same species in Malaya. Yet another feature of interest which appears to be characteristic of many of the light-weight Shorea timbers (7) is a marked pattern of density change from the centre of the tree outwards to the cambium. Thus in one log of S.smithiana, nominal specific gravity (based on green volume and oven-dry weight) increased steadily from 0.276 at 10 cm to 0.508 at 96 cm from the pith and in a log of S.pauciflora from 0.314 at 10 cm to 0.454 at 38 cm from the pith.

An unusual structural feature of the four light red seraya timbers and also S.pauciflora was the presence of faint criss-cross markings giving rise to a diamond-shape pattern on flat-sawn surfaces. These markings are due to a localised wound tissue sometimes accompanied by a very slight grain deformation. Their effect is to cause a very slight blemish to the decorative appearance

of the wood. They are described and illustrated by KOBAYASHI and SUGAWA (5) and a likely explanation is that they are caused by cambium damage following some type of insect attack. Our observations confirm those made in Japan that the feature appears to be confined to timber from the northern Borneo area.

One other species of a red meranti section of Shorea (Pachycarpa) has been studied but the appearance and technical performance of its timber is such that commercially it is unacceptable as a light red meranti. Shorea macrophylla (formerly known as S.gysbertsiana) has a very light weight wood (335 kg/m^3) which is straw yellow in colour; the test logs were also characterised by a high proportion of brittleheart timber and, on the whole, its generally poor quality suggests that regeneration of the species as a source of timber is hardly justified.

In comparison with the light to medium weight red Shorea timbers, those that are yellow or white have assumed much less commercial significance. The yellow timbers, yellow meranti and yellow seraya (section Richetioides), are somewhat finer textured and marginally heavier than light red meranti but are particularly susceptible to damage by very small pinhole borers. Damage was observed in all but one of the logs of the three species examined, S.acuminatissima, S.faguetiana, and S.hopeifolia, and while it has no effect on the mechanical performance of the timber it detracts from its otherwise often very attractive appearance. In contrast to the yellow timbers, those of the section Anthoshoreae are commonly free from insect attack. However, they characteristically contain silica which, if present in amount, makes their utilisation difficult. Two Borneo species have been examined, S.symingtonii and S.virescens, and, although mostly of medium weight, the amount of silica present, from 0.6-1.8 per cent of the dry weight of the wood in S.symingtonii and 0.4-1.3 per cent in S.virescens, was high and must cause considerable difficulty in sawing and machining, especially when the wood is dry, unless special tools are used. The most promising use for light to medium weight species with silica is for plywood and the export of white meranti logs from Malaya and Sabah is for this purpose.

Besides the species of Shorea other dipterocarp timbers have been examined, notably species of Parashorea, Dipterocarpus and Dryobalanops.

In contrast to Shorea, Parashorea is a relatively small genus of not more than a dozen species. Their timbers are somewhat variable in weight but those of outstanding commercial importance are the light to medium weight woods known as white seraya in Sabah and bagtikan (one of the timbers of the white lauan group) in the Philippines. The botanical nomenclature of these timbers is confused although it is likely that both are produced by the same species. This has been known as P.plicata in the Philippines and P.malaanonan in Sabah. In 1938 SYMINGTON (8) described a variety tomentella of P.malaanonan and more recently this has been given species status (6). It has been a matter of considerable commercial interest to know whether or not P.malaanonan and P.tomentella have timbers which differ significantly. A comparative examination of extensive material, including five logs of each species, suggests that differences between them are slight. Both have medium weight woods (450-625 kg/m^3 at 12 per cent moisture content) with P.malaanonan slightly heavier and stronger, but differences between logs of a species were much greater than the difference between the average for the two species. There was some evidence that movement under changes of relative humidity was less for P.tomentella but, in general, there is no reason for marketing the species separately. Both have a white or very pale pink wood, which is non-resinous and with good working characteristics. In this last respect white seraya (Parashorea spp.) differs markedly from white meranti or melapi (Shorea spp.) and must be recognised as a quite distinct timber.

