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## Introduction

Eucalypts are almost a defining feature of Australia. They are the dominant tree of the higher rainfall areas of the country, and sparsely represented in the driest regions. There are nearly 900 species which have adapted to nearly every environment. In EUCLID we include the long-standing genus *Angophora*, which is exclusive to eastern Australia excluding Tasmania, and the recently recognised *Corymbia*, occurring primarily in northern Australia. See [Evolutionary relationships in \*Eucalyptus sens.lat.\*](#) for more detail of generic relationships.

Eucalypts must have been known by Europeans from the early 16th century when the Portuguese colonised Timor. There are at least two indigenous species, *E. alba* and *E. urophylla* on the island. Following the Portuguese occupation, it is probable that eucalypts were established from seed in Brazil which was colonised about the same time, although records are too hazy to confirm this. *Eucalyptus* came into recorded history in 1788 when the French botanist, L'Héritier de Brutelle, described *Eucalyptus obliqua*, the well known Messmate of widespread distribution in the wetter regions of the south-east of the continent. This species was named from a specimen collected at Adventure Bay on Tasmania's Bruny Island by David Nelson, one of the botanists on Captain James Cook's third voyage in 1777.

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## Evolution and distribution



Eucalypts are likely to have evolved from rainforest precursors in response to great changes in the landscape, soils and climate of the continent. No point of origin is possible to determine but it is assumed to have been on the Australian landmass from which several species have migrated probably by land bridges to islands north of the continent.

One species, *E. deglupta*, is distributed as far as the island of Mindanao, in the southern Philippines which places one eucalypt naturally in the northern hemisphere. However, the genus is now cultivated world-wide in tropical and temperate countries and in some places has become naturalised.

Eucalypts are now of great importance commercially in other countries, particularly South Africa, China, India and Brazil and to a lesser extent in central and northern Africa and in Mediterranean countries. They have many advantages apart from the timber and fibre which are the basis of huge paper industries. Eucalypts are also notable for their oils, use in lowering water tables, horticulture, shade and simple ornamentation, largely for the bark features and colourful flowers in many species.

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## ■ Identifying eucalypts

Innumerable books have been published on eucalypts. Some include a wide range of information on a regional basis, others concentrate on the more spectacular flowering species while others specialise in identification. Identification has always been regarded as difficult, partly due to the lack of instruction on specific botanical characteristics. Understanding the eucalypt plant is a vital element in attempting the identification process.

It is a fact that, to the uninitiated, most eucalypt species tend to look the same, and while taxa in some groups are indeed difficult to distinguish, in general there are good features and clear characteristics to use in identification. In EUCLID we have made particular effort to explain specific eucalypt features and to aid identification.

Eucalypt leaf morphology provides a range of diagnostic features as well as injects a level of confusion in the change from seedling to juvenile to sapling to adult leaves that takes place in the majority of species. In eucalypts there is a striking array of juvenile or seedling leaf types from opposite and completely connate pairs of leaves (e.g. *E. uncinata*), to crowded and spirally arranged short linear leaves (e.g. *E. brockwayi*), to disjunct petiolate ovate leaves (many species, e.g. *E. obliqua*, *E. ewartiana*, *C. terminalis*), even leaves with peltate leaf bases (e.g. *C. citriodora*). The descriptions accompanying every species in EUCLID include details of seedling, juvenile and adult leaves.

Some species never, or seldom, develop true adult leaves in the mature crown but instead retain their juvenile leaf phase where the leaves are commonly glaucous and rounded. This condition is rare in eastern Australian species but is notable in *E. risdonii* an endemic to Tasmania and in *E. cinerea* of New South Wales and Victoria. In south-western Western Australia many more species have the glaucous crown, probably the most spectacular being the glaucous-leaved *E. macrocarpa* which produces large red flowers. Across northern Australia there are fewer species with these characteristics but the widespread tropical box *E. pruinosa*, the abundant Queensland and New South Wales ironbark *E. melanophloia*, the highly restricted Kimberley endemic *E. ceracea* and the well-known desert mallee or tree *E. gamophylla* are examples with the crown of retained glaucous juvenile leaves.



In south-eastern Australia, nearly all eucalypt species have green leaves of roughly similar size and fairly inconspicuous white flowers. Only two species in south-eastern Australia, *E. sideroxylon* and *E. leucoxylon*, can have strongly coloured flowers; in south-western Australia *C. ficifolia*, *E. erythrocorys* and *E. caesia* provide examples of species with spectacular flowers. A few tropical species have brilliantly coloured flowers, e.g. *E. miniata*, *E. phoenicea*, *C. ptychocarpa* and *C. cadophora* subsp. *pliantha*.

Eucalypt fruits (gumnuts) also show great diversity in form and size with the smallest occurring in northern Australia, e.g. *E. raveretiana* in central Queensland, *E. brachyandra* in north-western Australia, and among the largest being *E. gigantangion* from the Top End of the Northern Territory, *C. abergiana* from the Atherton area of Queensland, *C. calophylla* from the Perth area in Western Australia, and *E. youngiana* from the Great Victoria Desert of South Australia and adjacent areas of Western Australia. There is great variation in size between these extremes throughout the country, but in south-eastern Australia fruits tend to be smaller than elsewhere.



So the problems of identification in EUCLID for eastern Australian species usually fall back on the less conspicuous and accessible but highly diagnostic characters, often ones that may be less relevant in other plant groups, and this is also true in other parts of the country. In Western Australia or northern Australia, however, if the tree or mallee has brightly coloured flowers or has very large or very small fruit, identification may be easier.

In working with eucalypts in the field it is important to recognise whether the trees are cultivated, or occur naturally. If cultivated, they could be from anywhere in Australia and the identification cannot take into account [the geographic regions used in EUCLID](#). If identifying a specimen from a natural stand then geographic regions can aid in making an identification but it is not essential if the specimen has sufficient morphological features.

