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Photography by M. Fagg

SOFT TREE FERN—*Dicksonia antarctica* Labill.

A grove of soft tree ferns in cultivation in the Canberra Botanic Gardens.

AUSTRALIAN FERNS

Propagation — Cultivation — Identification

AN INTRODUCTION TO FERNS

by J. A. Adamson & I. R. H. Telford, Canberra Botanic Gardens

The plants included under this name comprise an entire order, made up of some distinct families. They include plants varying in size from a hair-like creeping stem bearing a few simple moss-like leaves, to tall trees eighty or more feet in height, with a stem or trunk nearly a foot in diameter. The extremes in size are both found in tropical regions, in which most of the species abound. Most of the ordinary species. as well as the larger part of those in cultivation, consist of erect underground stem or rootstock with leaves, often called fronds, clustered in dense crowns, or in the cases of creeping stems, with scattered leaves. In gardening parlance, other plants are sometimes called ferns, such as species of *Lycopodium* and *Selaginella,* as well as *Asparagus plumosus.*

CLASSIFICATION

The ferns are commonly classified as *part* of a group of spore-bearing plants, with vascular (woody) tissue in stem and leaves. This group is technically known as the Pteridophytes, and, based on Engler's 1954 edition of Syllabus der Pflanzenfamilien (Reimers), includes the (living) groups *Psilotopsida, Lycopsida, Sphenopsida,* and *Pteropsida.*

Some botanists widen the definition of the *Pteropsida* to include not only the megaphyllous pteridophytes, but also the gymnosperms and angiosperms, on the supposition that all three groups are related. However it appears to be preferable to retain the distinction between pteropsida (true ferns) and seed-plants, and exclude all but the ferns. Even so, the group is enormous, and shows such a wide range of form and structure that is almost impossible to name one character which is diagnostic of the group. Accordingly, there are almost as many different ways of classifying the group.

Great diversity also has existed in the matter of the separation of the ferns into genera. Hooker, relying mainly on artificial characters drawn largely from the sorus, recognized about seventy genera only, many of them heterogeneous groups of plants with little resemblance in structure, habit, or natural affinities. John Smith relying on stem characters, Presl on variation in venation and habit, Fee, Moore, and others, have recognized a much greater number of genera ranging from 150 to 250, or even more. In the very unequal treatment by Diels in Die Natulichen Pflanzenfamilien (Engler and Prantl), some 120 genera are recognized. A somewhat similar difference exists in regard to the number of species. The Synopsis Filicum of Hooker and Baker (1874), supplemented by Baker's New Fern (1892), recognized some 2,700 species, but this work failed to recognize many valid species which have been described by German and French botanists; it also massed under one name very diverse groups of species from distant quarters of the world. The Index Filicum by Carl Christensen (1905), recognized 150 genera and 6,000 species which has now increased to over 10,000.

(Continued on page 180)

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FERNS—Many people interested in these fascinating plants have become frustrated by the meagre and conflicting information about them. We have delayed articles on ferns in "Australian Plants" for 10 years seeking a competent botanist with artistic ability, to systematically present the whole fern family in a clear, easily followed, illustrated series. We have secured the services of Ian Telford who commences with "Tree Ferns" opposite. ENVIRONMENTAL RESEARCH—We should all be vitally concerned with the preservation of the environment Nature has bestowed upon us. The new era of co-operation and mutual assistance by Government agencies with the people to whom they are responsible is evident in this issue. Readers, do more!

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AUSTRALIAN NATIVE FERNS

by Ian Telford, Canberra Botanic Gardens

The Tree Fern Families

Ferns make popular garden, pot or hanging-basket subjects and many native species are suitable. However, it must be stressed that many fern species are protected plants and their removal from the bush is prohibited by law.

This is the first of a series of articles presenting comprehensively the range of ferns (class *Pteridophyta)* and fern allies (classes *Psilopsida* and *Lycopsida* including club mosses and tassel ferns) occurring naturally in Australia. The taxonomy of the ferns is in considerable confusion. In these articles, families and genera are those recognised in H. K. Airy Shaw's revision of Willis' "A Dictionary of Flowering Plants and Ferns" (1966) following Prof. R. E. Holttum.

Because of their popularity, the species described by the vernacular name "tree fern" will be discussed in this first article.

Tree ferns do not fall into one taxonomic group. The family *Cyatheaceae* includes most Australian tree ferns (genus *Cyathea)* and the family Dicksoniaceae contains the two species of the genus *Dicksonia.* Other ferns may develop a massive trunk—*Todea barbara* of the family *Osmundaceae* will here be treated as a tree fern. *Marratia salicina. Angiopteris evecta* and *Athyrium dilatatum* will be discussed in later articles.

Collection and identification of tree ferns:

When collecting specimens of tree ferns for identification, fertile fronds should be sought—fronds bearing sori, small rounded structures on the underside of the pinnules where the spores are borne. As fronds may reach 4 m in length, collection of a complete frond is impractical: portion of a fertile frond is sufficient. The frond butt is important in identification—the bottom 20 cm or so, together with the scales or hairs which occur at the base, will suffice.

Characters used in the following descriptions will be kept as simple as possible; those easily seen by the naked eye or with the aid of a hand lens where necessary.

Family *CYATHEACEAE*

Australian species of the family *Cyatheaceae* possess upright trunks, usually bearing one crown of fronds; the trunk sometimes branched and often thickened, particularly at its base, by wiry adventitious roots. Fronds are large and spreading, 2-pinnate or 3-pinnate with the pinnules toothed to deeply lobed. The frond bases (stipes) bear characteristic scales, each scale up to 5 cm long, coarse or silky. Frond butts may persist on the trunk making it rough and prickly or fall cleanly leaving a smooth scar. Sporangia are grouped in orbicular sori, with indusia present (cup-shaped, hemispherical or scale-like) or absent. Sori are borne in one to three rows on each side of the midvein of fertile pinnules, in the forks of the veinlets and away from the pinnule margin.

As treated here, the family is represented in Australia by the single genus *Cyathea* with seven endemic mainland species. The genus *Alsophila* to which several Australian species were assigned, has been discarded.

Cyathea baileyana (Domin) Domin WIG TREE FERN

This relatively uncommon species inhabits mountain rain forests at altitudes above 3,000 feet (915 m) in north-eastern Queensland from Mount Spurgeon, w of Mossman to the Evelyn Tableland.



C. baileyana is a slender stemmed tree fern, the trunk reaching 4 m in height with a diameter of 4 to 10 cm. Fronds are 2-pinnate, to 3 m long, the lamina glossy dark green above, paler beneath, the pinnules with long acuminate serrate tips. The characteristic "wig" which appears to sit atop the trunk is formed by the reduction of the lower pinnae to branching hair-like growths. Stipe bases are reddish-brown tuberculate, with dark brown or black scales, and persist on the trunk when the fronds fall. Sori are orbicular, lack indusia, and are borne in two or three irregular rows on each side of the midvein of fertile pinnules.

Cyathea brownii Domin

This species does not occur in mainland Australia, being endemic to Norfolk Island.

C. brownii resembles *C. cooperi* but is generally more robust. The trunk is marked by smooth oval leaf scars. Scales at the stipe bases are of two types; the larger pale brown, the smaller red-brown.

Cyathea celebica Bl.

This rare species has been recorded in Australia from the Evelyn Tableland and the coastal range behind Rockingham Bay, north-eastern Queensland, in rain forest near creeks. Outside Australia, *C. celebica* is distributed through New Guinea, the Moluccas Islands and Java.

The trunk reaches 6 m in height, bearing a crown of 3-pinnate fronds which are dark green above, pale with whitish cob-webby hairs beneath. Stipe bases are usually persistent, purplish-black, with short sharp black spines. Sori are orbicular, 2 to 6 pairs per pinnule, with cup-shaped indusia.

Cyathea cooperi (Hook. ex F. Muell.) Domin

C. cooperi inhabits mountain rain forests of the coastal ranges of eastern Australia from Cooktown, Nth. Qld., south to Wollongong, N.S.W. A naturalized population occurs near Bedfordale, SE of Perth, Western Australia.

The trunk reaches a height of 10 m with a diameter of 15 cm. Smooth oval leaf scars mark the trunk, the fronds being shed cleanly. Fronds are 3-pinnate, the pinnules toothed, green or light green, paler beneath. Stipe bases are brown, with dark brown tubercles and bear scales of two types; long silky and whitish mixed with shorter red-brown scales. Sori are orbicular, up to 10 pairs per pinnule, with indusia consisting of rings of scales.

Cyathea australis (R.Br.) Domin COMMON or ROUGH TREE FERN

C. australis is probably the most common tree fern of south-eastern Australia, ranging from the Blackdown Tableland of central Queensland to Tasmania and Portland, south-western Victoria. Favoured habitats are rain forest gullies and wet sclerophyll forest from near sea level to 4,000 feet (1 220 m) altitude.

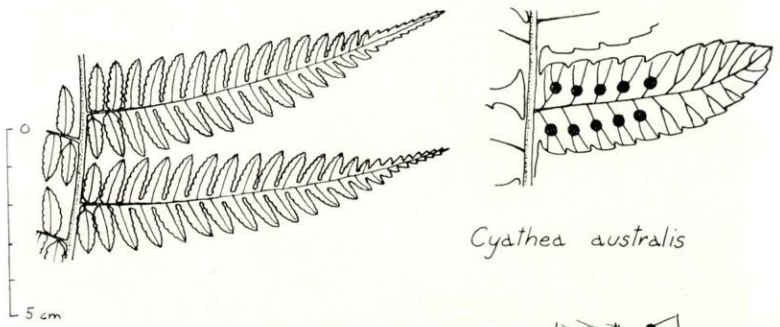


Common or Rough Tree Fern—*Cyathea australis* (R.Br.) Domin

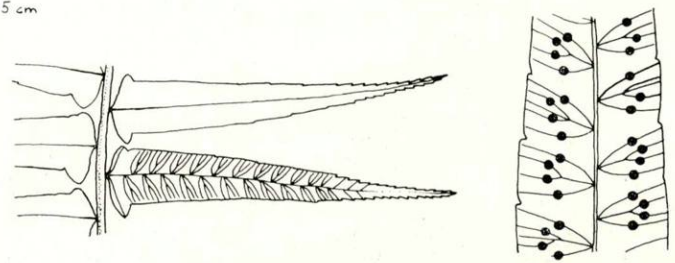
This robust tree fern is so named because of persistent rasp-like frond bases on the upper part of the trunk. The inset shows the underside of a fertile frond. Sporangia in rounded sori on each side of the midrib of fertile pinnules.

The trunk is large and rough, up to 20 m tall and 16 cm diameter, sometimes thickened to 1 m through at the base by wiry adventitious roots. Fronds are 3-pinnate to 4 m long, the pinnules toothed, pale green above, paler to glaucous beneath. Stipe bases are dark brown, rasp-like with many pointed tubercles and bear shining brown narrow scales. Broken frond butts persist on the upper part of the trunk. Sori are orbicular, either lacking indusia or with a semicircular group of scales, and occur in a single row on each side of the midvein of the pinnules, to 8 pairs per pinnule.

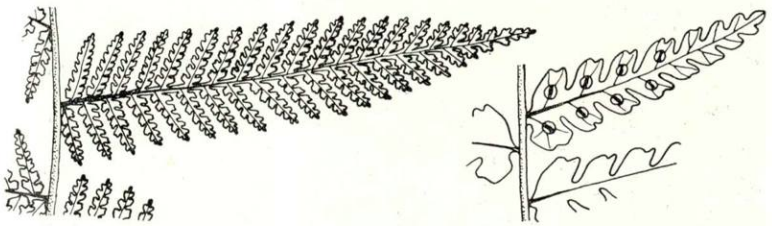
Family CYATHEACEAE



Cyathea australis



Cyathea baileyana



Cyathea cunninghamii

Cyathea cunninghamii Hook. f. SLENDER TREE FERN

This species occurs in moist forest gullies in Victoria from Gippsland to the Cape Otway Ranges, in Tasmania, New Zealand and the Chatham Islands.

The trunk is tall and slender, reaching 20 m in height with a diameter of 3 to 14 cm, the taller specimens considerably thickened at their bases. Fronds are 3-pinnate, the pinnules lobed, dark green above, paler beneath. Stipe bases persist for a time, are dark brown, tuberculate, with pale to dark brown scales. Sori are orbicular with cup-shaped indusia, up to 7 pairs per fertile pinnule, one per lobe of the pinnule margin.

Cyathea dealbata (Forst. f.) Swartz

This common New Zealand tree fern occurs on Lord Howe Island but not in mainland Australia.

The trunk reaches a height of 10 m, roughened by persistent stipe bases. Fronds are 2-pinnate-pinnatifid to 3-pinnate, dark green above, glaucous beneath. Stipe bases bear yellow-brown scales. Sori are orbicular with cup-like indusia.

Cyathea grevilleana Mart.

The collection in Australia of this species, known elsewhere only from Jamaica, seems improbable as *Cyathea* species do not show such widespread disjunct distributions. Originally named *C. lindsayana* Hook., the Australian specimens were supposedly collected on Mount Lindsay in the McPherson Range on the Queensland-N.S.W. border in 1858. It has never been recorded since in Australia. Perhaps this anomaly may be explained by a mix-up of herbarium labels.

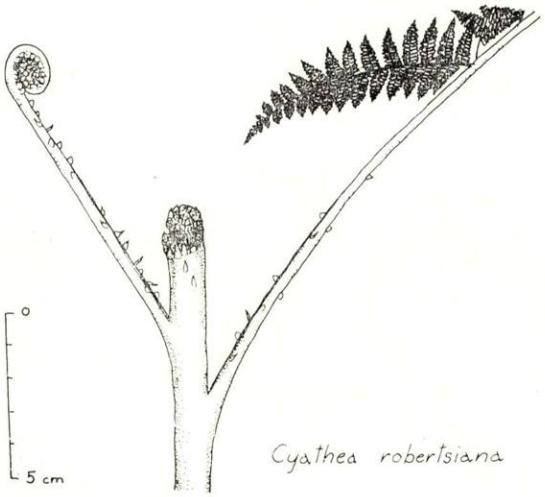
Cyathea rebeccae (F. Muell.) Domin

C. rebeccae is a common tree fern of the rain forests of north-eastern Queensland, occurring at altitudes from near sea level to 5,000 feet (1 525 m) from Cooktown to the Eungella Range. Outside Australia, this species has been recorded from the inland of Flores, Indonesia.

Closely related to *C. baileyana, C. rebeccae* has similar fronds, being 2-pinnate, the pinnules dark green with long serrate tips, but the "wig" growths are lacking. The trunk is slender, 2 to 6 m tall and 3 to 10 cm in diameter. Stipe bases are persistent, tuberculate, coloured a dark purplish-brown, with purplish-brown scales. Sori lack indusia and are borne in two or three irregular rows on each side of the midvein of fertile pinnules.

Cyathea robertsiana (F. Muell.) Domin

This graceful, slender trunked species occurs in mountain rain forests at altitudes above 2,000 feet (610 m) in north-eastern Queensland from Mount Spurgeon south to the Eungella Range.