Two species of Dipterocarpus have been subjected to technical appraisal. D.acutangulus is a typical keruing, with an average weight when dry of 770 kg/m^3, only marginally less than the general average for keruing, 800 kg/m^3. The timber has an attractive appearance and was not marked by excessive resin exudation. Resin exudation was also slight in D.caudiferus, but the point of particular interest for this species was the unusually light weight of the timber from two logs, at 590 kg/m^3, and that from three others, at 670-720 kg/m^3, was well below the average for keruing. As in all species of Dipterocarpus, the wood contains silica which has a marked blunting effect on cutting edges and especially saw teeth; it was also somewhat low in its durability rating compared with other keruing timbers.

Another group of timbers which characteristically contain silica are the species of Dryobalanops. Commercially known as kapur, the timber has a resistance to fungal decay considerably better than keruing and, unlike keruing, kapur does not exude resin. Technical knowledge of kapur was largely based on experience with the principal Malayan species, D.aromatica. In Sabah, D.aromatica is a rare tree and the common species is D.lanceolata. Its timber was found to be very like that of D.aromatica, marginally lighter in weight on average but otherwise so similar that their woods cannot be

differentiated either on structure or appearance. Another species, D.beccarii, was also very similar and with the possible exception of timber of D.rappa, a swamp forest tree, the various types of kapur appear fairly uniform in character, especially in comparison with the variability of different species producing keruing.

Finally, lest it is imagined that attention is directed only to the dipterocarp woods, reference must be made to a number of non-dipterocarp timbers currently under test. These include belian (Eusideroxylon zwageri), kembang (Heritiera simplicifolia) and ranggu (Koordersiodendron pinnatum). Only kembang is known on the European timber market, under its Malayan trade name of mengkulang, but belian is an important primary structural timber in Borneo with a combination of technical properties which compare favourably with those of greenheart (Ocotea rodiaea).

Acknowledgement

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CO-OPERATIVE WORK ON TROPICAL TIMBERS

by

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Ever since the idea of founding our Association was broached during the Botanical Congress held in Cambridge in the summer of 1930, tropical timbers have held a special interest amongst our membership. This is natural in view of the wealth of different woody species which are found in the tropics and their rich diversity in character and anatomical structure apart from their commercial significance. Moreover, the tropical woody flora represents the world's principal storehouse of hardwoods, much of it yet unharvested and much of it still unknown.

Many of our members have played some part through their investigation of structure and properties in establishing a sound basis for utilisation of many tropical species which were quite unfamiliar to timber markets in 1930. In the United Kingdom only a comparatively small amount of tropical timber was imported at that time. In 1936, the first year for which detailed information is available, 22 per cent (by volume) of imported hardwoods came from the tropics but 30 years later the figure had risen to 59 per cent. The British Standard list of commercial timbers now includes nearly 240 tropical hardwoods, over 70 per cent of the total number imported, about the same proportion incidentally as is present amongst the Princes Risborough Laboratory's collection of 30'000 wood specimens. Of the numerous timbers subjected to extensive testing there over 80 per cent have been of tropical origin.

Before discussing recent proposals for fresh initiatives in co-operative work on tropical timbers it should be recalled that since its early days, thanks to the enthusiasm of our principal founder and first Secretary-Treasurer, the late Samuel J.RECORD, there was a valuable exchange of information about these timbers through the medium of the journal "Tropical Woods". Although this journal ceased publication with its 113th number in 1960, it is still used as a valuable source of information on the occurrence,

nomenclature, anatomy, technical properties and uses of tropical species. Another enduring form of co-operation has been the exchange of wood specimens between members leading to the formation of valuable reference collections in many countries of the world. The production of a standardised terminology for wood anatomy, which has been published as a glossary running to three editions, is another example of co-operative effort largely, but not exclusively, connected with woods from the tropics. Reference should also be made to the ambitious co-operative scheme for a universal identification card key, intended for computer sorting, on which a considerable amount of work was done by a Sub-Committee at the time of the Botanical Congress held in Paris in 1954 and reported in the September 1954 issue of the News Bulletin. The untimely death of one of the principal proposers of this scheme and the heavy commitments of the other members led, unfortunately, to the matter being shelved indefinitely.