To aid identification the observer in the field also needs to take into account other aspects of the specimen, viz. the height of the plant, the number of stems or trunks, the colour of the crown, the overall appearance of the crown to determine if it is composed of juvenile or adult leaves, general size of the leaves (very small, e.g. *E. parvula* or *E. kruseana*, or very large, e.g. *E. globulus*) and the type of bark, basically, whether rough or smooth, and extent of coverage by the rough bark of the smaller branchlets. The observer also needs bear in mind there is often considerable variation in some characters between trees of the same species in one population, especially in size of parts, such as length and width of leaves, length of petioles, bud sizes, lengths of peduncles and pedicels, and fruit dimensions and position of the disc relative to the rim of the fruit.

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## ■ Inspection of specimens

The 'internal' features of the eucalypt plant, such as the number of opercula in the bud, arrangement of stamens, number of ovule rows and seed shape, are usually more reliable for identification than the 'external' features. They are relatively protected from the elements and from various forms of predation. They are the parts that require handling and close inspection or even dissection, as opposed to macro observation.

Specimens for study may be obtained in several ways from a living tree. Sampling smaller trees and mallees is usually easy because the leaves and flowering structures are often at about head height and no sophisticated methods of collection are needed. For most trees, however, a weighted length of rope can be thrown over a low branch which can then be broken off with a sharp tug and pulled to the ground for close inspection of the parts (shown in image). Alternatively, for trees of moderate height, pole pruners can be used less destructively than the weighted rope. For tall trees it is a curious fact that the flowers and fruits are small and scarcely visible to the unaided eye, e.g. *E. regnans*. Then the canopy needs to be inspected with binoculars and a useful branch selected. If it is above rope-throwing height, the branch may be reached with the use of a [shanghai](#) by shooting a lead weight attached to a fine, light line over the branch and then attaching a thicker, stronger rope to one end of this line and then pulling this line up over the branch. Often the smallest trees or mallees have the largest buds and fruits, e.g. *E. pyriformis*. These plants are the easiest to sample, examine and assess.



The whole process of identification begins in the field with broad external assessment and ends with microscopic examination. The characters in this sequence of investigations have reliabilities that vary from very low to high and finally absolute. With experience the user is able to weigh up these relative values and apply them with confidence.

In summary it might be said that the number of opercula on the developing flower bud is of absolute reliability, staminal inflexion, ovule row numbers and seed shape are of high reliability, bud numbers, flower colour and bark type of medium reliability, leaf colour of low reliability, bark colour of very low reliability. External features are very susceptible to seasonal and intra-population variability.

When choosing a specimen for identification there are some things to be avoided. For example always choose 'typical' leaves on the specimen for assessment, avoiding the largest and the smallest. Similarly, be cautious when using fruit that are lying on the ground, especially if in a mixed eucalypt species stand, for they may not belong to the tree under which they are found. When searching for juvenile leaves make sure they belong to the tree or mallee you are investigating – if there is any doubt do not use them. A mixed species stand may produce a variety of juvenile leaves. Time spent looking at both adult and juvenile growth in a stand will be very rewarding.

If an identification is proving difficult then growing of seedlings may be a help in resolving it. Obviously this slows down the process, but valuable information can be obtained from observing seedling growth, firstly the shape of the cotyledons and secondly whether the leaves become disjunct early in growth or persist as opposite for many pairs. The shape of seedling leaves, whether they are stalked or stalkless and other leaf features can help also.

Understanding some of the important characters in the eucalypts, will aid in the process of identification. Descriptive information on some of the important parts of the eucalypt plant follows.

### Habit

**Tree - erect single-stemmed woody plant with various crown forms.**

The definition of tree deliberately has no upper or lower height limit. If the user finds it difficult to decide whether the specimen is a tree or a shrub it is probably better to avoid using this character. The definition of tree includes the two special categories in common usage only in Western Australia - mallet and marlock (see more below). Note that a tree may have a lignotuber at the base of the trunk and epicormic shoots on the trunk or stems, or lack either or both of these means of vegetative recovery after disturbance such as fire.



Tree

**Mallee or shrub - a mallee is a woody plant that is multistemmed from ground level and seldom taller than 10 m. In eucalypts a shrub is a low growing and reproductively mature plant, that may be less than 1 m tall, and is usually growing in an extreme environment. There is no clear distinction between mallee and shrub.**

A mallee has at the base of the stems a woody structure, [the lignotuber](#), that has numerous dormant buds that enable vegetative recovery after fire or other disturbance. The term *mallee* is often applied to eucalypts and has wide currency in southern Australia. *Shrub* is infrequently applied to eucalypts, good examples being [E. vernicosa](#) in high mountain areas of Tasmania, [E. yalataensis](#) on the Nullarbor Plain and [E. surgens](#) atop coastal cliffs at Toolinna Cove in Western Australia. Naturally low-growing marlock plants are included here as well as below, e.g. [E. mcquoidii](#) which may be reproductive at about 0.4 m tall.



Mallee (top) or Shrub (bottom)

**Mallet or marlock (only applies to Western Australian species) - a mallet is a tree with a slender trunk with branches steeply angled on it, and lacks both lignotuber and epicormic buds (e.g. [E. astringens](#)). A marlock is a single-stemmed shrub or small tree with spreading branches that are densely leafy often almost to the ground, and lacks a lignotuber (e.g. [E. platypus](#)).** Correctly used *mallet* or *marlock* has great discriminating value. Species with *mallet* habit are also included in *Tree* above. *Marlock*, as here defined, is easily understood whilst the plants are relatively small, but from 8 m tall the distinction between marlock, mallet and tree is often unclear. *Marlock* applies to relatively few species, but some are frequently cultivated e.g. [E. platypus](#), [E. conferruminata](#), growing taller than they do in the wild.



Mallet (left) or Marlock (right) (WA only)

### Bark

Having taken into account the habit features, the next important character to assess in eucalypts is the type of bark. It pays to think in terms of the growth processes. Each year there is an increment of living bark that results in the continual expanding girth of the tree. In all species the outermost layer dies each year. In about half of the species this dead layer completely sheds, exposing a new layer of living bark, and the process continues year after year. These are known as the smooth barks. The dead bark may be shed from these trees in [large slabs](#), in [ribbons](#), or in [small flakes](#). Invariably the newly exposed living bark is relatively smooth and [brightly coloured](#) but this fades with weathering. Often the dead bark comes off in pieces at various times of the year such that the trunk is mottled depending on the amount

of time the newly revealed patches of bark are exposed to weathering.