C. robertsiana bears its fronds scattered along the upper part of the trunk, not in the typical crown of the other Australian *Cyathea* species. The trunk is smooth, marked by oval leaf scars, reaching a height of 5 m with a diameter of 5 to 10 cm. Fronds are 3-pinnate, with the pinnules lobed almost to the midvein, and joined by decurrent wings, of a soft pale green, softly hairy beneath. Stipes are brown, scaly but not prickly, falling cleanly. Uncoiled fronds are densely covered by broad scales. Sori are orbicular with scale-like indusia, one per lobe of the fertile pinnules.

Cyathea leichhardtiana (F. Muell.) Copel. PRICKLY TREE FERN

C. leichhardtiana occurs in mountain rain forests of eastern Australia from the Eungella Range, w of Mackay, Queensland to Bruthen, Gippsland, Victoria.

This slender trunked species reaches 7 m in height with a diameter of 5 to 10 cm, the upper part rough and prickly with persistent frond butts.

Fronds are 3-pinnate, the pinnules deeply lobed, dark green above, paler beneath. Stipe bases are purplish-black or dark red-brown, bearing sharp black spines and pale, silky basal scales. Sori are orbicular, to 5 pairs per pinnule, close to the midvein.

Cyathea marcescens N. A. Wakefield SKIRTED TREE FERN

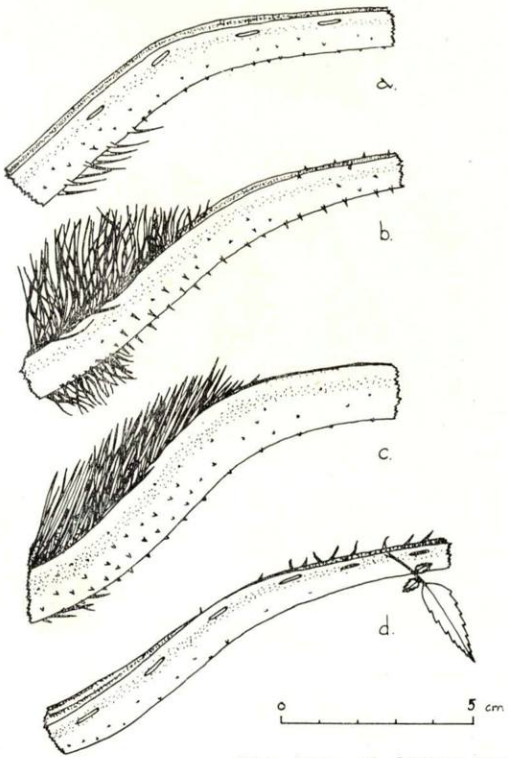
This rare species has been recorded only from Victoria in Gippsland (Mount Drummer and the Tarra Valley) and the Cape Otway Ranges.

The trunk is massive, up to 9 m tall and a diameter of 30 cm, clothed throughout in a "skirt" of hanging dead fronds. Fronds are large and broad, to 6 m in length, 3-pinnate, the pinnules sometimes lobed, dark green above, paler beneath. Stipe bases are black with black spines and shining brown scales. Sori are orbicular, 6 to 9 pairs per pinnule, the indusia formed by incomplete rings of scales.

Cyathea woollsiana (F. Muell.) Domin

C. woollsiana inhabits rain forests or creek banks usually in the mountains of north-eastern Queensland from Mount Spurgeon south to Cardwell.

The trunk is slender, to 5 m tall. Fronds are 3-pinnate, dark green above, paler to glaucous beneath. Stipe bases are dark red-brown, tuberculate and bearing a group of curved woody spines. Sori are orbicular, each partly surrounded by a hemispherical indusium, and occur in 1 to 4 pairs towards the base of fertile pinnules.



a. Stipe base of *Cyathea woollsiana*

b. Stipe base of *Cyathea leichhardtiana*

c. Stipe base of *Cyathea australis*

d. Stipe base of *Cyathea rebeccae*

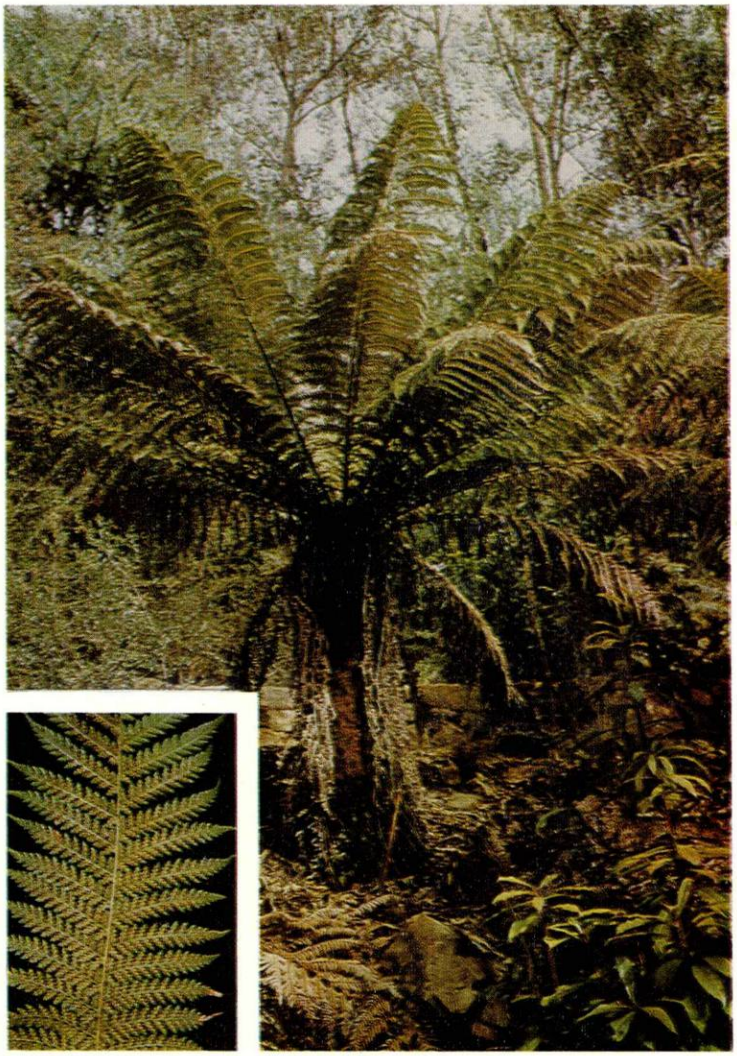
Stipe bases of Cyathea species

Some modern treatments of the family Cyatheaceae also include *Dicksonia*, but here the family Dicksoniaceae is retained.

Family *DICKSONIACEAE*

Members of the family Dicksoniaceae possess rhizomes which are upright (trunk-forming in *Dicksonia)* or creeping. Fronds are large, 2- or 3-pinnate. Sporangia are grouped in sori, rounded and marginal, terminal on the veinlets, with bivalvate indusia, the outer lips being formed by the recurved pinnule margins.

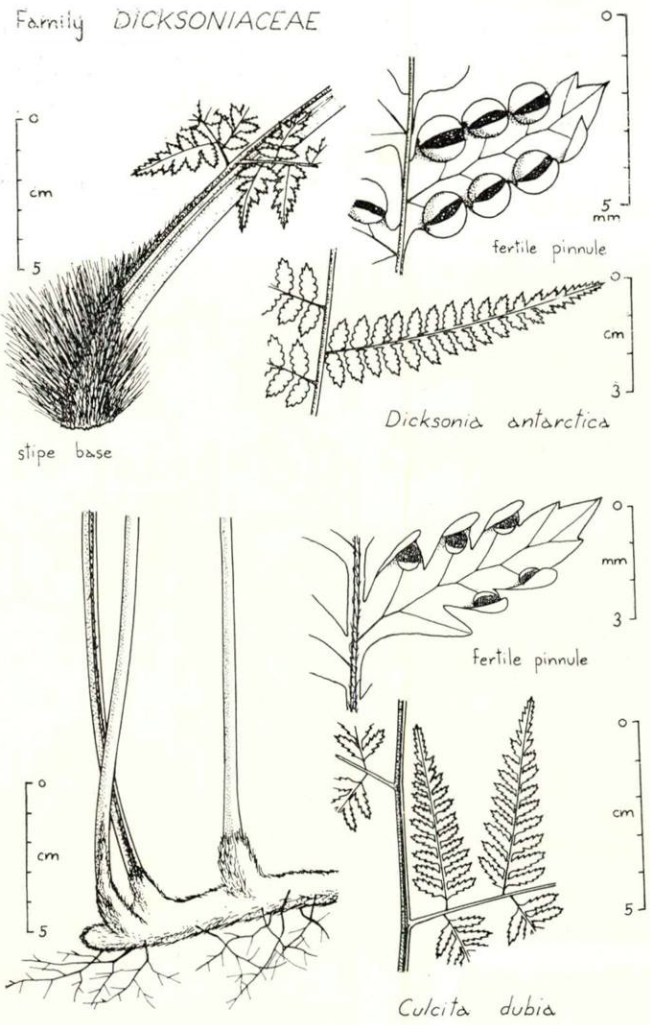
In Australia, this family includes two genera of large terrestrial ferns: *Dicksonia* with two species of tree ferns and *Culcita* which, though not a tree fern, will be discussed here for convenience.



Photography by M. Fagg

Soft Tree Ferns—*Dicksonia antarctica* Labill.

The insert shows the underside of a fertile frond. Sporangia in globular sori on the margins of the midrib of fertile pinnules.



Dicksonia antarctica Labill. SOFT TREE FERN

This common tree fern of south-eastern Australia is distributed from the Bunya Mountains of Queensland south to Tasmania, formerly west to the Mount Lofty Ranges of South Australia where it is now extinct. Shaded rain forest gullies and wet sclerophyll forest of moist mountain sides are the preferred habitats; large groves, tree fern "jungles", are a feature of the Victorian forests.

The trunk is massive, to 15 m tall, upright or leaning, bearing usually one crown of fronds, sometimes several. Fibrous roots densely cover and thicken the trunk, particularly at its base—large specimens may be up to 2 m through, supporting a mass of epiphytes. Fronds are 3-pinnate, the pinnules lobed and serrate, glossy green, paler beneath. Stipes are smooth, green to brown, clothed at their bases with soft red-brown hairs. Sori are globular, about 1 mm in diameter, marginal in the lobes of fertile pinnules. Indusia are bivalvate and cup-shaped, the outer formed by the reflexed pinnule margins.

Dicksonia youngiae C. Moore

This species inhabits moist forest sites, usually near creeks, from north-eastern Queensland south to north-eastern N.S.W.

The trunk grows to 5 m in height and 20 cm diameter, marked by the bases of fallen fronds. Fronds are 3-pinnate, the pinnules deeply lobed. Stipes are clothed in dark brown hairs. Sori are similar to those of *D. antarctica* but are larger, 2 mm in diameter.

Culcita dubia (R.Br.) Maxon COMMON GROUND FERN

C. dubia occurs in *Eucalyptus* forests in shaded gullies or open slopes, from north-eastern Queensland south to Tasmania, west to Glenelg, Victoria.

The rhizome is creeping, 1 to 1.5 cm in diameter, softly hairy with intermixed red-brown and silvery hairs. Fronds reach a length of 150 cm, the lamina 3-pinnate, the pinnules lobed, pale yellowish-green. Stipes are mottled yellow-brown, dark brown at the base. Sori are rounded, one per lobe of the fertile pinnules, with bivalvate indusia—the inner valve delicate, the outer formed by the reflexed pinule margin.

Culcita villosa C. Chr.

Recorded in Australia from Mount Spurgeon, w of Mossman, Queensland, this species occurs throughout New Guinea and Celebes.

C. villosa produces a short trunk bearing fronds to 150 cm long, 3-pinnate, with the pinnules lobed. Stipes are dark at the base, clothed in shining brown hairs. Sori are similar to those of *C. dubia.*

(Continued on page 188)

Editor's Note: It is regretted that articles need to be interrupted and continued later in this manner but the colour plates can only appear on certain pages.

FERN STUDY GROUP—Those interested in ferns may join this group and correspond with the leader Steven Clemesha, 18 Wesson Road, Pennant Hills, N.S.W. 2120. He will be submitting notes on the cultivation of ferns and a report on the tree ferns mentioned here. He would like to hear from anyone who is growing these tree ferns successfully, especially the uncommon ones.

REGISTRATION OF AUSTRALIAN PLANT CULTIVARS

The Australian Cultivar Registration Authority was established some years ago in Melbourne after negotiations with the International Commission for the Nomenclature of Cultivated Plants in Utrecht, Holland. This Authority was set up to prepare and maintain an official register of all named cultivated forms (cultivars) of Australian native plants, which may differ from or are improvements upon the natural or wild species.

Work of the Authority has lapsed over recent years but it has now been reconstituted and is based at Canberra Botanic Gardens.

It is proposed to publish a descriptive list of registered Australian native cultivars as soon as present data is collated. To enable this to be carried out we require the co-operation of nurserymen and growers in advising us of the cultivars that they are growing.

The procedure is to submit to the Authority any name which is being applied or which it is proposed to apply to an Australian cultivar which has originated through breeding, selection etc. A cultivar is defined as follows in the International Code of Nomenclature of Cultivated Plants—1969. "Article 10—(p. 12)"

> "The international term cultivar denotes an assemblage of cultivated plants which is clearly distinguished by any characters (morphological, physiological, cytological, chemical, or others), and which, when reproduced (sexually or asexually), retains its distinguishing characters.
>
> The cultivar is the lowest category under which names are recognised in this Code. This term is derived from cultivated variety, or their etymological equivalents in other languages.
>
> Note 1. Mode of origin is irrelevant when considering whether two populations belong to the same or to different cultivars.

(Continued on page 179. This is our chance to get action!)

A WARATAH HYBRID

R. W. Boden* & R. H. Powell**

Waratahs are spectacular and well known Australian plants cultivated in many parts of the world for garden decoration and sale as cut flowers. In New Zealand for example they are grown to perfection.



The hybrid *T. mongaensis* x *T. speciosissima* (rear cover)

* Department of the Northern Territory, Canberra, A.C.T.
** Department of the Capital Territory, Canberra, A.C.T.

Telopea took pride of place in Vol. 1, No. 1 1959 of *Australian Plants,* with articles on the botanical and horticultural characteristics of the genus, to which readers are referred for information on the botany and cultivation. The parents are shown in colour, one below and the other on the rear cover page.

There are four species confined largely to the south-eastern regions of the mainland and the island of Tasmania. The most spectacular species is *Telopea speciosissima* R.Br., the floral emblem of N.S.W., which occurs naturally in dry sclerophyll forest on sandstone areas from the mid south coast to Gosford, 40 miles north of Sydney. Willis (1959), also records



TELOPEA MONGAENSIS

Braidwood Waratah, *Telopea mongaensis* has proved the most reliable Waratah In Canberra Botanic Gardens. Good specimens are growing In a flat sheltered bed shaded In parts by tall Eucalypts. Soil was added from river excavations and a recently added layer of leaves and bark chips has spurred on growth. Younger plants on the Rain-forest Gully are growing more quickly. This Waratah could be popular in gardens if watered well—Extracted from "Growing Native Plants", Vol. 3, 1973, the most recent of a series of 20 page booklets produced by the Canberra Botanic Gardens, Canberra, A.C.T., and available from them only at 60c each plus 12c postage.

an isolated occurrence in the ranges north-east of Glen Innes). The species has a wide altitudinal range from sea level to above 3,000 feet on the Blue Mountains.