These historical notes form a background to the current upsurge of interest in planning international co-operation which, one way or another, aims to put to good use in a systematic and economical manner the accumulated information on tropical timbers. It is also the aim to prevent duplication of future effort by investigators in this field. Late in 1967 several interesting proposals were made at the meeting at the Centre Technique Forestier Tropical, Nogent-sur-Marne, held to celebrate the first 50 years of research on tropical timbers in France. These included the interchange of information on testing methods between the principal research institutes with a view to facilitating the comparison and exchange of test results since, despite many past attempts at international standardisation, the different institutes have for the most part held to their own traditional methods. The collation of the systematized data in a form suitable for rapid retrieval possibly by means of a computer, would be the next step. It was envisaged that a wide range of interest would be covered including anatomy, chemical, physical and mechanical properties, resistance to insects and micro-organisms, wood protection and utilisation. Forest resources would also be taken into account bearing in mind the many valuable enumeration and other forest surveys carried out under the aegis of F.A.O. through the agency of I.U.F.R.O. The ways and means of implementing these important proposals is now in process of being worked out.

Another example of developing interest in tropical timbers is the conference being organised at the State University College of Forestry at Syracuse, New York and due to be held in the summer of 1969. This is to consider problems associated with the utilization of these timbers with particular regard to the expected increase in their consumption in the coming years.

Recently, a conference sponsored by the United Nations Committee on Trade and Development (U.N.C.T.A.D.) in co-operation with F.A.O. and attended by delegates of some 35 countries was held in Geneva to assess the various aspects of the problem of developing the rational utilisation of tropical timbers and especially the so-called secondary species. In many areas of the tropics, the mixed forests contain only a very small proportion of species known and accepted on world markets. In many cases the supply of these timbers is dwindling or at least, failing to keep pace with increasing demands, and their extraction becomes more and more expensive. For various reasons it is becoming imperative that a larger proportion of the forests should be utilised. To help in achieving this, proposals put forward by some of the developing countries were accepted which would lead to the setting up of bureaux, one in Europe and another in the United States of America, for the collection and dissemination of commercial and technical information on behalf of the timber exporting countries. A useful contribution in preparation for such a scheme is the report recently published by GATT (the Organisation for General Agreement on Trade and Tariffs) in co-operation with the International Trade Centre entitled "The Markets for Tropical Sawnwood in Europe". The promotion of the orderly marketing of secondary species by the bureaux would be based on precise knowledge of market requirements on the one hand, and of the availability of supplies and of the technical properties of the timbers and their utilisation possibilities on the other.

It is expected that this basic information especially that on the lesser known species, needed for these extensive projects will be derived from the research records of wood scientists throughout the world amongst which may be numbered several members of our own Association. If the objects of these schemes can be achieved it will be a matter of considerable satisfaction to wood scientists generally that they will have played a useful part in the more fruitful development of large areas of the world's resources of tropical timbers.

Acknowledgement

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PHYSIOLOGICAL ASPECTS OF WOOD ANATOMY

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The appearance of tall land plants on the face of the earth has been made possible by development of tissues we call "wood". Wood serves two major functions in the plant, it gives it mechanical strength, thus making the tree selfsupporting, and conducts water and dissolved soil nutrients from roots to leaves. Wood, therefore, has acquired two important properties, namely structural strength and features permitting efficient and safe water conduction. Man has made use of the first of these two properties since pre-historic ages. Wood is still widely used in our modern technology, and most wood anatomists are therefore interested in wood from a technological point of view. In this brief paper, I would like to discuss a few aspects of the second major property of wood, that required by nature for water conduction. This second requirement partly explains why wood is constructed the way it is.