A curious but easily recognised bark type is the minnirichi which is restricted to a few species from southern Western Australia and arid Central Australia. This bark seems rough at first glance and on close inspection is seen to be formed of partly shed longitudinal strips that curl outwards, initially exposing pale or greenish underbark. The older attached strips turn deep red on aging. In one minnirichi species, in particular, the lower bark becomes thick and fibrous while only the upper bark is typical minnirichi.



In many species the smooth bark is uniform over the whole trunk in both texture and colour, e.g. *E. mannifera*, *E. tintinnans*, *E. salmonophloia* and *C. aparrerinja*. In others the bark is mottled, e.g. *C. maculata* and *E. dawsonii*, while in a few species, particularly the red gums and the grey gums, the newly exposed smooth bark can be brilliant orange or yellow, fading to greys, the surface texture of which becomes granular with age.

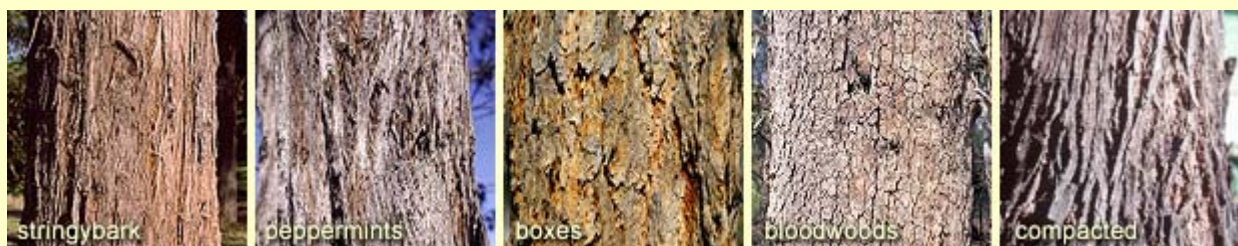


scribble.

The irregular markings on the living bark of some smooth bark species are known as scribbles and are caused by burrowing insect larvae. Insects are attracted to some species and not others, whether to eat the leaves, suck nectar or to lay their eggs. Some insects are particularly partial to species in *Eucalyptus* subgenus *Eucalyptus* - stringybarks, ashes, peppermints, and related species, and lay their eggs in the bark. The larvae then eat their way through the surface of the bark leaving a characteristic zig-zag trail or

In the ribbon gums the long strips of dead bark are imperfectly shed and hang conspicuously in the crown, particularly around the trunk.

In great contrast are the remaining half of the eucalypts, the rough barks, in which the outer annual increment of dead bark simply dries out, leaving the natural fibres which do not shed and which accumulate year after year. These may remain loosely intertwined as in stringybarks, e.g. *E. macrorhyncha*, or the peppermints, e.g. *E. radiata*, or more tightly adherent as in the boxes, e.g. *E. leptophleba* or many of the rough-barked bloodwoods e.g. *C. gummifera*.



In some species rough bark becomes infused with gum exudates which harden, resulting in the ironbark, e.g. *E. crebra*, *E. jenseni* or the compacted types of rough bark, e.g. *E. smithii*, *E. elata* and *E. sargentii*.

The ironbarks only occur in northern and eastern Australia but some species from south-western Western Australia have very hard rough bark that is thinner than that of the eastern ironbarks to which they are only very distantly related, e.g. *E. indurata*.

In many species of bloodwood and some ghost gums rough bark develops that becomes tessellated to a greater or lesser extent, e.g. *C. tessellaris*, *C. cliftoniana*.



Assessing rough bark type is one of the most difficult features in identifying eucalypts. The rough bark may cover the whole trunk and branches, or it may shed from the branches, or develop on the trunk only, to certain characteristic

heights up the trunk. Consequently we refer to species as being wholly rough-barked or partly rough-barked, half-barked, or with rough bark only at the base (black butt). There is usually a range of variation in the bark between trees of the same species. This is illustrated by *E. decipiens* which is divided taxonomically into three subspecies diagnosed by the extent and type of rough bark. Since there are so many different types of rough bark, defined by their texture, colour and persistence on the trunk, we suggest that bark, because of the variability and imprecision of the descriptive terms, is a feature of only medium reliability for identification purposes.



### More about rough bark types

## ■ Leaves

The mature crown consists of a branched leafy canopy in which flower buds, flowers, fruits and seed are formed. The leaves of a mature crown are adult in most species but in many others, leaf advance is arrested at the juvenile phase and the tree is reproductively mature when in juvenile, not adult leaf. In the development of any eucalypt there is no distinct point at which the juvenile stage changes to the intermediate and the intermediate leaves become adult. The stages are useful although imprecise reference points.

Every leaf begins as a minute bundle of cells, whether it is on a seedling or a grown plant. The ultimate functional structure is a mature leaf which can be on a eucalypt plant at any growth stage. This means that there are mature seedling leaves, mature juvenile leaves, mature adult leaves etc. and the term 'mature' must not be used interchangeably with the word 'adult'.



In the great majority of eucalypts, the leaves are formed in the following sequence. The first recognizable organ to emerge from a germinating seed is the root which pierces the seedcoat and penetrates downwards. It is usually white and covered with fine hairs. Then an aerial shoot appears and a pair of cotyledons soon unfolds. These are situated on the opposite sides of a 'square' stem (a seedlot will occasionally produce seedlings with cotyledons in threes placed symmetrically around a six-sided stem, but this condition changes to the normal four-sided stem after a few nodes).

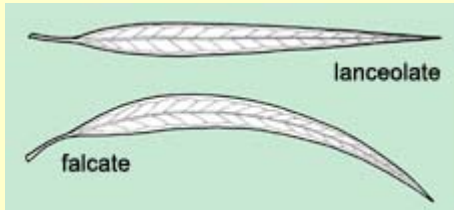
Above the cotyledons, the true leaves are formed in opposite pairs (see exceptions next paragraph), each succeeding pair being at right angles to the pair below. While the leaves in most species continue to be formed in opposite pairs for the whole life of the tree (this can be checked at the growing tips on a mature crown), from the late seedling to the adult stage the leaves become displaced at their point of attachment on the stem such that they appear to be alternate. In some species, however, the leaf development does not advance to the adult stage, and the crown is composed of opposite leaves for the life of the tree. These may be broad, glaucous in some species e.g. *E. pruinosa*, setose or scabrid in others e.g. *C. dunlopiana*, but always juvenile in character. In only a few species is the mature crown composed exclusively of opposite, apparently adult (lanceolate or falcate, green) leaves, e.g. *E. doratoxylon*, *E. erythrocorys*, and in some *Angophora* species, e.g. *A. floribunda*, *A. bakeri*.