Telopea mongaensis Cheel. also occurs in N.S.W. in a relatively restricted area east and south east of Braidwood. The third species *T. oreades* F. Muell. occurs in both south-eastern N.S.W. and East Gippsland, Victoria, and the fourth species, *T. truncata* R.Br., is endemic to Tasmania, where it is widespread in wet, mountainous regions.

Telopea oreades sometimes attains tree height with a stem diameter of 1-2 feet whilst the other species are erect or spreading shrubs often multi-stemmed reaching 5-10 feet in height.

The flowers of all Telopea species are arranged in dense, terminal racemose clusters giving the appearance of a head. The size, shape and colour of the inflorescences of the different species vary markedly as do the involucres of large, red bracts at the base of each floral cluster.

Although the N.S.W. Waratah has the most spectacular flowers of the genus it has a stiff, erect growth habit and leathery harshly toothed leaves and in the non flowering season is unattractive as a garden plant. By contrast *T. mongaensis* has a more slender growth habit with leafier and softer foliage, but with far fewer flowers in the inflorescence.

As part of the plant breeding programme of the Parks and Gardens Branch, Department of the Capital Territory, Canberra it was decided in 1962 to attempt to hybridise *T. speciosissima* and *T. mongaensis* seeking to produce a hardy Waratah for Canberra conditions, with enhanced foliage and softer toned inflorescences. Similar experiments were carried out by Mr. R. Willing, Botany Department, Australian National University.

Several plants of *T. mongaensis* were collected and raised to flowering stage in containers. As no information was available on self compatibility within the genus it was decided to emasculate the flowers. As the Waratah flower matures the style grows faster than the perianth segments, forcing its way between them and emerging in the shape of a hook. At this stage it is simple to cut the perianth segments and lift them carefully from the stigma. Any pollen already shed onto the unreceptive stigma can be removed with a soft brush.

The pollen was collected by Rev. Colin Burgess near Wentworth Falls, altitude of 2,600 feet, following a search for flowering plants of *Telopea speciosissima* at the coldest point in the range for the species. This was done to ensure that any hybrids produced might have the greatest possible frost tolerance.

Pollination was carried out by dusting the moist stigmatic surfaces of emasculated flowers of *T. mongaensis* with pollen from the opened anthers of the male parent. Seven follicles developed yielding 29 fertile and 18 undeveloped seeds.

A number of seedlings was raised successfully some flowering consistently since the spring of 1970. The hybrid illustrated on page 168 with flowers of both parents, appears intermediate between the two, bearing fewer flowers in each head than *T. speciosissima* (colour plate page 204) but more than *T. mongaensis* (colour plate page 169). Flower colour was a cherry red resembling *T. speciosissima* more closely than *T. mongaensis.*

Whilst the flowers of the hybrid may be less spectacular than the N.S.W. Waratah the plant has a more attractive growth habit and could be a useful addition to Australian native gardens, especially in areas where *T. speciosissima* is difficult to grow.

Experiments, including the use of cuttings and air layers, to establish effective methods of vegetative propagation to perpetuate the hybrid are in progress.

New Fund for Research on Australian Plants

L. A. S. Johnson, Director, Royal Botanic Gardens, Sydney

Research on Australian plants is continuing in Herbaria and Universities in several major Australian cities. These depend primarily on Government support, largely from State sources, but often the support available is severely limited and thus research progress is much slower than we would wish. People interested in Australian plants who have consulted professional botanists for plant identifications or on other questions have often been disappointed by the frequency with which they are told "we know of that species but it has not yet been described and named" or, perhaps, "no one has made the necessary studies to give a definite answer to that question".

There are good, though regrettable, reasons for this ignorance. The 200 years since our flora first received scientific study is a relatively short period compared with the time over which the flora of Europe, for instance, has received botanical attention. Progress has generally depended on surprisingly few botanical specialists, although others, in particular amateur plant collectors, have contributed important information. Moreover, many areas have only rather recently become accessible, and even now some rare species with limited distributions can be reached and studied in their natural habitats only with considerable effort.

Additional funds are needed to speed the progress of research of all kinds on the Australian flora. Although the pace has sometimes been slow in the past, more rapid progress is increasingly necessary as so many of the habitats of our plants are altered or threatened by development. For these reasons, a fund for public subscription, the N.S.W. Royal Botanic Gardens and National Herbarium Scientific Research Fund, has been set up to promote research at the National Herbarium of New South Wales in Sydney. Its establishment was recently announced by the Hon. G. R. Crawford, New South Wales Minister for Agriculture.

It is not our intention to compete with projects underway in other States. Indeed, work on Australian botany, wherever it is done, advances our knowledge of the flora of the entire country. The emphasis will be on plant groups well represented in New South Wales but studies may extend outside our State as plants do not abide by such rigid boundaries. In at least one other State a similar fund exists to support botanical research.

In the first instance, attention must be given to developing present lines of work, rather than starting on new projects. Research into the cultivation of Australian plants cannot be among our first concerns. However, basic research on plant classification is relevant to the enthusiastic grower who is keenly interested to know just which plant he is cultivating. Taxonomic botanists are, of course, concerned with far more than formal classification into genera and species. They are interested in geographic and ecological variation, natural hybridization and reproductive and general biology. All these may throw light on evolutionary relations as well as being worth studying in their own right. The significance of variation and hybridization to the grower of native plants is self evident.

The National Herbarium of New South Wales has many projects underway. These include work on *Eucalyptus, Acacia, Plantago, Tetratheca,* Orchidaceae, Pteridophytes, Proteaceae and Gramineae. In the Gramineae we have detailed studies using the fine structures of cells in the elucidation of major groupings within this large and complex family. In the Rutaceae, work on pollination and floral biology is proceeding. *Acacia* is being investigated in a phytochemical survey, jointly with a noted chemist in South Africa, to determine species relationships. Work on *Eucalyptus* aims to determine its major groupings and their evolutionary development as well as detailed relationships

(Continued on page 197—Please read this article carefully)

APATOPHYLLUM

A SMALL AUSTRALIAN GENUS IN THE PLANT FAMILY CELASTRACEAE

D. J. McGillivray,
National Herbarium of New South Wales, Royal Botanic Gardens, Sydney



APATOPHYLLUM CONSTABLEI

In 1964 Mr. E. F. Constable, the Botanical Collector for the Royal Botanic Gardens, Sydney, collected near Glen Davis, N.S.W. an unusual shrubby plant resembling in habit an Epacrid. On looking at it more closely it was found to belong to the family Celastraceae, but its relationship with other genera was not clear. By a strange coincidence another species in the same genus was discovered in 1966 on the Many Peaks Range near Gladstone, Queensland. Searches through herbarium collections in Australia and overseas did not reveal any other collections of these species.

Subsequent study led to the publication of a new genus *Apatophyllum* with two species, *A. constablei* (Glen Davis) and *A. olsenii* (Many Peaks Range) [D. J. McGillivray in Kew Bull. 25:401-406 (1971)]; see adjoining figs 1 and 2. The name *Apatophyllum* is derived from Greek, and means "deceiving leaves", a reference to its superficial resemblance to the Epacridaceae. The genus is closely related to *Psammomoya,* a Western Australian genus with two species.

Recent Research on the Classification of Australian Plants

by L. A. S. Johnson, Director & Chief Botanist, Royal Botanic Gardens, Sydney

Research workers in plant classification sometimes gain a doubtful reputation of being involved largely in altering the familiar names by which plants are known. Actually, their concern as botanical scientists is in increasing knowledge of many aspects of the groups they study so as to gain understanding of the relationships and evolutionary history of the plant groups. Their aim is a classification which is both practical in use and is consistent with the affinities of the plants. Often they are concerned, too, with the way in which development and distribution of the genera and species are linked with the history of the regions in which they occur.



Fig. 1—*Apatophyllum constablei*



Fig. 2—*A. olsenii*

The results of this work are normally reported in scientific publications. However, it is sometimes possible to present some aspects in a shorter and less technical form and the Editor has invited us to contribute short notes drawing attention to recent developments, in order that readers may keep up to date with some of the work which is going on. Even when the work does unfortunately result in unavoidable changes of plant names, it is desirable that those interested should become aware of the new situation and the correct botanical name as soon as possible.

The article opposite and that following are the first of what we hope will be a continuing series, published from time to time, of notes reporting work at the National Herbarium of New South Wales. Although their emphasis may often be on our own State, some of the plants dealt with will be of interest well outside this region. More detailed technical accounts of the work

reported here are published in the *Contributions from the New South Wales National Herbarium* (the title will soon be changed to *Telopea* for future issues) and in the series *Flora of New South Wales,* obtainable from the office of the Royal Botanic Gardens. I should mention that the latter, the Flora series, is a long-continuing project which has at present covered only a small fraction of the plants of the State and therefore does not yet provide the type of comprehensive treatment of our plants which would be of most general interest.

Current Research on Eucalyptus

L. A. S. Johnson and D. F. Blaxell,
National Herbarium of New South Wales, Royal Botanic Gardens, Sydney

Following the publication in 1971 by L. D. Pryor and L. A. S. Johnson of "A Classification of the Eucalypts", a series of papers has been commenced by L. A. S. Johnson and D. F. Blaxell (National Herbarium, Royal Botanic Gardens, Sydney) entitled "New Taxa and Combinations in *Eucalyptus*". The first was published in the "Contributions from the N.S.W. National Herbarium" (soon to be re-titled "Telopea") in December 1972.

Pryor and Johnson's new classification of the difficult genus *Eucalyptus* included all the known species, whether named or not. It contains about 80 of these known, but unnamed, taxa (i.e. species and sub-species) from all parts of Australia, Southern New Guinea and Timor. Some of these species are well known to many native plant enthusiasts and have widely known common names (e.g. "Faulconbridge Mallee Ash").

Also, there are many groups previously regarded as species but which seem best considered only as subspecies, whereas quite a number of "varieties" are worthy of species status. The series by Johnson and Blaxell will deal with such cases and many of Blakely's varieties will be raised to subspecies rank.

Since 1971, several new species have been discovered in various parts of Australia, 6 or so in Western Australia, 2-3 in Queensland and two on the Southern Tablelands of N.S.W. It is hard to imagine that more will be found, but this statement was also made in 1971!

Following are notes on the species treated in Johnson and Blaxell's paper.

1. *Eucalyptus sphaerocarpa,* "Blackdown Stringybark"—restricted to the Blackdown Tableland (about 160 km west of Rockhampton, Qld.). This is a very common tree on the top of the Tableland and is commercially valuable. It is a tree up to 25 m high and has a fibrous bark to the smallest branches but, despite its common name, is not botanically one of the true Stringybarks. The name *"sphaerocarpa"* means "round or spherical fruit". This species is most closely related to *E. planchoniana,* "Bastard Tallow Wood", and somewhat less closely to *E. pilularis,* "Blackbutt", neither of which occurs near the Blackdown Tableland.

2. *E. stenostoma,* "Jillaga Ash"—known only from four small (a few hectares) areas in the Jillaga region NW of Nerrigundah, in the South Coast ranges of N.S.W. It was first discovered by a local Forester who noticed patches of flowering trees in larger stands of other species (which were not flowering) on aerial photographs. Checking on the ground resulted in specimens being sent to the N.S.W. National Herbarium for identification. The tree proved to be closely related to *E. fraxinoides,* "White Ash", a common tree of the region. However, the new species differs from the "White Ash" by (i) narrower openings to the fruit; (ii) more numerous buds per inflorescence; (iii) glaucous leaves, stems, buds and fruits; (iv) the lateral veins at a more acute angle to the midvein, and (v) absence of insect "scribbles" on the trunk (these are a noticeable feature of *E. fraxinoides).*

The name *"stenostoma"* means "narrow mouth", alluding to the opening of the fruit.



E. sphaerocarpa
buds and fruit

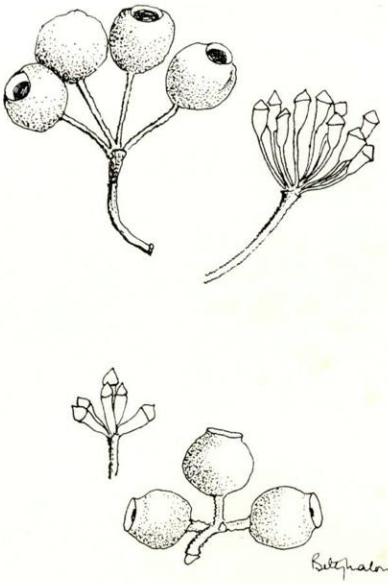
E. burgessiana
leaf, buds and fruit

3. *E. dendromorpha*—this was first described as *E. obtusiflora* var. *dendromorpha,* but is considered different enough from the "Port Jackson Mallee" *(E. obtusiflora)* to be treated as a species. It is a small tree or tall mallee on moist, semi-sheltered sites on the Blue Mountains and southward to west of Nowra. It is common above Wentworth Falls and also around Fitzroy Falls.

4. *E. burgessiana,* "Faulconbridge Mallee Ash"—a restricted species of mallee habit; locally common north of Faulconbridge and Linden in the Blue Mountains. Its nearest relatives are *E. obtusiflora* and *E. stricta* and it is named in honour of the Rev. Colin Burgess who first brought it to the attention of the botanists at the N.S.W. National Herbarium.



E. paliformis



E. stenostoma—buds and fruit
E. fraxinoides—buds and fruit

5. *E. rupicola,* "Cliff Mallee Ash". This is a small, dense, many-stemmed shrub of mallee habit between 0.5 and 2 metres high with a bluish-grey colour to the leaves and young stems. This bluish colouration tends to diminish with age. The species is quite common on the edges of the high cliffs of the Jamieson, Megalong, Kedumba and Grose Valleys of the Blue Mountains. The name *"rupicola"* means "cliff dwelling".

6. *E. barberi,* "Barber's Mallee"—confined to granitic, rocky ridges in sclerophyllous scrub north of Cranbrook, eastern Tasmania. It is a mallee to about 5 m high and is related to *E. ovata* "Swamp Gum", *E. camphora* "Broad-leaved Sally" and *E. yarraensis* "Yarra Gum". It is named in honour of the late Professor H. Newton Barber who investigated some abnormal plants of this species in 1952 and who made important studies on the genetics of *Eucalyptus,* especially in Tasmania.