Among the tallest trees, those with the highest requirements for water conduction, are representatives of both conifers and dicotyledons. We can therefore see that two quite different structures successfully serve the same function. Nature has found two different solutions for a single problem.

It is certainly true that large vessels are better water conductors than small ones, for we know that the volume flow of water through capillaries is proportional to the fourth power of the radius! Why, then, are some conifers able to grow so tall? The answer is found as one studies the mechanism of sap ascent through xylem: water is pulled up into the crowns of trees under most conditions, the liquid is therefore almost always under tension. This involves the risk of gas embolism, which can be caused by mechanical injury, by cosmic radiation or can even occur spontaneously. Most important for trees of temperate and cold climates, it is induced by freezing (SCHOLANDER, 1958). The risk of gas embolism is greater the larger the volume of the conducting unit (tracheid or vessel); therefore it is interesting to see that not only conifers, but also large-porous (i.e. ring-porous) trees can survive cold winters. In contrast to coniferous wood which largely resists embolism (HAMMEL, 1967), the large vessels of ring-porous species go regularly out of function during the winter, but their newly formed earlywood vessels are such excellent conductors that they are sufficient to supply the crown with water throughout the summer (HUBER, 1935). Significantly, earlywood vessels are formed before the leaves emerge, i.e. before much water conduction is required. It is also interesting to see that ring-porous trees which operate a highly effective water-conducting system at high risk, are very vulnerable (Castanea, Ulmus).

Lianas (vines) are among the longest plants (some Calamus species reportedly reach as much as 150 meters in length) and, because their stem diameter is small in comparison with a tall tree, must have a very efficient water-conducting system, i.e. wide and long vessels. It is interesting to see that most of these grow in the tropics and thus avoid gas embolism by freezing. The few tall vines that do grow in areas with cold winters (e.g. Vitis), refill their vessels with root pressure in late winter or early spring.

Let us now look at the wood anatomy to see which of the features facilitate water conduction. HUBER (1956) has pointed out that many large-porous trees have vasicentric parenchyma, presumably because vessels surrounded by living tissue are better protected against injuries from the outside. Vasicentric parenchyma can, of course, be seen on single transverse sections. Other properties facilitating water conduction, on the other hand, can only be seen if wood is studied throughout its axial extent, in the third dimension. Most tree species show spiral grain to a lesser or greater extent; moreover, the pitch of the spiral grain often changes from year to year. This was demonstrated by VITE (1958) who introduced dyes from radial bore holes at the base of conifers. The radial dye pattern at the base of the tree became a spiral pattern higher up. The helical path of water movement up the stem is therefore different in different growth rings. This means that there is an axial supply of water from a single root to several branches, or vice versa, a single branch is supplied by a number of roots. With such experiments VITE and RUDINSKY (1959) found characteristic moisture distribution patterns in various coniferous groups and pointed out the physiological significance of this phenomenon.

One of the apparently important features of dicotyledonous wood is the fact that vessels (which are of limited length) practically never end in isolation but always in clusters. This means that the water-conducting units do not have dead ends. Water can always pass through a large number of pits from one vessel to another or to several others, just as it can, in conifers,

pass from tracheid to tracheid. That this method of water conduction is highly efficient is indicated by the fact that the hydraulic conductivity of coniferous wood is only about one third of that of an equal number of endless capillaries of tracheid diameter (MUENCH, 1942).

Vessel clusters are common in wood species; but even in those species which have "solitary" vessels, pairs can be found. It remains to be seen whether these pairs are overlapping vessel ends. We do know that this is the case in the palms (ZIMMERMANN, 1966).