In a small group of species, after the first two or three pairs of leaves, the stem becomes five-sided and the subsequent leaves form in a 2/5 spiral (e.g. *E. oleosa*). This is detected by examining the seedling closely. No leaves will be opposite and any two leaves appearing consecutively, one above the other on any leaf-bearing face, will be separated vertically by four other leaves distributed around the other four vertical faces (e.g. *E. longicornis*). Vertically adjacent leaves will occur on the next leaf-bearing face but one, never the adjacent face. This produces a spiral arrangement of leaves that occurs often in seedlings with very narrow seedling leaves.



A different spiral formation is seen in a small group of Western Australian eucalypts. In these the stem is three-sided and a three-leaved spiral forms in the seedling and persists throughout the life of the tree (e.g. *E. lehmannii*).

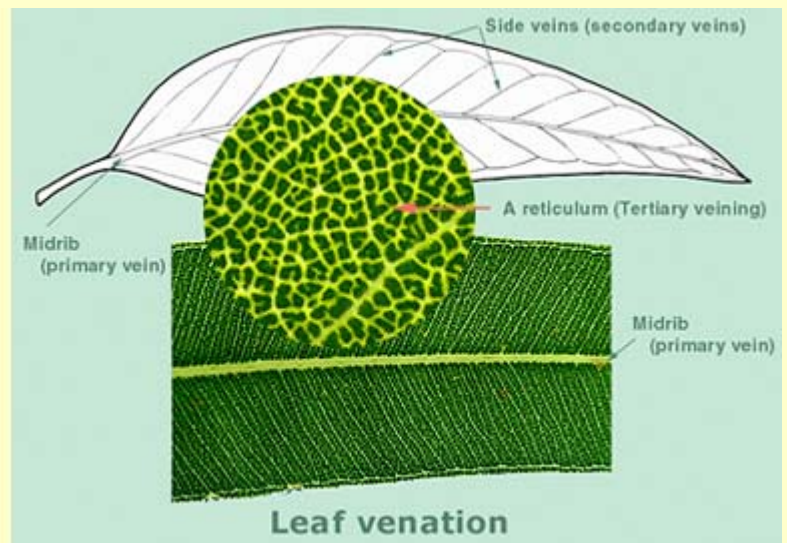
Adult leaves are formed in the crown of the eucalypt plant, be it a mallee or tree, and for species in temperate and sub-tropical areas these leaves probably remain on the plant for some 2 to 3 years although this is not well-known. In monsoonal northern Australia many species are deciduous or semi-deciduous in the dry season which lasts from May to November. Examples are the red gum *E. tintinnans* and ghost gum *C. confertiflora*. New leaves form about October.



Adult leaf shape is not much use in identification as most species have lanceolate or falcate (curved) leaves. Leaf shape is a character of low reliability for identification. Leaf size is less useful as many species have leaves about the same size. It is most useful if the species typically has adult leaves much larger (e.g. *E. globulus*) or much smaller (e.g. *E. parvula*) than most other species.

Most eucalypt species have adult leaves that are more or less the same colour on both sides. But if an adult leaf is distinctly **discolorous** (the upper face is darker and greener than the lower), then this is a fairly powerful tool in the discrimination of species. The discoloured appearance of the leaf is a factor of internal structure. The green photosynthetic tissue (composed of cells with chlorophyll-bearing chloroplasts) is near the upper surface of the leaf and is lacking towards the lower surface in this type of leaf. The discoloured appearance is sometimes maintained on fallen dead leaves although somewhat faded. Juvenile leaves in all species are usually slightly to distinctly discoloured, so care must be taken in assessment of colouration. It is thought that the discolorous (or dorsiventral) leaf is an atavism (a reversion to an ancestral form), maintained in species of humid or high rainfall regions that most resemble the probable environment of the rain forest precursors of the eucalypts. It is seen in *E. intermedia* in eastern Australia and in *E. diversicolor* of the far south-west of Western Australia. *E. cladocalyx* of South Australia with its very discolorous leaves is probably a curious survivor of the ancient forests.

Another character not influenced by the environment is the leaf venation and this can be characteristic of certain groups such as the red bloodwoods, e.g. *C. hylandii*, which have many parallel side veins at a wide angle in a **regularly pinnate (feathery) pattern**. Other species have generally **fewer side veins at more acute angles**, the extreme being the Snow Gums (*E. pauciflora*) and Black Sally (*E. stellulata*) which have **side veins more or less parallel to the midrib**. While the angle of the side veins is highly diagnostic for the wide-angled and for the parallel-veined species, it is of little value for angle states between the extremes.



The midrib of a leaf is the primary vein, the side veins are the secondary veins. When these are the only veins apparently present or visible as in *E. suberea*, there is **no reticulation**, a strong character in assessing leaves for identification. Tertiary veining links the side veins and forms a reticulum. Some species have quaternary veining and the reticulum is consequently very fine. There is no absolute distinction between these categories and we use the terms: no visible reticulation, sparse reticulation, moderate reticulation, dense and very dense reticulation to describe them.

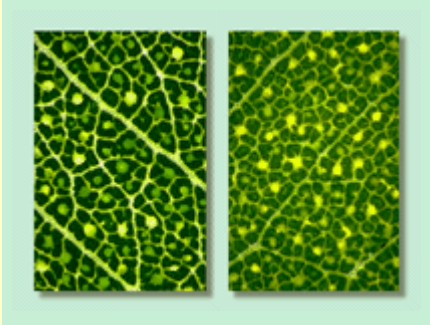


Eucalypts are notable for their oil glands in the leaves. In a dried specimen the glands can only be seen with reflected light and appear as black dots on the undifferentiated surface. But if a fresh leaf is held up towards the sun and inspected with oblique light through the leaf, the glands will be seen as white or yellowish or green structures.