7. *E. sturgissiana,* "Sturgiss' Mallee"—a very restricted species from the Sassafras region SW of Nowra, N.S.W. It is only known from 3 stands, two with no more than 30 or 40 plants and the other with 2-3. It is a very distinctive mallee with rounded, bluish-green juvenile leaves, green adult leaves and very glaucous stems, buds and fruits. It grows in areas of heath on very shallow soil with no other eucalypts (although others may be nearby on different sites). It is named for Major Jim Sturgiss of Sassafras who discovered it some 25 years ago. Following directions from Major Sturgiss, a patch of this species was located some three years ago about 12 miles north of Sassafras on the Ettrema Plateau. One other stand NE of Sassafras was known but could not be re-located by searching on the ground. Therefore a light aircraft was used to fly over and locate the Ettrema Plateau stand and when it was recognised, aerial traverses were made in search of similar sites. One such was found near Tianjara Falls, plotted on the map and subsequently visited on the ground.

This species is very distinctive but appears to be related, though not extremely closely, to *E. kitsoniana,* "Kitson's Mallee" and *E. neglecta,* "Omeo Gum".



Eucalyptus sturgissiana—juvenile leaves, mature leaves, fruit and buds.

THE MAINLAND BEDFORDIA

by A. M. Gray, Canberra

Bedfordia arborescens Hochr. in Candollea 5:332-334 (1934), "Blanket Leaf".

This fairly common shrub or small tree of the moister sub-montane gullies of eastern N.S.W. and A.C.T. and Victoria has, in the past, been mistakenly referred to *B. salicina* (Labill.) DC. The latter, a species confined to Tasmania, was first described in 1806 as *Cacalia salicina* by the famous French botanist J. J. de Labillardiere from material he had collected himself.

Investigation by the present author, early in 1973, indicated that the mainland plant differed from the Tasmanian one sufficiently to warrant their separation into two distinct species. In the course of the research relevant literature was consulted, fresh specimens and herbarium collections from widely differing localities were examined and expert opinion was sought. Work was well under way towards publishing a name for the mainland *Bedfordia*.

For further comparisons of the mainland *Bedfordia* with *B. salicina*, a request was made through the Australian Botanical Liaison Officer at Kew Herbarium for photographs of the type specimen of the latter species. A letter in reply brought to the author's attention the fact that the mainland species had already been named by B. P. G. Hochreutiner, in 1934, as *B. arborescens* and the description could be found in "Candollea", a French-Swiss scientific journal! Apparently, by an unusual chance Hochreutiner's work had been missed or overlooked by botanists since 1934.

By coincidence, Dr. N. T. Burbidge of the Australian Herbarium in Canberra, had, at nearly the same time, also received information regarding the separation of the two species.

A table setting out the differences between *B. arborescens* and *B. salicina* is given at the end of this article. These two species are separate in their geographical distributions; there are no intermediates or connecting forms between them. It is worthy of note that intermediates between *B. salicina* and *B. linearis* (another species confined to Tasmania) do occur. Typical representatives of the two Tasmanian species are well-defined but the intermediates are difficult to classify.

Table summarizing the major differences between the two species.

B. salicina	*B. arborescens*
Leaves—10-17 cm x 1.0-2.5 cm.	—18-24 cm x 2.0-4.5 cm.
Venation—impressed on upper surface, prominent on lower surface, not terminating at the margins with a mucro.	—impressed on upper surface, obscured and not readily noticeable on the lower surface, the major lateral veins terminating at the margins with a small, blunt mucro.
Margins—sub-crenate, shortly and closely revolute.	—crenate, obscurely revolute, the infolding obscured by the indumentum.
Indumentum—very short and dense, a single layer of very closely appressed, tangled hairs, not obscuring the prominent veins.	—in two layers, under layer dense, tangled and closely appressed; the secondary layer of long, floccose hairs obscuring the veins. The hairs of this "secondary" layer originate from the apices of glandular protuberances which arise from the cell surface; some of these long, tangled hairs may be irregularly branched 2-3 times, although the majority are quite simple.

Inflorescence—short, quite dense axillary panicles. Rhachis quite stout. Rhachilla short, stout, axes lengthening only slightly after anthesis. Peduncles mostly absent or to 3 mm long. The bracteoles short, stout. Indumentum very short, dense, the individual hairs not discernible to the unaided eye.

—long, loose axillary panicles or corymbs. The rhachis relatively insubstantial, brittle. Rhachilla almost as long as the rhachis, also thin and brittle; axes lengthening following anthesis. Peduncles 1-2.5 cm long. Bracteoles long (c.1.0 cm), filiform, dry. Indumentum long, loose but thick, the hairs quite distinguishable.

An interesting fact arises with respect to the application of the common names "Blanket Leaf" or "Flannel Leaf". To the author's knowledge neither of these names has ever been given to the Tasmanian *B. salicina* and appear to be applied only to the mainland species. Perhaps this is due simply to the fact that *B. salicina* does not possess the long woolly hairs on the young stems and undersurfaces of the leaves so characteristic of *B. arborescens.* The hairs on the stems and leaves of *B. salicina* are very short and tightly crisped, not at all woolly, and certainly not resembling the nap of a blanket.

ACKNOWLEDGEMENTS

I am indebted to Mr. G. M. Chippendale, Australian Botanical Liaison Officer at Herbarium Kew, for valuable assistance in bringing to my attention the existence of a valid name for the mainland *Bedfordia,* and for procuring photographs of type material.

Dr. N. T. Burbidge, Herbarium Australiense; Mr. J. H. Willis, National Herbarium, Melbourne, and Mr. M. I. H. Brooker, Forest Research Institute, Canberra, all offered extremely useful advice.

Thanks are also due to the staffs of the Melbourne and Sydney National Herbaria for their help in enabling me to examine the collections of *Bedfordia* held by these institutions.

For valuable criticism and assistance with the compilation of the manuscript I offer my appreciation to Mr. N. Lander, National Herbarium, Sydney.

REGISTRATION OF AUSTRALIAN PLANT CULTIVARS—*cont. from page 167*

Note 2. The concept of cultivar is essentially different from the concept of botanical variety, varietas. The latter is a category below that of species. Names of botanical varieties are always in Latin form and are governed by the Botanical Code."

The following information is also required:

(1) The name of the originator or introducer if any, and the date of its introduction.
(2) The parentage when known.
(3) A full description of the plant including shape of bush, approximate height, flower colour etc.
*(4) A fresh flowering specimen to be submitted to the Authority.
(5) Two colour prints, one showing habit and one showing flower.

*Flowering specimen should be a fresh cut approximately 40 cms. long and packed in damp newspaper or polythene so flowers remain fresh during transit.

The Authority will, in due course, inform you that your name has been accepted, provided that the proposed name is not already in use for another plant and that it conforms with certain requirements of a Code of Rules.

Briefly, these requirements are that the cultivar name is in a modern language (not Latin unless applied before 1959), not over difficult to pronounce or too long (preferably of one or two words only) not misleading or unfair to other growers, not too similar to a name already in use in the same genus. It is hoped that copies of the Code of Rules will be available from the Secretary before the end of the year. The price is uncertain but will be in the order of $1.50. Orders without payment will be accepted now.

All submissions should be made to Mr. J. W. Wrigley, Secretary, Australian Cultivar Registration Authority, c/- Botanic Gardens, Canberra, A.C.T. 2601.

For inclusion in the published list of Australian Cultivars all submissions must be received by 31st December, 1973.

WORLD FERN FAMILIES

The introduction to ferns on page 158 is continued here for those interested in classification. The more general article is continued on page 182.

The only recent work to include all fern genera is E. B. Copeland's Genera Filicum (1947). Pichi-Sermolli (1958), published a scheme of classification including both fossil and living genera.

In the 1966 revision of Willis' Dictionary of Flowering Plants and Ferns, Professor R. E. Holttum has combined Copeland's and Pichi-Sermolli's ideas. Holttum regards several of Copeland's families as unnatural, particularly *Pteridaceae* and *Aspidaceae*, preferring Pichi-Sermolli's arrangement of families to which Copeland's genera have been allocated. This provides a complete and workable system of classification for the world's ferns, at least temporarily; modification may be necessary as further taxonomic research is completed.

(Phylum) *PTERIDOPHYTA*

* groups with no representatives native in Australia.

(Class) *LYCOPSIDA*

(Orders) Isoetales,	(Family) Isoetaceae (quill worts).
Lycopodiales	Lycopodiaceae (club-mosses, tassel ferns).
Selaginellales,	Selaginellaceae (club-mosses).
**SPHENOPSIDA*	
*Equisetales,	*Equisetaceae (horse tails).
PSILOPTOPSIDA	
Psilotales	Psilotaceae (skeleton club-moss).
	Tmesipteridaceae (fork-ferns).

PTEROPSIDA (FILICOPSIDA) true ferns
(sub-order FILICIDAE)

Aspidiales	Aspidiaceae
	Aspleniaceae (includes Asplenium the birds-nest ferns and spleen worts).
	Athyriaceae
	Lomariopsidaceae
	Thelypteridaceae
Blechnales	Blechnaceae
Cyathales	Cyatheaceae (including tree ferns of genus Cyathea).
	*Lophosoriaceae
Davalliales	Davalliaceae (includes Davallia spp., the hare's foot ferns).
	Oleandraceae (includes Nephrolepis the fishbone fern).
Dicksoniales	Dennstaedtiaceae (includes Pteridium bracken spp.)
	Dicksoniaceae (includes Dicksonia tree ferns spp.)
	Lindsaeaceae
Gleicheniales	Gleicheniaceae
Hymenophyllales	Hymenophyllaceae (filmy ferns).
*Hymenophyllopsidales	*Hymenophyllopsidaceae
*Loxsomales	*Loxsomaceae
*Matoniales	*Matoniaceae
*Plagiogyriales	*Plagiogyriaceae
Polypodiales	*Cheiropleuriaceae
	*Dipteridaceae
	Grammitidaceae
	Polypodiaceae (includes Platycerium spp. the staghorns).

Pteridales	Adiantaceae (includes Adiantum spp. maiden hair ferns).
	*Cryptogrammataceae
	*Negripteridaceae
	Parkeriaceae
	Pteridaceae (includes Pteris spp. the brakes).
	Sinopteridaceae
	Vittariaceae
Schizaeales	Schizaeaceae
MARATTIIDAE	
Marattiales	Angiopteridaceae
	*Danaeaceae
	Marattiaceae
	*Kaulfussiaceae
MARSILEIDAE	
Marsileales	Marsileaceae (includes Marsilea Nardoo spp.)
OPHIOGLOSSIDAE	
Ophioglossales	Ophioglossaceae (includes Ophioglossum spp. the adder's tongue fern).
OSMUNDIDAE	
Osmundales	Osmundaceae (includes Todea spp. tree ferns).

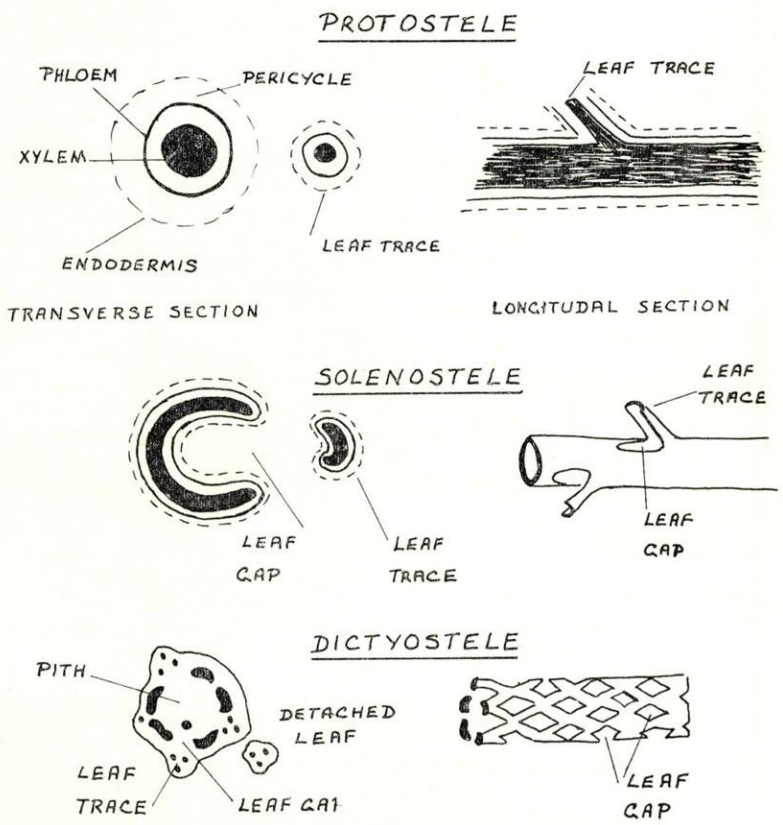


FIG. 1

FERNS

BOTANICAL DESCRIPTION

The ferns differ from all other groups in having relatively large, usually compound leaves, each leaf being curled like a crozier when young. The fertile leaf or sporophyll usually carries numerous small sporangia, and the group is by far the most abundant of the Pteridophytes.

Ferns are perennials, almost always with some kind of root-stock or rhizome. A few species form unbranched trees, though the "trunk" in such cases is largely composed of matted adventitious roots. Most ferns are recognisable as such, the rolling of the young leaves (hardly to be found in any other group of plants) being one of the best clues. There are, however, some specialised ferns of very atypical aspect. Some aquatic ferns are not at all fernlike in appearance, and some forest-dwelling species—filmy ferns—resemble mosses in their texture.

In most ferns every organ (stem, leaf, or root) has a single apical cell, from the division-products or segments of which all the tissues are produced. In radially symmetrical structures, roots and the majority of stems, the apical cell is a tetrahedron or triangular pyramid; in a stem this has three cutting faces, but in a root, the fourth or outer face is active in producing the root cap. In dorsiventral structures, leaves and some creeping stems, the apical cell often has only two cutting faces.

There is little that is remarkable in the outer tissues—epidermis, cortex, mesophyll—of ferns, and these tissue systems are basically parenchymatous, similar in construction to the tissues of dicotyledons. In the stems and petioles there is a strong tendency for the outer cortex to become sclerotic, and the rigidity of these organs often depends far more upon lignified cortical tissue than upon the vascular system, which is mechanically weak in all ferns. In general the leaf lamina (blade) displays the characteristic features of shade leaves—poor differentiation between palisade and spongy mesophyll, chloroplasts (bodies containing chlorophyll) in epidermal cells etc. The vascular tissues of ferns are highly distinctive in their structure and arrangement. The xylem consists mainly of scalariform tracheids, a type which is relatively uncommon in seed plants. The side wall of a scalariform tracheid has bordered pits which are elongated sideways, the wall as a whole therefore presenting a ladderlike appearance. These tracheids are often of great size, and are embedded in a small-celled non-lignified xylem parenchyma. In addition there are small patches of protoxylem, in which the tracheids are smaller, and may have spiral thickenings. The phloem consists of sieve cells and parenchyma. The sieve cells are elongated with pointed ends, with sieve areas upon their side walls. There are no highly specialised sieve plates, and no companion cells. Fibres do not occur in the vascular systems of ferns, nor is there usually any lignification of the xylem and phloem parenchyma, nor, in the vast majority of ferns, is there the slightest sign of cambial activity.