If one looks at sequential transverse sections of wood with the motion-picture technique (ZIMMERMANN & TOMLINSON, 1967), one can see that individual vessels continuously wander from cluster to cluster. This phenomenon, first found by BRAUN (1959) in a small piece of Populus wood with conventional anatomical methods, is a very common one. Even in Fraxinus, a ring-porous wood, vessel pairs are formed over appreciable distances where two vessels cross, thus facilitating water exchange between individual vessels (ZIMMERMANN & TOMLINSON, 1967). The functional significance of cluster-to-cluster contact can easily be seen in a dye-ascent experiment. If dye is introduced at a point into the base of a transpiring tree, the dye spreads tangentially within the growth rings as it ascends. This means that any one point at the base of a tree stem is in direct axial contact with a good part (or all) of the circumference of the top of the tree. As in the conifers, a single root therefore supplies many branches axially with water. Limited vessel length and these axial cross connections as well as the changing spiral grain in conifers are features of the xylem that are invisible on single sections, but make wood an efficient water conductor which is safeguarded against all sorts of possible dangers to which the living tree is constantly exposed.

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IAWA Bulletin 1967/1, 2-6

BOOK REVIEWS

FAHN, A.* "Plant Anatomy"
Translated from the Hebrew by Sybil Broido-Altman
Pergamon Press, London, 1967, pp 534, price 87/-

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This volume is a comprehensive text of classical plant anatomy. It consists of 479 text pages with 220 illustrations, a glossary of terms, author and subject index. Literature citations are conveniently located at the end of each chapter. A detailed introduction consists of a description of general morphology, the cell, and meristems. Four major sections then follow, describing mature tissues, primary and secondary plant body, and reproductive organs. The book is well organized and contains a good subject index, useful features of a reference volume.

Writing a comprehensive textbook is such an enormous amount of work that the danger is great that parts go out of date before the whole book is completed. In classical plant anatomy, this danger is perhaps not quite as great as in other fields in which fast progress is made on many more fronts. Nevertheless, the danger does exist and the statement one occasionally hears that "we know all about plant anatomy" is far from true.

This English edition is a translation from the original Hebrew text, the publication date, 1967, is therefore somewhat deceiving. The newest articles referred to in the book are of 1964, i.e., they were three years old at the time of publication of the English edition. Occasional parts of the book, therefore, are somewhat out of date. Fig. 48-2, for example, shows callose cylinders in sieve pores which reduce the pore opening (i.e. its transverse-sectional area) to less than 50%. Great efforts have been made in the early 1960ies by various authors to show that such massive callose cylinders are fixation artifacts in normally functioning sieve elements.

The book contains a wealth of information and is not merely based upon a few temperate species. It describes plants of many parts of the world, including tropical plants which are so often neglected. The fact that it has been written for students of Israel and therefore emphasizes adaptations to arid habitats is by no means a disadvantage for other readers. In summary, then, it is a book of broad and comprehensive coverage, useful as a text as well as a source of information for those who casually want to refer to it.

M.H.Zimmermann

TSOUMIS, G. "Wood as raw material"
Pergamon Press Ltd. Oxford, 1968,
pp 276, price 80/-

Wood sciences are in rapid development; wood anatomists and wood technologists all over the world try to get new information on the most complex nature of wood. The sponsorship of up-to-date professional education in wood sciences runs parallel to these research endeavours. A visible expression of all these efforts are the new handbooks on wood, written for students of all levels. "Wood as raw material" by George Tsoumis, Professor of Forest Utilization at the Aristotelian University of Greece, is one of these new books which show the world-wide tendency for a better understanding of wood. The subtitles of Tsoumis' book are: Source, Structure, Chemical Composition, Growth, Degradation,and Identification. The volume deals mainly with forest trees as sources of wood, microscopic, macroscopic, and physical characteristics of wood, as well as its chemical composition and ultrastructure. Mechanisms of wood formation, formation and structure of bark, tree growth and variation of wood structure, the wood of branches and roots, abnormalities, degradation, and finally identification of wood and techniques for microscopic investigation of wood are covered.

The very well organized work is supplemented with photomicrographs and a wealth of references. It can be recommended to all who are interested in wood as a research object and to those who are interested in using it for teaching purposes.

H.H.Bosshard