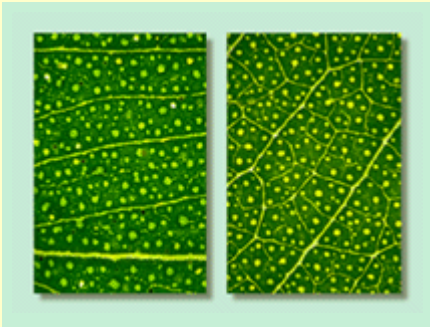
obviously within the tissue of the leaf. This inspection should always be done on the upper surface of the leaf (i.e. holding the lower leaf face towards the sun). This is to ensure comparability between specimens. The leaves of some species look the same when viewed through either face, but most show far more features when viewed with the underside towards the light source.

Many species will show quite different patterns between top-side or under-side viewing. Because most eucalypt leaves turn on their stalks and hang down in the crown, some experience is needed to determine which are the upper and lower faces. This decision is easier to make if [the petiole](#) is flattened on the upper surface, as it is in many species. Difficulty will be experienced in other species in determining the upper and lower surfaces of a leaf if the leaf stalk is slender and not flattened. In these instances both sides should be examined and the image with clearer reticulation and glands assessed, as this is the upper surface. Then comparable assessment can be made.

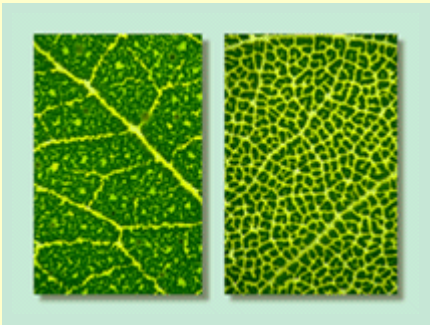
Leaf oil gland categories are usually strong aids to identification as related species tend to have similar patterns.



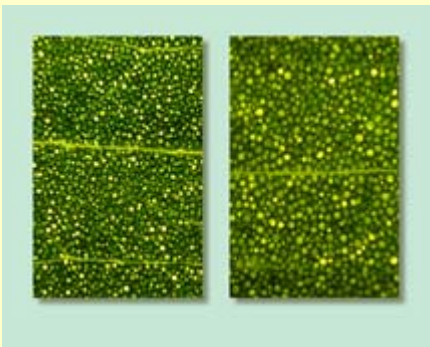
The oil glands may be positioned either at the intersections of the veinlets, e.g. *E. squamosa*, and *E. mannensis*, where they appear to be star-shaped, being connected from the points by a linear chain of cells (appearing as veinlets) to the tertiary veins.



In sharp contrast, the glands may appear as 'islands', e.g. *E. muelleriana*, *E. loxophleba*, *E. marginata*, and *C. bunites*, within the un-veined areas (areoles). 'Island' glands usually appear round although in some species as in the gimlets, e.g. *E. salubris*, they are very irregular.



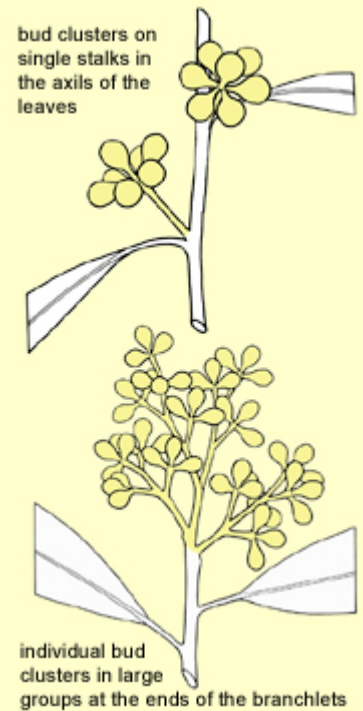
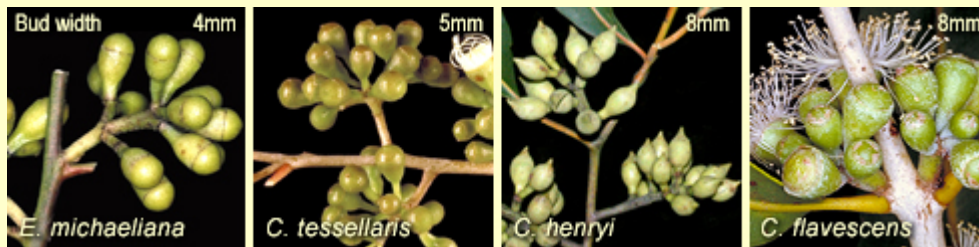
In some species the oil glands are obscure, e.g. *E. baxteri* which is probably a result of their appearance through thick leaf tissue. In a few species the glands are apparently absent, e.g. *E. ovata*, and *E. todtiana*. Apparent presence or absence may be variable within a species and although rare, is seen in *E. rigidula* whose leaves in southern populations are clearly glandular while populations in more arid regions of the species distribution to the north appear to be glandless.



While oil glands in the leaves are mostly described as intersectional, island, absent or obscure, another category almost confined to southern Western Australian species is defined as 'abundant' or 'crowded'. In these species, e.g. *E. eremophila*, *E. annulata*, and their related species, the oil glands are extremely numerous, round, crowded, often obscuring any venation apart from the midrib. The abundant category of glands is a character of high reliability being mostly confined to the series as represented by the species named above. In eastern Australia, only *E. froggattii* has similarly crowded glands, making identification easy for trees in natural stands..

## ■ Inflorescences, buds and flowers

Floral structures *traditionally* hold the defining aspects of species. There are numerous characters associated with them. Basically there are two contrasting forms of floral architecture, the individual flower buds or flowers, and then their arrangement on the branchlets. In most species of eucalypts, the buds occur in clusters on single stalks in the axils of the leaves. The flowers are mostly small and whitish and are not conspicuous in the crown.