The arrangement of the tissues in the root conforms closely to that seen in seed plants. A majority of fern roots are diarch, though other forms occur. Lateral roots arise from the endodermis rather than the pericycle, a rule which applies also to the origin of 'adventitious' roots from a fern stem.

The arrangement of the vascular tissues in fern stems is so different from that in the stems of seed plants that a special terminology is needed. See fig. I. We cannot recognise in the ferns any counterpart of the vascular bundle in the higher plants. The simplest pattern is that in which the xylem forms a solid rod in the centre of the stem with a layer of phloem surrounding it. This is known as a protostele. All ferns are protostelic in the early stages of growth; some remain protostelic throughout life, but in the majority the vascular system assumes a more elaborate form as the plant matures. The diagram of the protostele introduces two principles which apply almost universally to all fern stems. Firstly, the whole vascular system, leaf traces

included, is completely clothed in layers of pericycle and endodermis similar in all essential features to those normally seen in roots. Secondly, the number and arrangement of the protoxylem groups in ferns is so variable that no general statement can be made, and the protoxylem clearly has little if any influence upon the form of the vascular system as a whole.

Protostelic stems are usually small, and the departure of the single leaf trace strand occasions little disturbance. In many ferns of greater size, the departure of a leaf trace leaves an appreciable cavity in the xylem core. This cavity is lined with phloem, pericycle, and endodermis, and there is a tendency for such cavities to continue from one node to the next. This gives us a solenostele, a tubular system with a central pith which meets the cortex at every node through the leaf gap. The layers of phloem, pericycle and endodermis are uninterrupted inside as well as out. Some ferns, having achieved the solenostelic condition, maintain it to the end, others pass on to further elaboration.

An increase in the number of openings from pith to cortex produces a dictyostele. In some ferns, e.g. *Dryopteris,* the dictyostele arises simply because the internodes are so short that several leaf gaps are visible in every T.S., but in other cases e.g. *Pteridium,* there are perforations, openings in the stele which are independent of any leaf. In T.S. a dictyostele appears as separated meristeles, i.e. partial steles; a meristele, because of its concentric structure and because it often has several widely-spaced protoxylem groups, is quite a different thing from a vascular bundle. In many dictyostelic ferns there are several traces to a leaf, and the petiole may have an elaborate structure. As well, some ferns produce internal stelar systems inside the pith of the first one, giving polycyclic dictyosteles, or sometimes polycyclic solenosteles.

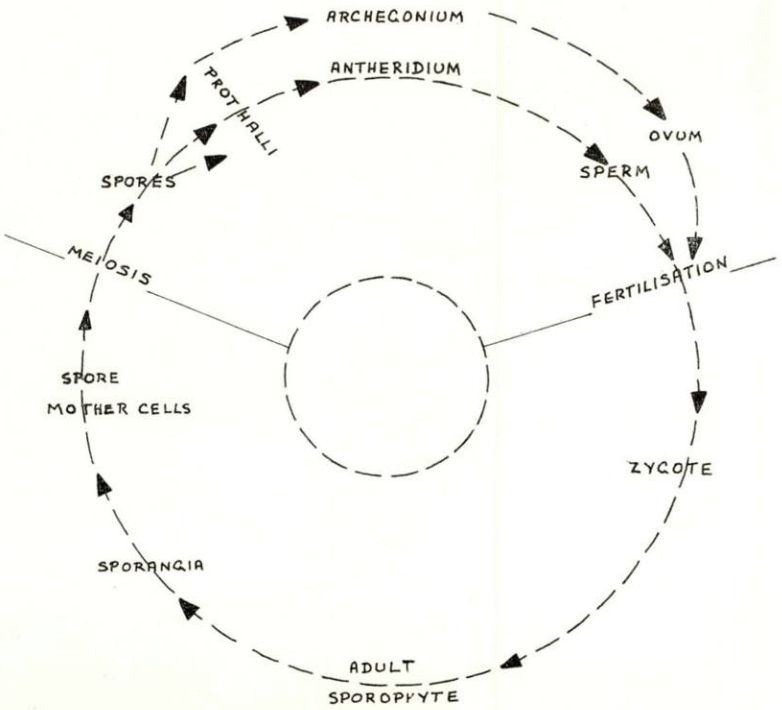


Fig. II—Life cycle in homosporous Pteridophytes

REPRODUCTION OF FERNS

The basic life-cycle, common to bryophytes and pteridophytes, can be represented diagrammatically (see Fig. II). Under normal circumstances there is a regular alternation between a gametophyte (sexual, the prothalli) phase and a sporophyte (asexual, the mature plant), phase. On the prothalli (see Fig. III), the male gametes, produced in numbers from antheridia, are known as antherozoids, since they are flagellated and are able to swim in water, while the female gametes (egg-cells), are non-motile and are borne singly in flask-shaped archegonia. Fusion between an egg and an antherozoid results in the formation of a zygote, which contains the combined nuclear material of the two gametes. Its nucleus contains twice as many chromosomes as either of the gamete nuclei and it is therefore described as diploid consequently developing into the mature plant. Ultimately, there are released from the sporophyte a number of non-motile spores, in the formation of which meiosis brings out a reduction of the nuclear content to the haploid number of chromosomes. The life-cycle is then completed when these spores germinate and grow, by mitotic divisions, into haploid gametophytes (the prothalli).

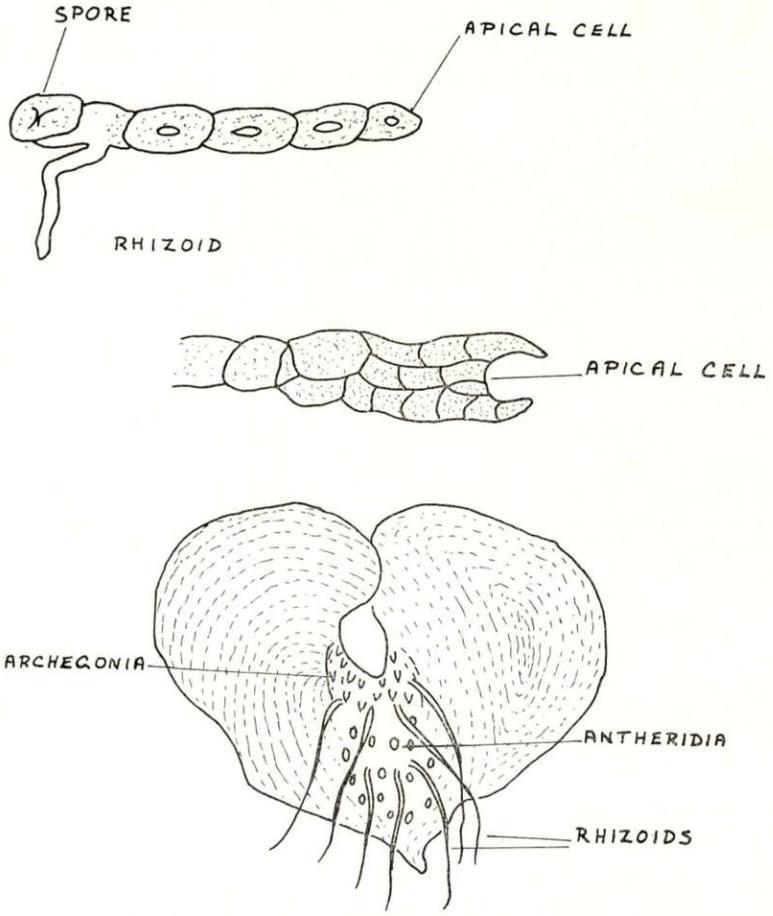


Fig. III—Germination of Spore and Development of Prothallus of Fern

In mosses and liverworts, the dominant phase in the life-cycle is the gametophyte, for the sporophyte is retained upon it throughout its life,

and is either partially or completely dependent on it for nutrition. By contrast, among pteridophytes the sporophyte is the dominant generation, for it very soon becomes independent of the gametophyte (prothallus), and grows to a much greater size. Along with the greater size is found a much greater degree of morphological and anatomical complexity, for the sporophyte is organised into stems, leaves and (except in the most ancient fossil pteridophytes and the most primitive living members of the group), roots. Only the sporophyte shows any appreciable development of conducting tissues (xylem and phloem), for although there are recorded instances of such tissues in gametophytes, they are rare and the amounts of xylem and phloem are scanty. Also, the aerial parts of the sporophyte are enveloped in a cuticle in which there are stomata, giving access to complex aerating passages that penetrate between the photosynthetic palisade and mesophyll cells of the leaf. All these anatomical complexities confer on the sporophyte the potentiality to exist under a much wider range of environmental conditions than the gametophyte. However, in many pteridophytes these potentialities cannot be realized, for the sporophyte is limited to those habitats in which the gametophyte can survive long enough for fertilization to take place. This is a severe limitation on those species whose gametophytes are thin plates of cells that lack a cuticle and are, therefore, susceptible to dehydration. Not all gametophytes are limited in this way, for in some pteridophytes they are subterranean and in others they are retained within the resistant wall of the spore and are thus able to survive in a much wider range of habitats. It is notable that wherever the gametophyte is retained within the spore, the spores are different sizes—heterosporous—the larger megaspores giving rise to female prothalli which bear only archegonia, and the smaller microspores giving rise to male prothalli bearing only antheridia.

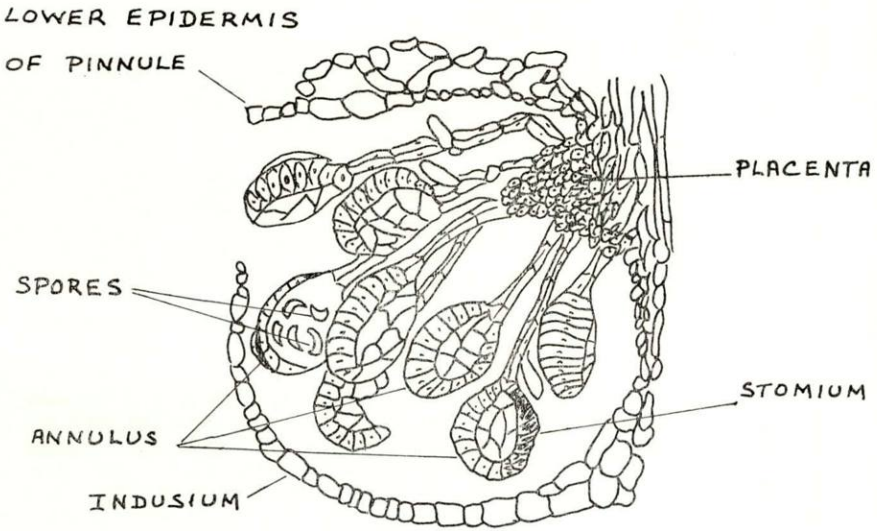
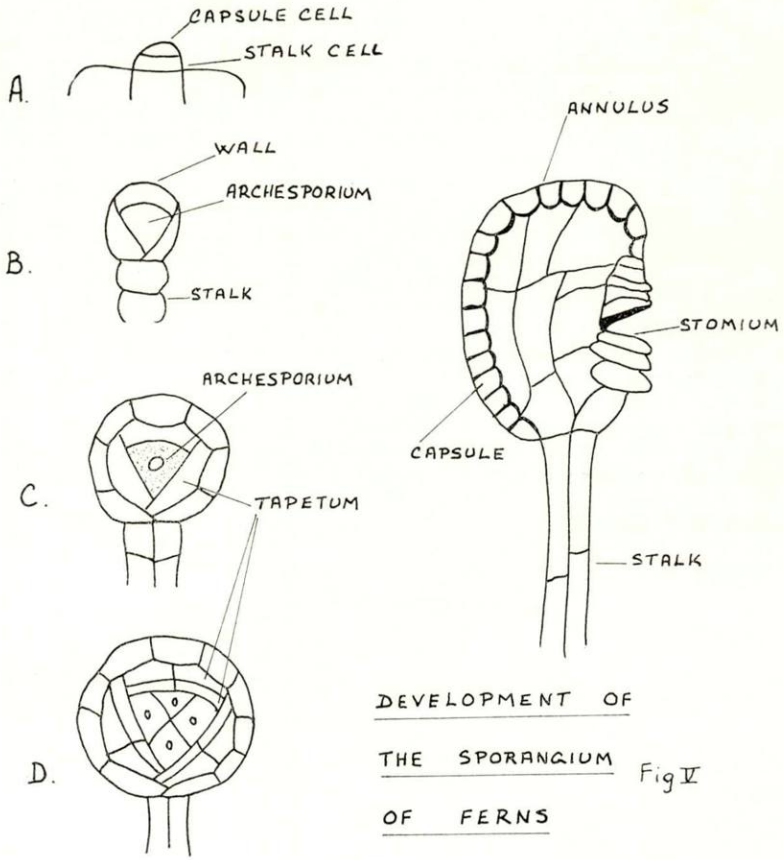


Fig. IV—Pinnule of Fern Through Sorus—Vertical Section

Some ferns such as bracken, have active rhizome-systems, but in many others there is little power to spread vegetatively. Only a few species have more specialised means of vegetative propagation such as bulbils on the leaf; all ferns however, produce sporangia.

The primitive pattern of fern sporangium is a globular structure as much as a millimetre in diameter, with a wall several cells thick, and a central cavity in which spore mother cells divide meiotically to form tetrads of spores. Such sporangia are found in a small number of living species.

The output may be more than a thousand spores from each sporangium, and dehiscence by a slit involves no great structural refinement, with the sporangial wall merely bending back a little as it dries. In the great majority of living ferns, the sporangium is much smaller and more delicate, with a refined dehiscence-mechanism, and with a spore output of about sixty-four (in *Dryopteris* usually only forty-eight).



DEVELOPMENT OF THE SPORANGIUM OF FERNS Fig V

Sporangia are produced in large numbers on the lower side of the leaf, or sometimes on its edge. A group of sporangia is called a sorus (See Fig. IV). The slight thickening of the leaf to which the stalks of sporangia are attached is the placenta, and the membranous flap which often covers the sorus is the indusium. The sori and indusium vary a great deal in shape and arrangement from species to species, and in fact the classification of ferns is largely based on this fact. In most ferns the leaves which produce sori are not otherwise very different from those which do not, but in some examples the fertile leaves (or parts of leaves) show a great reduction in the extent of the lamina.

In most sori the development of sporangia is spread over a period, so that sporangia of different ages stand side by side. In the development of the common type of sporangium the sequence of cell divisions is very regular, giving a wall one cell in thickness, a tapetum or nutritive layer, and an archesporium or spore-producing tissue. The stalk commonly consists of two or three rows of cells. There is no vascular tissue in the sporangia

themselves, the placenta is vascularised. The head of sporangium is encircled by a special row of cells, some of these cells having all their walls heavily thickened except the outer one, and forming the annulus, others forming a line of weakness at the stomium (see Fig. V). The cells of the annulus play an important part in the liberation of the spores. As the sporangium ripens, it tends to dry out. The annulus cells are full of water, but some of this evaporates through the outer wall, which is consequently drawn inwards. The cohesion of the water and its adhesion to the wall are strong enough to set up in the annulus a tension which ruptures the stomium, and indeed the body of the sporangium is torn almost in half across the middle, the

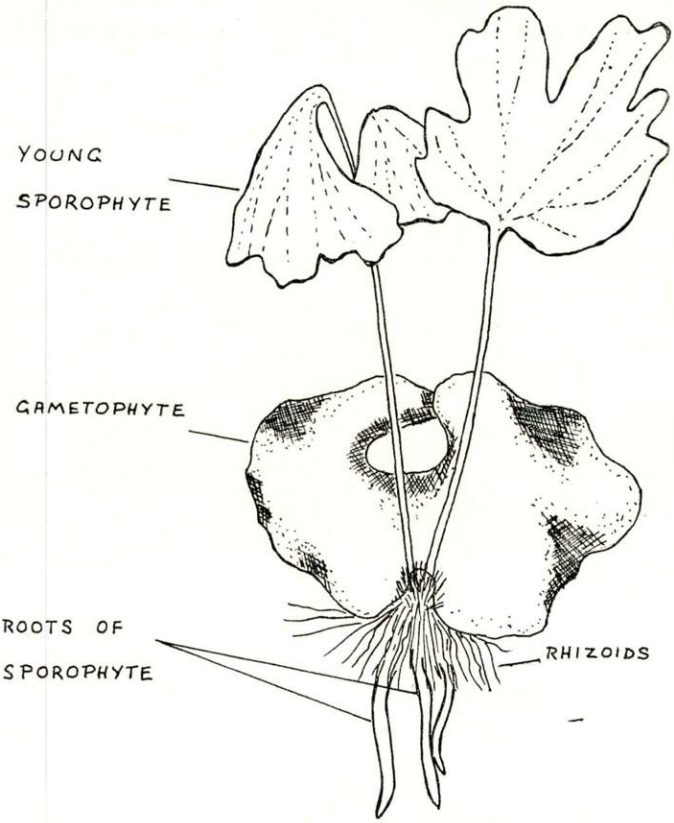


Fig. VI—Fern Gametophyte with attached young sporod.

upper portion being thrown right back like the hinged lid of a box. This movement is quite slow, but as drying continues, a point is reached at which the water in the cells breaks suddenly, the upper part of the sporangium then returning to its original position with a jerk which throws out the spores to a distance of a centimetre or so, thereby setting them free in any passing current of air. Spores which then find a favourable environment may proceed to develop slowly by mitosis and meiosis (q.v.) through the prothalli stage to the mature fern, as described (See Fig. VI).

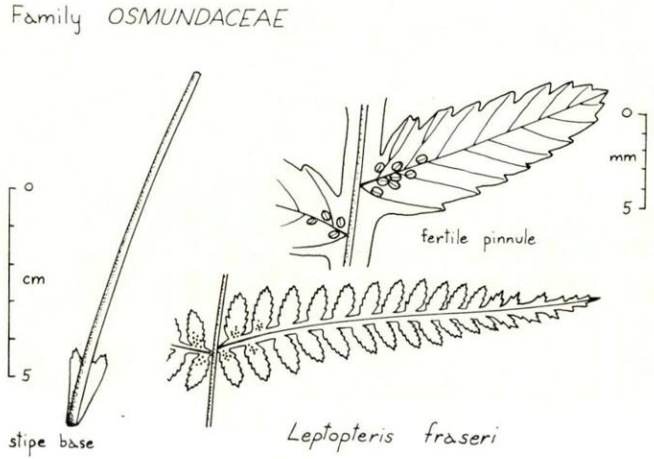
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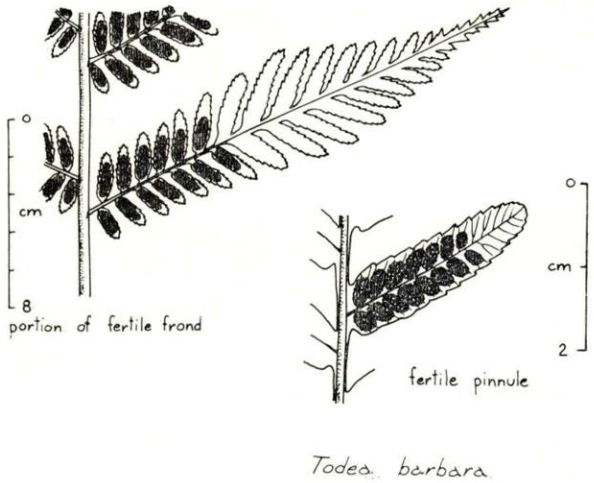
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THE AUSTRALIAN TREE FERN FAMILIES—*continued from page 167*

Family *OSMUNDACEAE*

In Australia, the family Osmundaceae includes two large ferns which, though out of taxonomic context, are sometimes regarded as tree ferns. They are terrestrial ferns with erect trunks bearing crowns of spirally arranged fronds. Sporangia are borne on the underside of the pinnules towards the base of fertile fronds. In the family Osmundaceae, sporangia are not grouped into sori—they are uncovered, globular structures opening by a slit, either scattered singly or in oblong or confluent masses. The two genera in Australia are *Todea* and *Leptopteris*, each represented by one species.





KING FERN OR SWAMP TREE FERN



Photography by M. Fagg

The insert shows sporangia are not grouped in sori but in oblong masses becoming confluent at maturity on *Todea barbara.*

Todea barbara (L.) T. Moore KING FERN or SWAMP TREE FERN

Occurring in Australia from north-eastern Queensland south to northern Tasmania and the Mount Lofty Ranges of South Australia, the distribution of *T. barbara* extends to New Zealand and South Africa. This species prefers moist situations beside creeks or in crevices in rock faces, from the coast to the mountains.

The trunk is massive, up to 3 m tall and over 1 m broad, bearing several crowns of fronds up to 3 m long. Fronds are 2-pinnate, the pinules serrate, shining green above, paler beneath. Stipe bases bear stipular wings. Sporangia are massed on the undersurface of the lower pinnae of fertile fronds in oblong or confluent clusters, coloured dark red-brown.

Leptopteris fraseri (Hook. et Grev.) Presl.

Inhabiting wet shaded gullies, often in caves beneath waterfalls, this species occurs in eastern Australia from the mountains of north-eastern Queensland to the South Coast of N.S.W.

This species develops a short trunk 1 m in height, bearing a single crown (rarely several crowns) of fronds. Fronds are up to 150 cm long, the lamina filmy,

2-pinnate, the primary pinnae almost opposite, the pinnules serrate and joined by decurrent membranous wings. Stipe bases bear two red-brown stipular wings. The sporangia, coloured orange-brown at maturity, are clustered irregularly towards the base of fertile pinnules.

CULTIVATION OF TREE FERNS:

Provided plenty of water and some shelter, tree ferns are hardy garden subjects and adaptable to pot or tub culture. With the exceptions of *Dicksonia antarctica, Cyathea australis, Cyathea cooperi* and *Todea barbara,* tree ferns are rare in cultivation.

Dicksonia antarctica is a particularly hardy species, enduring frost and snow. Thus it is suitable for climates as severe as Canberra. Offered for sale in many nurseries of south-eastern Australia as cut-off trunks, *D. antarctica* establishes readily. If potting into tubs or large pots, the size of the container should allow about 10 cm of loam around the trunk. A rich sandy loam is an ideal medium; mulching is beneficial. Watering should be done at least twice a day until established. Removal of most of the fronds will cut water loss.

Cyathea species are generally not as hardy as *Dicksonia antarctica* though *C. australis* will survive in Canberra given protection. The more tender species such as *C. robertsiana* require glass-house cultivation in the severe climates.

Todea barbara is hardy and easily grown, thrives when potted and thus sometimes called "tub fern".

Tree ferns are easily raised from spores. This method of propagation will be covered in a future article.

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COLEANTHERA—*continued from page 191 opposite*—

3. *Coleanthera virgata* Stschegl.

This erect shrub, up to 30 cm high has thin wiry branches frequently somewhat pubescent. The linear or linear-lanceolate leaves which are usually glabrous have inconspicuous veins. Flowers are white and the corolla-lobes are bearded at the base only.

KEY TO THE SPECIES

A. Leaves strongly veined below, usually hairy ..... 1. *C. coelophylla*
Leaves smooth, veins fine and not prominent, usually glabrous. B.
B. Leaves ovate or orbicular;
corolla-lobes more or less bearded to the end ..... 2. *C. myrtoides*
Leaves linear or linear-lanceolate;
corolla-lobes bearded at base only ..... 3. *C. virgata*

Editor's Note: Betsy Jackes has described all species in many of the genera in the family Epacridaceae in series form. I try to accompany the series with a colour plate of at least one species but this time I failed. Will Western Australian readers make a special effort to find these species during this season and take colour slides. You may send specimens to her at the University in Townsville, Qld.

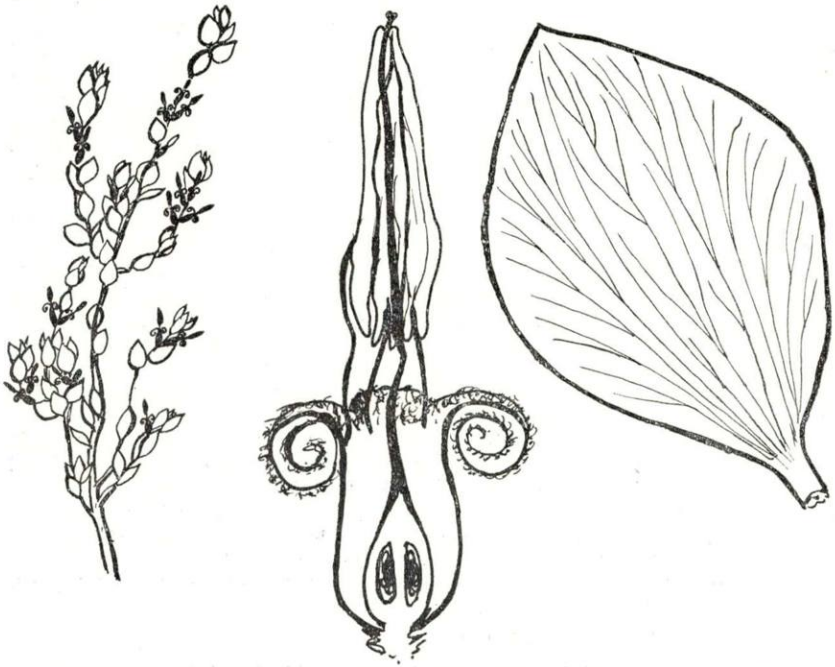
COLEANTHERA

The Genus by Betsy R. Jackes, James Cook University of North Queensland

The Genus *Coleanthera* Stschegl. belongs to the plant family Epacridaceae. It is easily distinguished from *Styphelia* and *Leucopogon* by the exserted anthers which are connate around the style. The frequently coiled corolla-lobes are narrow, and bearded, at least at the base.

Three species have been described from the south-western corner of Western Australia chiefly in the Districts of Stirling and Eyre, particularly in open sandy areas.

Although these species have been described and maintained in "How to Know Western Australian Wildflowers" by W. E. Blackall and B. J. Grieve, the West Australian Herbarium considers that there is probably only one species *C. myrtoides,* and that if the other two exist then they are rare and should anyone locate them, they would be most interested to receive specimens.



Coleanthera myrtoides—Habit x 2/3rds; Flower cut in half x 12; Leaf x 10.

1. *Coleanthera coelophylla* (A. Cunn.) Benth.

This species is easily distinguished by the strongly veined ovate or lanceolate leaves and the general hairiness of the plant. An erect bushy shrub 30-60 cm high; the leaves are frequently grouped resulting in a pseudo-whorled appearance.

The small axillary flowers are usually deep pink but sometimes white ones are found. Flowering occurs mainly in November.

2. *Coleanthera myrtoides* Stschegl.

This is the most widespread species being found in the districts of Stirling, Eyre and Coolgardie. An erect bushy shrub 30-100 cm high the branches of which may be somewhat pubescent. The glabrous leaves are ovate or orbicular with inconspicuous veins. The flowers are pink, sometimes white, the coiled corolla-lobes are bearded to the end. Flowering period is September-January.

(Continued on opposite page, number 190)

Toxicology of Chemicals used for Insect Control on Trees and Shrubs

By Dr. JOHN A. WEIDHAAS, Jr.
Extension Entomologist, Virginia Polytechnic Institute, Blacksburg, Virginia
(Presented at the 3rd Annual Meeting of the Society of Municipal Arborists, Richmond, Virginia, October 7, 1967)

How do insecticides kill insects? This is interesting but complex, and difficult to understand, especially without some knowledge of biochemstry and animal physiology. I have attempted to simplify the subject. Many technical terms would be necessary to describe in more detail the effects of complex chemicals on intricate biological systems.

As for the chemicals, relatively few have been studied intensively. DDT, malathion, parathion, and several others have been investigated in great detail. Nevertheless, the mode of action of DDT is still somewhat uncertain. We believe the mode of action for the organic phosphates is more conclusive. For many other chemicals, such as lindane, we do not know yet the exact mode of action. The majority of the voluminous literature on toxicity of insecticides is observational as to: the kinds of insects or mites which are susceptible; whether or not there is a residual effect; the presence or degree of resistance; the symptomatology of poisoning; the LD 50's of various chemicals; the chemical structure of insecticides; and many other observable phenomena.

The relative toxicity of insecticides is common knowledge to arborists and nurserymen. Lindane is very effective for aphids, leaf-miners, lacebugs, and borers in cut pine logs, but not for mites, Japanese beetle, elm leaf beetle, or taxus weevil. DDT is remarkably effective for elm bark beetles, leaf-feeding caterpillars, lilac and dogwood borers, white pine weevil, holly and boxwood leafminers, and many other pests, but is not effective against most aphids, mealybugs, ants, roaches, and numerous other species. Not only is DDT ineffective against mites, but it, along with carbaryl or Sevin, contributes to increases in mite populations.

There is considerable variability also in relative toxicity among chemicals themselves. DDT and other chlorinated hydrocarbons have a long residual effectiveness. Within the phosphate group TEPP has practically no residual effect; malathion is effective for no more than 2-3 days; yet diazinon has relatively long residual effects. The degree of toxicity varies between mammals, fish, birds, and insects, and between groups and species of each.

First, we will examine the general characteristics of insects and insecticides and then discuss what is presently thought to be the mode of action of our commonly used insecticides.