A very few species have the inflorescences in complex clusters in the leaf axils, e.g. *E. michaeliana* or on expanded axillary shoots as in some ghost gums, e.g. *C. bella*, *C. tessellaris*, and the spotted gums e.g. *C. henryi*, *C. maculata*, or in more contracted though still branched axillary shoots as in most ghost gums e.g. *C. flavescens*, *C. polysciada*. Four species from eastern Australia, *E. fastigata*, *E. pachycalyx*, *E. regnans* and *E. squamosa*, form their buds consistently in twin clusters in the leaf axils. In contrast, several large groups, the bloodwoods, some of the boxes and some of the ironbarks, form the individual bud clusters in large groups at the ends of the branchlets, with few or no leaves. In season these result in conspicuous sprays of flowers on the outside of the crown. A prominent example is the yellow bloodwood (*C. eximia*) of the sandstone regions of central eastern New South Wales, where the creamy white flower clusters stand out in the forest. In the south-west of Western Australia the widespread marri (*C. calophylla*) exhibits the same prolific flowering affect, although the southern Red-flowering gum (*C. ficifolia*) and the commonly cultivated northern Swamp bloodwood, *C. ptychocarpa*, are the most spectacular of the flowering eucalypts. One species, *E. cladocalyx*, has ramiflorous inflorescences, with the buds formed on the leafless part of the branchlets well inside the crown. Some ghost gums from northern Australia which are deciduous in the dry season, e.g. *C. confertiflora*, also appear to flower on leafless branches but these are cases where the floral buds have formed in the axils where last-season's leaves used to be and the inflorescences are axillary, not truly ramiflorous. Very useful diagnostic information can be derived from these inflorescence patterns, although the structures can be modified by various external factors including predation.

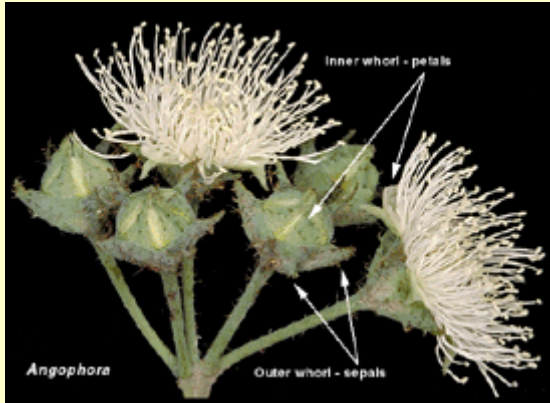
A common modification of the basic axillary inflorescence of the eucalypts can be seen in many 'box', 'ironbark' and 'bloodwood' species. In these, bud clusters are formed in the usual way in the axils of developing leaves towards the ends of the annual growth of a branchlet. The arrangement of these leaves and floral primordia is initially decussate, and subsequent uneven elongation of the axis gives the appearance of alternation. Each branchlet terminates with a vegetative bud. In many 'box', 'ironbark' and 'bloodwood' species, this terminal vegetative bud aborts and the now apparently alternate leaf primordia cease their development. The floral primordia however, continue to develop, resulting in a 'leafless' compound inflorescence, terminating the branchlet. Good examples of this are *E. paniculata*, the common grey ironbark of south-eastern Australia, and *C. calophylla*, or Marri, common in south-western Australia.



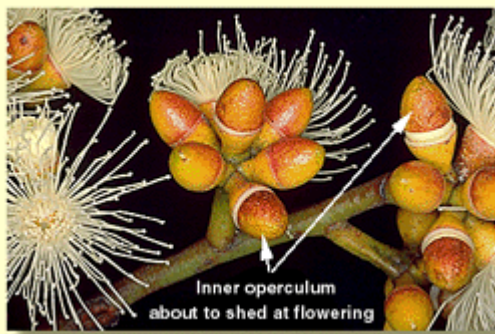
The individual bud clusters in most eucalypts can be seen on close inspection to be in symmetrical patterns. A few species have a single bud in the inflorescence, e.g. *E. globulus* and *E. macrocarpa*, but the basic numbers in *Angophora*, *Corymbia* and *Eucalyptus* are 3 or 7. In a 3-budded inflorescence there is a central erect bud and two subtending side buds, all in a plane at right angles to the stem, forming a 'cross'. A 7-budded inflorescence has a central erect bud, two subtending side buds plus two buds each subtending the side buds. Bud numbers higher than 7 form by the addition of further pairs of subtending buds, and the number of buds in an intact inflorescence is always odd (never an even number), although very high bud numbers may occur in an obscured pattern. Also, in

inflorescences with high numbers, one of a pair of subtending buds may be suppressed, probably by compression in the very young inflorescence which is tightly held within [bracts](#) which are soon deciduous. When assessing bud numbers, it is important to take into account the fact that during inflorescence development, which often takes more than a year, individual buds may be lost. This is particularly the case by the fruiting stage when the structures under examination have been exposed for a long time and subject to various traumas including predation and simple death of individual buds.

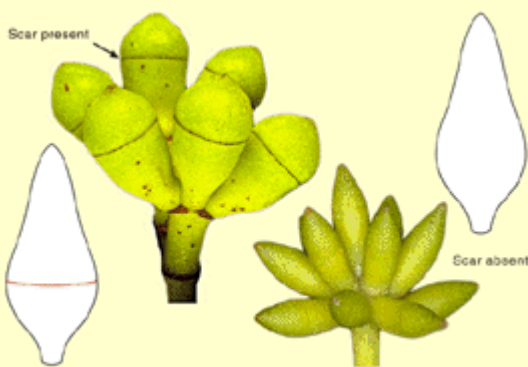
*Angophora* species and some of the northern bloodwoods (*Corymbia setosa* and related species) have simple hairs and bristle glands (erect multicellular hairs or setae) somewhere on the inflorescence, peduncle, pedicel, and often on the bud. The buds of *Eucalyptus* species are glabrous for their whole life cycle.