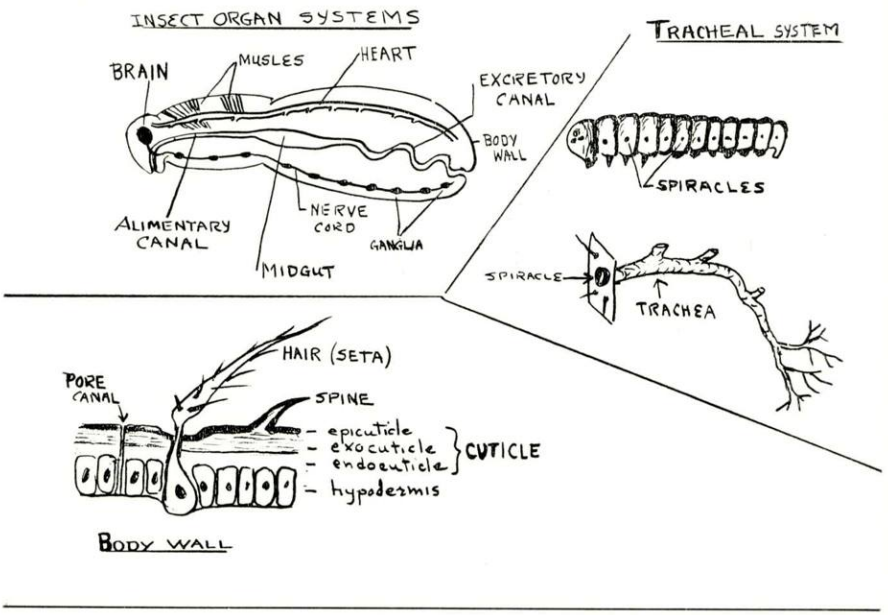
IMPORTANT CHARACTERISTICS OF INSECTS

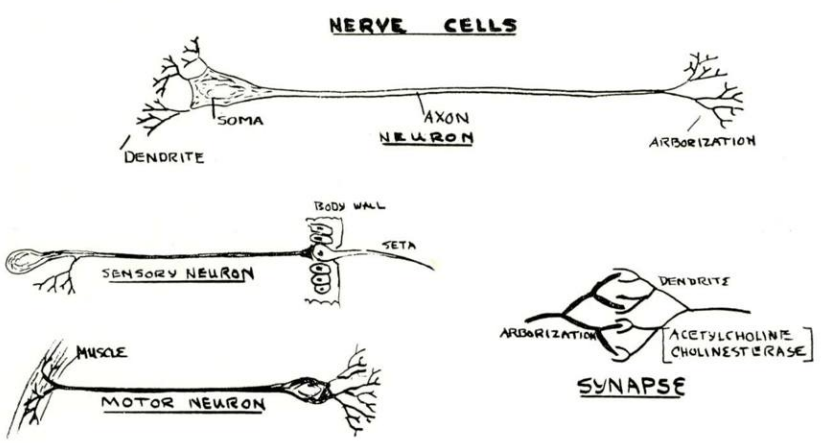
Insects are cold-blooded animals. Thus their metabolism rate proceeds as a function of the environmental temperature, not an internal constant one as in warm blooded animals. In addition the blood is a copper-type compound in contrast to the iron-constituted blood of mammals.

The Body Wall

One of the more important structures of the insect is its cuticle or outer layer which protects the body from excessive water loss and gives it rigidity. The cuticle is a thin layer of waxy material secreted by epidermal cells of the body wall. It is found not only externally but also lining the alimentary canal and excretory canal. Only the midgut where digestion occurs is free of cuticle. Even the breathing tubes or tracheae are lined with cuticular material some distance inwardly from the spiracles.

The body wall of the insect generally is composed of a layer of basal living cells, the hypodermis, plus 3 main layers of cuticle. The outer cuticle or epicuticle is a lipoid and strongly resistant to acids, although easily dis-





solved by alkalis and fat solvents such as acetone and chloroform. The inner two layers, endo- and exocuticle, contain the components which provide the rigidity in the insect body wall. The cuticle then consists of wax-impregnated, proteinaceous material which has undergone a "tanning" process of oxidation and polymerization. It is highly resistant to water penetration. However, its molecular structure is not unlike numerous organic chemicals which can be synthesized by man. The cuticle is extremely thin in some insects and much thicker in others which undoubtedly is of consequence in explaining the variability in insect susceptibility to various external influences. The body wall contains numerous types of special structures such as sensory hairs, pore canals, and dermal glands. Sensory hairs are often outgrowths of hypodermal cells. These are surrounded by thinner membranes, and have close connections to nerve endings.

In reference to toxicology, chemicals with a natural, organic affinity to lipoid cuticle can as easily penetrate the insect as alcohol can mix with water. Various structures in insects, particularly the legs and "feet", have numerous hairs and membranes which are sensitive to chemical as well as touch stimuli. It is through these avenues which insecticides can penetrate the insect's body.

The Tracheal System

Insects "breathe" by means of an intricate system of tubes or tracheae. These extend from openings in the body wall called spiracles through branching tubes to all of the internal organs and tissues within the body. "Breathing" takes place as an exchange of gas molecules, primarily oxygen and carbon dioxide. Insecticides which volatilize can enter the body through this site of action. Interference with tracheal activity is also possible with insecticides such as the plugging or suffocation by means of petroleum oils.

The Digestive System

Insect feeding is of two general types: chewing or consumption of solid plant tissue, and piercing-sucking or the ingestion of cell sap. The presence of a toxic chemical either as a residue or host plant parts or as a systemic within the plant's viscular system offers a means of getting an insecticide into the metabolic processes of pest insects. Most of the newer insecticides function as somach poisons, although their main mode of action is as a simple contact function.

The Nervous System

Since most of the modern, widely used insecticides are contact poisons or nerve poisons, the nervous system is extremely important and has been studied extensively. However, it is very complex and much is yet to be learned of biochemical and physical functioning of the nervous system.

As with any animal, an insect is a highly organized mass of living matter with an amazing potential of physical and chemical activity. Insects not only react to external stimuli but also respond to internal factors such as hormones, enzyme systems, chemical imbalances, metabolism, and respiration. The insect as a whole reacts to its environment but in addition, each organ, tissue, and cell reacts to its individual environment internally. All action and reaction is controlled and co-ordinated by the nerves. In order to explain the mode of action of modern organic insecticides it is necessary to describe the essential structure and function of the insects' nervous system. The basic unit in the nerve system is the nerve cell or neuron (see sketch). It is composed of a single, large cell called a soma with a more or less elongate fibre or oxon. At the end of the fibre and on some aspects of the cell there are arborizations, or forked filaments also called dendrites. Nerve impulses are accepted by the arborizations and passed along the fibre through the dendrites from nerve cell to nerve cell. Fibres often occur together in large numbers producing nerve trunks. In insects, there are co-ordination centres in each segment in addition to the brain. These are called ganglia and are large groups of neurons or nerve cells. There are two major types of nerve cells: motor neurons which are attached to muscles; and sensory neurons, either free strands of nerve fibre in the body cavity or nerve strands reaching to sensory hairs on the body.

The area in which arborization of the sensory nerve cell, for example, meshes with the terminal arborization of the motor neuron fibre is most important in understanding mode of action of insecticides. This area is called the synapse. The synapse is a highly specialized structure in which certain impulses can pass in orderly fashion in effective temporal sequence, usually only in one direction. The transmission of impulses from cell to cell is a complex process. After each impulse passes through the synapse, there is a recovery period. These are extremely rapid and usually measured in milli-seconds. At the synapse this is essentially a chemically controlled transmission. A remarkable chemical known as acetylcholine is released at the synapse. Before another impulse can be transmitted the acetylcholine must be broken

down chemically to restore the synapse to its original condition. This is accomplished by an enzyme known as cholinesterase, also produced naturally by the insect.

In addition to the activity at the synapse there is a second phenomenon of critical importance. This involves the functioning of the nerve cell or neuron itself. Each living cell is surrounded by a membrane. Internally the cell fluid is maintained in a form characteristic of that cell. The insect blood, or external fluid may be of somewhat different make up. The membrane is permeable, that is it will permit certain chemical components to pass in or out depending on the condition and needs of the cell. It has been found that there is a delicate balance in electrical charges in the nerve cell. These are produced by various ions or particles carrying a plus or minus charge. Involved primarily are sodium (Na+), potassium (K+), and chlorine (Cl—). Other charged particles are present but do not pass through the membrane.

When ready for an impulse, a nerve cell carries an electrical potential of 60-100 millivolts internally. As an impulse is received K and Na ions move through the membrane in a very orderly fashion. Following the impulse the membrane permits movement of particles to re-establish the electrical potential necessary to transmit another impulse. Thus the normal functioning of the nerve depends on a definite pattern of K-Na exchange through the cell membrane.

In summary, two essential processes must be in perfect working order for the functioning of the nervous system: (1) increase of acetylcholine and its breakdown by cholinesterase at the synapse; and (2) proper K-Na ion exchange through the cell membrane of the neuron. Both functions are almost instantaneous, occurring in a few milliseconds and reoccur continuously.

CHEMICAL CHARACTERISTICS OF INSECTICIDES

It is not essential to go into great detail on the chemical composition of insecticides for purposes of this discussion. However some differentiation between major groups should be recognized.

Inorganic insecticides such as selenium, lime sulphur, lead arsenate, calcium arsenate, sodium fluoride are simple elements or elemental salts. They are simple associated molecules which are suspended or dissolve in water and precipitate as uncomplicated chemical combinations. Also in the same category are fumigants such as hydrogen cyanide, but which exist as gas molecules.

Plant derivatives are relatively complex organic molecules, including nicotine, pyrethrum, and rotenone. These are either crystalline materials or. as with nicotine, liquid. Nicotine is soluble in water and is released in a volatile state to provide fumigant action.

Petroleum oils are organic hydrocarbons not soluble in water. They are capable of suffocating insects by preventing gaseous exchange through the tracheae and also are toxic to insect cells near the tracheae.

The synthetic organic chemicals are highly complex molecules containing carbon as the major component and various other combinations of atoms such as phosphorus, chlorine, sulphur, nitrogen, etc. in complex bonds. The atoms occur in chains which are bonded or linked together in complex patterns. They are arranged in ring structures physically which are easily modified by biochemical processes in living organic matter. These chemicals are capable of metabolizing in the presence of similar chemicals or enzyme systems. There are literally thousands of organic chemical compounds which have potential as insecticides. Often the changing of a single ring or ring component results in a different effect on a given insect. In some cases a highly toxic compound is metabolized into non-toxic analogues; in others relatively low toxicity materials are changed into extremely toxic compounds. A good illustration of this occurs with systematic insecticides some of which are detoxified rapidly in plants, while others are metabolized into extremely toxic analogues. *Such reactions are of utmost importance in studying the hazard of insecticides to birds, animals, and man.*

MODE OF ACTION OF ORGANIC PHOSPHATES

The organic phosphates readily enter the insect body directly through the cuticle. The precise chemical and/or physical nature of penetration is not thoroughly understood. However, it is conclusive that penetration occurs. Radioisotope-tagged insecticides have shown this and complete as well as rapid distribution within the body by the blood. The site of action is the synapse. The phosphates can enter readily by ingestion; i.e. feeding. Insects may consume spray residue with plant parts eaten or take in plant sap containing a systemic insecticide.

At the synapse, or site of action, the organic phosphates inhibit the production of cholinesterase by the insect. As a result acetyecholine builds up and prevents proper functioning of the nerve cells. The synapse cannot transmit impulses effectively resulting in disruption of the nervous system. Muscular incoordination, organ malfunction, and metabolism are effected to the point where death occurs. The process may take a matter of minutes, hours, or longer. In some cases there may be recovery. Usually, however, the chemicals produce fatal indirect effects on vital organs and metabolism by disrupting the nervous system.

The biochemical processes and enzyme systems in insects, like other animals, are very complex. Gradually, however, more and more is becoming known on causes and effects and we are gaining a better understanding on mode of action. In regard to warm blooded animals, the phosphates are similar in mode of action, inhibiting the enzyme cholinesterase. Atropine is one of the major antidotes which counteracts the effect of cholinesterase inhibition.

MODE OF ACTION OF CARBAMATES

Toxicologists have established that carbamates also inhibit cholinesterase. However, it is felt that other processes must be involved also, which are not understood at the present time. Carbamates do not affect insects in exactly the same way as do the phosphates, but interference with cholinesterase and the chemical transmission of impulses through the synapse certainly is involved in the mode of action.

MODE OF ACTION OF DDT

Although DDT has been studied intensively since the mid-forties, the mode of action is still uncertain. However, there has been a new theory tested within the last 10 years. In fact, the next to last issue of Science included an article by Narashashi and Haas further substantiating it. Before discussing the mode of action, it should be pointed out that DDT is very efficiently absorbed through the insect cuticle, almost to the extent that DDT is attractive to the insect cuticle or vice versa. This may be the clue as to why DDT has been such an effective insecticide. Many of the sensory perceptions of insects are through hairs and surface receptors which have direct connections to the peripheral nerves.

It is well established that DDT does not inhibit cholinesterase. It was thought that DDT might influence some enzyme system, but if so, such action is not clear.

It appears that the present theory may be acceptable. DDT has the ability to penetrate and concentrate at the site of action (the nerve cell) and the ability to release HCl when absorbed at the site of action. The site of action is the permeable membrane of the axon referred to earlier. It is thought now that DDT forms an electrical charge transfer complex with a component of the axon which results in an imbalance of the K-Na balance necessary for proper nerve function. As a result the action potential of the nerve was delayed to 10 milliseconds compared to a normal 1.3 msec. The continuation of the effect in the cockroach resulted in convulsions.

GENERAL REMARKS

This discussion has been a gross over-simplification of the complex biochemical activities which take place in insects.

The mode of action for organophosphates is probably applicable to phosphates in general, although most have not been studied so thoroughly as a few. The mode of action of chlorinated hydrocarbons may be like that demonstrated for DDT. However, it should be remembered that a slight modification in chemical composition can result in major differences in effect on insects. It is still not known how lindane poisons insects, for example. It is known that carbamates such as Sevin, Zectran, and Temik also inhibit cholinesterase, but it is thought more is involved. The carbamates do not entirely fit the organic phosphate pattern.

Another interesting development has been the study of resistance in insects. Toxicologists have found that some insects, perhaps mutagenic in-individuals have enzymes which are capable of breaking down insecticides before they can seriously affect the insect. It has been suggested that an enzyme, DDT-dehydrochlorinase, is the reason houseflies can overcome DDT.

Insecticides are the result of serious, dedicated scientific investigation. We must remember that the biological world is a formidable complex we must understand in order to use it to the maximum benefit of society.

NEW FUND FOR RESEARCH ON AUSTRALIAN PLANTS—*continued from page 171*—Readers, will you help?

of the species, and the description of many species and subspecies for which no satisfactory names are at present available. Preparation of a Flora of New South Wales is continuing, as a long-term project, and we are working on the compilation of a new Census of plants of New South Wales.

The work done here underlies the production of handbooks by other authors, which present current knowledge in a concise form, such as Beadle, Evans and Carolin's "Flora of the Sydney Region". Also the producers of many less technical books rely on information the Herbarium provides.

In addition to research activities, the plant identification and information service of the National Herbarium handles up to 1,000 enquiries per month. The enquiries represent rural and commercial interests as well as educationists, keen gardeners, naturalists and the increasing numbers of the public who ar learning to appreciate our natural surroundings. The provision of accurate and up-to-date information must rest upon an active research programme. These services will continue to be maintained by government funds, as a component of the work of the New South Wales Department of Agriculture of which this institution forms a part, and the research fund will be used exclusively to make progress in scientific studies. It will make possible more field investigations and the acquisition of specialized equipment essential for newly developed methods of research. It will be administered by a research committee of botanists.