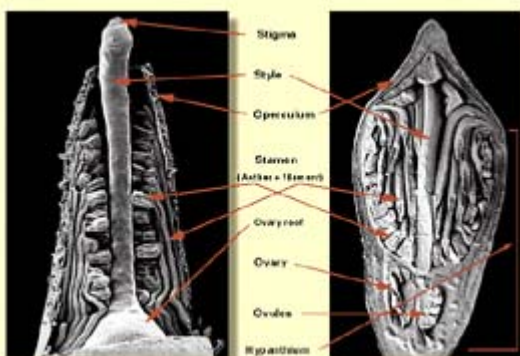
*Angophora* flowers



Inner opercula



Operculum scars



Inner bud anatomy

*Angophora* species are readily distinguished from other eucalypts in the flowers, by the presence of petals that have a green keel and white margin, and by persistent hard, woody, green sepals.

All *Corymbia* species and most *Eucalyptus* species do not have separate sepals. The exceptions are the species in *Eucalyptus* subgenus *Eudesmia* plus a handful of other species. Subgenus *Eudesmia* is widespread and consists of 21 species. In south-western Western Australia the most famous is the glaucous, juvenile-leaved Tallerack (*E. pleurocarpa*). In this and related species, the calyx is formed of distinct separate sepals which are usually evident as [four small teeth at the top of the hypanthium](#) and usually [persist to the fruiting stage](#). A northern example is the Darwin Stringybark, *E. tetradonta*, which in bud has prominent sepals that persist in fruit. Another group of eudesmids have their [sepals more or less fused to the corolla](#) right at the apex of the bud and usually are difficult to see. Examples of this are *E. baileyana* from Queensland and northern New South Wales, *E. ebbanoensis* from south-western Western Australia, and the orange-flowered tropical trees *E. miniata* and *E. phoenicea*.

Other *Eucalyptus* species having separate sepals are *E. microcorys*, which has, in early bud development, very small calyx lobes formed at the top of the hypanthium but which fall early and are seldom seen, and the south-western species *E. steedmanii* and *E. mimica* where conspicuous sepals are present in bud but are lost on flowering; the Queensland endemic species *E. curtisii*, *E. cloeziana* and *E. tenuipes*, with four small teeth present on the mid line of the bud which persist in *E. curtisii* but fall early in the other two. In all other species in *Eucalyptus* and in *Corymbia* the sepals are united to form the outer operculum or bud-cap.

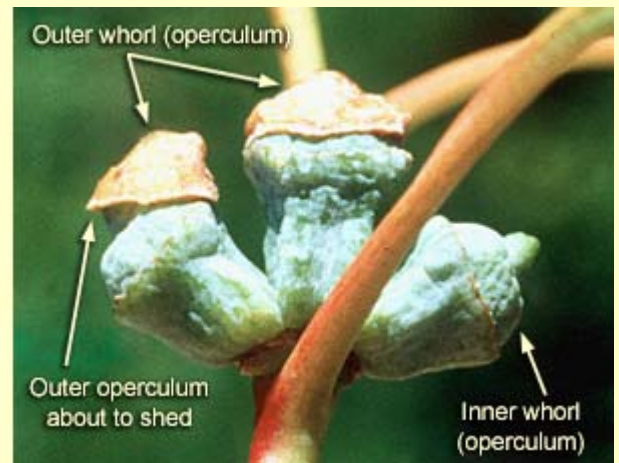


The individual flower buds have two opercula (bud caps covering the stamens and style) derived from the united sepals (outer operculum) and united petals (inner operculum). In some species of red bloodwood

the fusion of the petals to form the inner operculum may not be complete, but careful dissection is needed to see this. A longitudinal section through an almost mature bud can reveal whether or not the inner operculum is divided at all. Similarly, removing the outer operculum but leaving the inner operculum intact can also show whether the inner operculum is partially divided or not. Some examples in the bloodwoods are *C. ficifolia*, *C. zygophylla* and *C. deserticola*. *Eucalyptus guilfoylei* from the wet forests of southern Western Australia may also possess this feature of the inner operculum.

The flower buds of *Angophora* (illustrated above) are all very similar within the group of twelve species and subspecies and, apart from size, contain very few discernible characters that distinguish the species. The individual flower buds of the traditional eucalypts, however, contain a great deal of vital information, from the external superficial nature of the wall of the bud to the characters of much higher reliability contained within. One character of absolute reliability (no exceptions have ever been found) is the number of opercula, although this requires experience to assess.

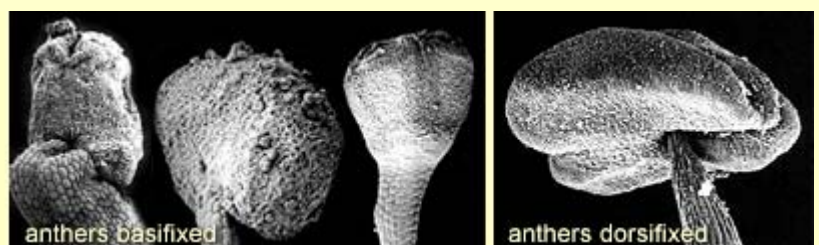
Except for *Angophora*, the eucalypt flower lacks showy petals. The petals are in fact united very early in bud development to form a cap or a cone-shaped structure that covers the stamens and ovary during their development. This is [the inner operculum](#), which sheds just before flowering when the stamens expand and are almost ready to shed their pollen. (There is a delay in pollen ripening and dispersal to lessen the chance of self-fertilisation and consequent inbreeding). The outer whorl of the floral parts is the sepals which, likewise, unite to form an operculum in most eucalypt species. In the majority of species, this, the outer operculum sheds early in bud development. In doing so, the tissue around the approximate middle of the bud, i.e. where the outer operculum attaches to the base of the bud, dies resulting in detachment. This leaves [a scar](#) around the middle of the bud which can sometimes be seen with the naked eye but is best seen with a lens.



About 130 species, comprising the *Eucalyptus* subgenus *Eucalyptus*, have lost the outer operculum altogether in the evolution of the group. Therefore, throughout the development of the bud in these species there is [no scar](#), and the side of the bud is smooth. Some species have two opercula that are fused giving the superficial impression that only a single operculum is present, e.g. *E. ochrophloia*. The boxes and ironbarks show parallel development in operculum characters. There are two groups, one in which the outer operculum sheds early leaving a scar, e.g. the box species, *E. behriana*, and the ironbark species, *E. paniculata*, and another in which the outer operculum is held to bud maturity, e.g. the box species, *E. microcarpa* and the ironbark, *E. sideroxylon*. The double opercula and their retention to bud maturity is a diagnostic feature of all the red bloodwoods (*Corymbia* informal section *Rufaria*). The ghost gums (*Corymbia* informal section *Blakearia* e.g. *C. bella*) and spotted gums (*Corymbia* informal section *Politaria* e.g. *C. citriodora*) shed the outer operculum during bud development leaving an operculum scar.