If enough money is subscribed there are major additional facilities we could very well use and new lines of work we would like to undertake. For example, scanning electron microscopy, although only a recent develop- For example, scanning electron microscopy although only a recent development, has shown itself as a very valuable tool. The great range of magnifications available, and the clarity of the results, make this most suitable for detailed observations for studies in plant classification. We hope that eventually the Fund may help to provide such vital, but expensive, equipment.

All contributions to the Fund, whether large or small, will be helping in the understanding of the Australian flora. We hope that, as well as the support from private individuals, from whom a pleasing response is already evident, major donors will be found amongst firms which recognise the value of native plants and scientific understanding and also perhaps from philanthropically minded persons of means.

Donations to the fund may be made through the Director, Royal Botanic Gardens, Sydney, 2000, or to the New South Wales Department of Agriculture, and should be made payable to the Director-General of Agriculture. Contributions of $2 or more will be allowable income tax deductions.

SOLUBLE FERTILIZER

The use of a soluble fertilizer has given good results with natives. The feeding of wildflowers for best results is often neglected and the Australian company that produces the proprietary line Aquasol has been invited to submit this article. Other Companies may like to supplement this with notes on their products.—Editor.

Aquasol is a complete soluble fertiliser which is taken up by plant foliage and roots. It is termed a complete fertiliser because it contains primary, secondary and trace elements essential for healthy plant life. Aquasol with its high content of potassium not only promotes quicker growth in plants but also makes them stronger, more resistant to fungus diseases and improves the colour of flowers and foliage.

Aquasol also contains a chelating agent. This chemical complexes all those trace elements that would normally combine with the phosphorus source to form insoluble metal salts. Chelated trace elements are also readily available to the plant regardless of the soil pH or other factors.

By analysing the plant nutrients contained in Aquasol we can see how and why the product works.

(A) PRIMARY NUTRIENTS

1. Nitrogen—Function in plants. Since Nitrogen is a part of the protoplasm and nuclei during the development of plant cells, there would be no development or growth in the absence of this element. Howver an imbalance of Nitrogen in relationship to other nutrients especially Potassium leads to succulent growth. Plants having such growth do not have proper rigidity—cell walls and stems will be weak, plants may fall down or lodge. Also these plants will often fail to develop sufficient exterior protection to safe guard themselves against diseases and insects. Root systems will not develop, the quality of flowers and fruit will be poorer and drought resistance is lowered under these conditions.

Aquasol contains 20% (N) in the following forms:

Nitrate (60% N)—Is immediately available to the plant, which is of particular importance during cold weather when nitrifying bacteria are least active. *Nitrate Nitrogen can be absorbed through the leaves as well as through roots.* When absorbed by the leaves it is conducted by the xylem tissues to the manufacturing centres of the plant, the living cells in the leaves. There it is combined with other chemical elements and their compounds are synthesized into organic compounds. If these are not fully utilized at this point they are transferred by the phloem tissues to other parts of the plant.

Ammonia (2.0% N)—Provides slightly slower available Nitrogen in that only a portion of the Ammonium Nitrogen is absorbed by the roots, most has to be converted by the Nitrosomonas bacteria to Nitrite and thence to Nitrate Nitrogen to be available to the plant.

Urea (12% N)—Can be absorbed by plant leaves where it behaves in a similar fashion to Nitrate. If applied via the soil it quickly breaks down to form ammonium compounds and carbon dioxide. The ammonium compounds then enter the Nitrogen cycle and break down similarly to Ammonia Nitrogen.

2. Phosphorus—Function in plants.

It is essential in all of the growing parts of plants, as it plays a major role in the synthesis of many of the organic compounds. The formation of sugars, starches, oils etc. are related in some manner to the phosphorus compounds in the plant. These compounds are stored in the seed to aid the germinating plants in their early energy requirements before they can utilize solar energy.

Phosphorus (5% P) all water soluble (Mono Ammonium Phosphate)—This form is the most available to plants as it achieves the widest dispersion

in the soil. This is important as water insoluble phoshorus tends to become fixed in the soil and has limited capacity to move through the soil.

3. Potassium—Function in plants.

It is not a part of plant structure but plays the role of the catalyst. It increase root growth and improves drought resistance. It builds cellulose and reduces lodging, with Potassium deficiency cell walls and stems are often weak. Potassium helps translocate sugars and starches to the points in the plant where they are needed and it reduces respiration so that more starches and sugar can accumulate. K encourages the building of proteins and if shortage of K occurs plants continue to take up nitrate and ammonium Nitrogen but non-protein Nitrogen tends to accumulate and production of true protein is slowed.

Potassium also aids in photosynthesis; Carbon Dioxide and water is converted to sugars using energy from the sun. The $C0_2$ enters the leaf through the stomata in the leaf surface, the guard cells of a fully opened stomate contain over twice as much K as a closed stomate. Hence Potassium helps keep the stomates open so $C0_2$ can enter. Potassium aids over 40 enzyme actions that help to control many plant functions. It also increases the natural resistance to diseases and improves the quality of flowers, fruit, etc.

Potassium (18% K) as Nitrate (Potassium Nitrate).—This form is the most available to plants as it achieves the widest dispersion in the soil. This is important as Potassium moves very little in most soils.

(B) SECONDARY NUTRIENTS

Magnesium (0.188% Mg) in chelated form—This element is an essential part of the Chlorophyll, where it has a role in the synthesis of plant materials. It has a part in the transportation of other plant foods, such as Phosphorus, to various parts of the plant.

Sulphur (0.4% S) in Sulphate form—Sulphur is an important part of every living cell, and is essential for protein formation and development. It aids in controlling the kind and structure of protoplasm and protein in plants and the formation of vitamins. It promotes nodule formation on legumes and stimulates seed production. Sulphur encourages vigorous plant growth.

(C) TRACE ELEMENTS

Zinc (0.05% Zn) Chelated form—Forms a part of the Auxins, the growth promoting compounds. Plays a part in the regulation and use of water.

Copper (0.06% Cu) Chelated form—Aids in root metabolism, Oxidation and reduction reactions, production of enzymes and in the utilization of proteins.

Molybdenum (0.0015% Mo)—Plays an essential part in the manufacturing process in the leaves. A plant with a deficiency of this element cannot utilize nitrate nitrogen or synthesize protein.

Manganese (0.15% Mn) Chelated form—Acts as a catalyst and has an essential role in the formation of Chlorophyll. A lack of this element effects the plants ability to utilize iron.

Iron (0.12% Fe) Chelated form—Acts as a catalyst to carry oxygen to the plant leaves for the synthesis of Chlorophyll.

Boron (0.012% B)—Aids in the plants' utilization of other nutrients especially nitrogen and phosphorus. It is essential for development of flowers, fruit and seeds of many plants.

FURTHER NOTES ON USE OF AQUASOL

1. Recommendations for efficient use are printed on the packages. Aquasol should be used in low concentrations i.e. 1 lb. to 100 gallons of water, about 1 teaspoon in 1 gallon of water every 2 weeks.
2. The plants should be well watered before applying *any* fertilizer.
3. Native plants require fertilizers. Let us see how much?
4. The application of Aquasol can be carried out with watering can or with spray equipment. Most of the insecticides and pesticides are compatible with Aquasol as they can be applied simultaneously if necessary, to the plants in the same spray.

SEED IS STILL NEEDED

Australia's unique flora could be promoted for use at home and abroad If we could be sure of supplies to meet orders. There is tremendous scope for wider use of the little known inland species, the Wattles, the Mallees, the Kennedia spp.

We would like to enrol many more observant local people as part-time collectors. even paying merely for information leading to legal acquisition of bulk lots by someone else.

This can be an interesting hobby and a remunerative side line operated from a knowledgeable person's own home. We have a special need now for collectors in the northern half of the continent, especially Central Queensland.

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Meetings of members in local suburban or town groups. Regular meetings with illustrated addresses in capital cities and major regional centres, free supply of seed and advice on cultivation, field trips, flower shows, publications *(Australian Plants* as well as State news journals) and participation in Study Groups into cultivation of selected groups of plants such as Orchids, Ferns, Wattles, Grevillea, Hakea, Banksia, Native Iris and Lilies, Mint Bushes, Boronia, Pea-flowered Plants, etc. Enquiries to State Secretaries listed above by mail.

PAST ISSUES OF "AUSTRALIAN PLANTS" AVAILABLE

Because of the vast wealth of our flora there is very little repetition.

VOLUME No. 1 Issues 1-12, no longer available bound but Issues 5, 6, 7 & 9 are available at 45c each, $1.85 incl. postage. However it is proposed to reprint Volume 1 as a fully bound book at a date in the future not yet decided upon.

VOLUME No. 2, Issues 13-20, all available only fully bound at $6.00 plus 20c postage. Including "A Descriptive Catalogue of Western Australian Plants".

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VOLUME No. 6, Issues 45-52. Available fully bound at $6.00 plus 20c postage including "Western Australian Plants for Horticulture—Part II" valued at $3.00. Available November 1973.

WHEN & WHERE ARE WE GOING

Issues of "Australian Plants" have got very much behind. Some have not been to the standard we desire. Are we producing articles that are wanted and needed? There is little doubt that the editorial staff has had a bad time and you have been very patient. Our printer has had a very bad time also but I have stuck with him and I am sure we will see a big improvement in the future. He now has a very competent staff to provide the best quality and service.

The Part 2 of "West Australian Plants for Horticulture" was delayed due to the serious illness of the author and then to the printing delays. This has, in turn, effected the binding of Vol. 6 which will now be ready in December, 1973. The index to all six volumes of "Australian Plants" needed considerable checking by a competent botanist and this is at last in hand following disappointments.

We work in an honorary capacity and these disruptions to the set pattern cause a considerable increase in the work load Fortunately most members have been very patient. Delays will be reflected in the next two issues.

The price has remained unchanged since 1959, possibly a record in this period of rising costs. The pending price increases on postage will demand a considerable rise. The periodical has been excellent value for its price and we shall make every effort to increase its area of interest and value to you in return for your support in the future—Editor.

BOOKS ON AUSTRALIAN WILDFLOWERS

The periodical "Australian Plants" with its 55 back issues, is the best reference to Australia's wildflowers. We produce other supplementary books advertised in previous issues. There are some very good books available from other publishers which the editor is prepared to recommend as the best and most suitable as reviewed below. The market has been swamped with small well illustrated books which are reviewed as they become available but the treatment is often, shallow and over commercial being really only a collection of pretty colour plates of the same often photographed species. In making these recommendations I do not wish to devalue many of the fine books available but simply to provide a service to the reader. It is inevitable that I have overlooked a valuable reference for which I apologise to the author—Editor.

DESIGNING AUSTRALIAN BUSH GARDENS by Betty Maloney and Jean Walker — Price $1.50 plus 30c postage.

First reviewed in our No. 28 issue, this valuable little book quickly went out of print. After dealing with the general aspects of ground cover and treatment, the use of wood, trees, stone and water in a landscape, the practical problem of how to create a bush setting on a block only 50 ft. wide in a suburban area, is squarely faced. Actual examples detail the treatment and plants recommended. The book reflects the competence and experience of the authors and their feeling of intimacy with the subject. Illustrations and sketches are only in black and white but the competence and skill of Betty Maloney is shown in sketches in Issues of "Australian Plants", especially the last one.

MORE ABOUT BUSH GARDENS—A sequel to above — Price $1.50 plus 30c postage

This book also quickly sold out but is now available. The theme "preserve your own little corner of bushland in your home garden" is maintained with many practical solutions that may suit your needs.

FLOWERS AND PLANTS OF WESTERN AUSTRALIA — Price $16.95 plus 55c postage by Rica Erickson, M. K. Morcombe, A. S. George and N. G. Marchant.

A fuller report will appear in the next issue as this fabulous book has just become available. There is little doubt that this book will be the best ever on W.A. wildflowers—11½ in. x 9 in., 216 pages with 500 colour plates. Those who have its sister book, "Flowers and Plants of Victoria" will know what a remarkable job this publisher does; the quality of the colour plates and the careful selection of species and presentation. One has then only to see the authors; Rica Erickson, author of many books on wildflowers and renowned botanist; Michael Morcombe, photographer for so many top quality books on Australia; Alec George, the leading botanist on W.A. flora, and N. Marchant. A pictorial presentation with simple descriptions of the Western Australia flora that will be unequalled.

FLOWERS AND PLANTS OF VICTORIA — Price $15.95 plus 55c postage by J. H. Willis, C. R. Cochrane, B. A. Fuhrer, E. R. Rotherham.

This fabulous book has been reprinted. We have reviewed this book often in the past ("Australian Plants", issue no. 36) as it sets a new high in the standard of presentation of the wildflowers in an area. It was so eagerly sought after by those who want a book that shows the entire range of wildflowers in full colour, grouped as found in various areas of Victoria, it quickly sold out. With the authors and photographers as listed, headed by Jim Willis, the nobleman of professional botanists, this book should be owned by all wildflower enthusiasts.

FLORA OF THE SYDNEY REGION — Price $13.95 plus 55c postage

Not a new book but worthy of recommendation in this listing of the best books on wildflowers. Not in the same style of the two above, originally produced as a reference to students of botany entering the Universities in Sydney, this is a most valuable reference.

HANDBOOK TO PLANTS IN VICTORIA—Vol. 2 by J. H. Willis — Price $21.00 plus 50c postage

Similar to "Flora of Sydney . . . " above, without the colour illustrations, this is an invaluable reference and if used with "Flowers and Plants of Victoria" above is a complete reference for all wildflower lovers in Victoria.

WESTERN AUSTRALIAN NATIVE PLANTS IN CULTIVATION by A. R. Fairall—Price $10.50 plus 50c postage.

Written by a world renown horticulturalist this beautifully illustrated book is a valuable guide to those who wish to grow the plants so well illustrated in "Flower and Plants of Western Australia" above.

BOOKS ON AUSTRALIA—ITS SCENERY, ANIMALS & WILDFLOWERS

BIRDS OF AUSTRALIA by J. D. Macdonald — Price $18.50 plus 60c postage

All the birds of Australia are described in groups and illustrated with line drawings and colour plates. 9¾ in. x 7¼ in. 552 pages, this is a magnificent book that will become the standard of reference.

OTHER BIRD BOOKS RECENTLY AVAILABLE

"Birds in the Australian High Country"—$9.95 plus 55c postage.
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Australia's Insects—Child & Currey	$4.95	+ 35c postage

Young Nature Library for Children 8-12; 16 pages of colour 10½" x 7½" each $1.95 + 25c postage—Titles; Kangaroos & Wallabies—Kookaburras & Kingfishers—The Platypus—Possums.



TELOPEA SPECIOSISSIMA—N.S.W. WARATAH

This magnificent plant may be readily grown in the garden, given deep well drained good garden soil with plenty of water. They are easily grown from seed that is readily available. This issue announces success with a hybrid of the N.S.W. Waratah and the Braidwood Waratah both of which are illustrated in full colour on pages 168 and 169.

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