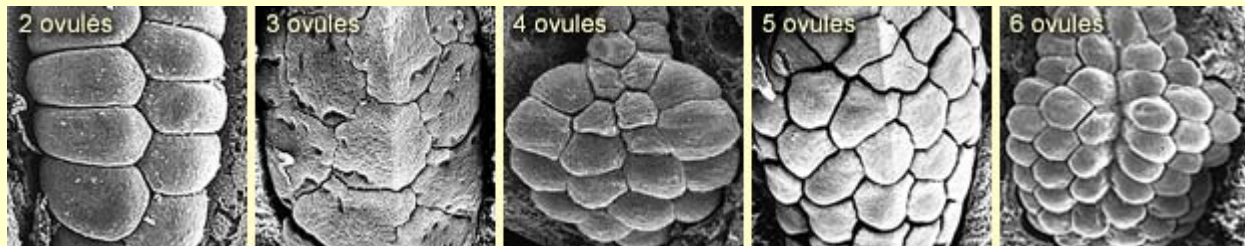


[Stamens](#) have various forms of orientation in the unopened bud. Some species have their stamens wholly erect. Others have them uniformly inflexed, while others have irregular orientation. Again, the extremes of positioning, i.e. complete inflexion or complete erection, are easy to assess. However there will be 'in-between' species in which the character is difficult to categorise. The attachment of the anther on the summit of the staminal filament is useful diagnostically. Some anthers are basifixed, with the tip of the filament attached rigidly at the base of the anther. This character is seen in the boxes and ironbarks and at its most extreme in *E. leptophylla*, *E. foecunda* and related species. In the majority of eucalypts the anthers are dorsifixed, by attachment loosely to the back of the anther, such that it can swivel, i.e. versatile. Some eucalypts have flowers with staminodes, where the outer stamens lack anthers or have reduced, non-functional anthers, e.g. *E. calycogona*.



The openings of the anther for pollen shed (dehiscence) is also an important diagnostic character. Most eucalypts have their anthers either opening by well separated [longitudinal slits](#) for the more or less cuboid anther, or, as in *Eucalyptus* subgenus *Eucalyptus* (e.g. *E. regnans*) with their more or less kidney-shaped anthers, have the openings oblique and touching near the apex, finally forming [confluent slits](#). The cuboid, freely dorsifixed anther occurs in many western species but the kidney-shaped anther with confluent slits is rare in western monocalypts but is seen in Jarrah (*E. marginata*) and a few related species. The butterfly-shaped anther in *E. guilfoylei* is unique in the genus. In a considerable number of species, particularly mallees, e.g. *E. oleosa*, the anthers are subversatile and open by small roundish [pores](#), either at the sides or the top of the anther.

Within the base of the bud is the ovary and this contains characters of high diagnostic reliability. The most useful is the number of vertical rows of [ovules](#). These can only be seen by dissection and is best done under a microscope but can be done in the field and seen with a 10x lens. Most eucalypts have ovule rows with 4 or 6 vertical rows. Another group has ovule rows consistently in 2s (*Eucalyptus* subgenus *Eucalyptus*), while others have rows of 3 or 5, or irregular patterns (bloodwoods and ghost gums).



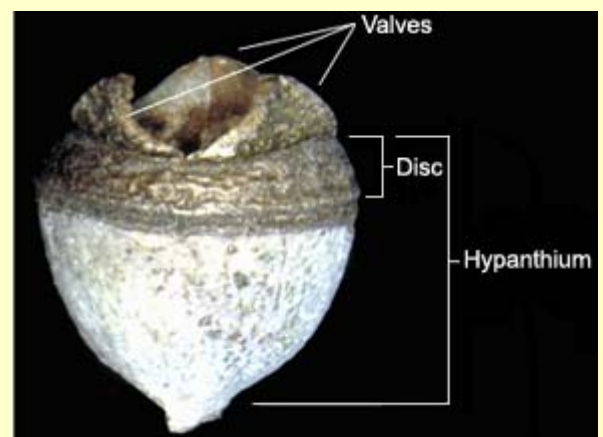
The top of the ovary is surmounted by the style which terminates in the stigma. The style is usually erect in all but a few species but can be spiral in some e.g. *E. albida*, making it a useful diagnostic character. In the great majority of species the style arises from the narrowed summit of the ovary. In some bloodwoods, in *Eucalyptus* series *Melliodorae* (e.g. *E. leucoxyton*) and some species of *Eucalyptus* series *Loxophlebae* (e.g. *E. loxophleba*) the style narrows at the base and is inserted into the roof of the ovary. The style is subsequently articulate, not rigid.

The pollen is transported to the stigma from another flower by insects, small birds or small mammals. On germination of the pollen grains, the contents including the vital nuclei migrate by means of a pollen tube down the stigma shaft to the ovary itself where several ovules at the base of the placentae are fertilised. The fertilised ovules mature into the seeds. The ovular structures on the upper part of the placentae are infertile or unfertilised and 'mature' into sterile particles smaller than the seeds known as the chaff.

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## ■ Fruit

In bud, the ovary is sunk into the expanded, invaginated top of the pedicel (individual bud stalk) known as the hypanthium. The side walls of the ovary are usually fused to the inner wall of the hypanthium such that they appear as one structure. Following fertilisation, the stamens fall from the flower, the style surmounting the ovary usually sheds, and the remaining structure becomes woody and matures into the fruit. The fruits of eucalypts, commonly called the gumnuts, are thus a compound structure of supporting tissue, the hypanthium, and the ovary. The rim of the fruit comprises the scar or circular 'platform' where the operculum was attached, then on the inner side, the narrow or broad ring of tissue that bore the stamens, and finally a band of tissue that links the rim with the ovary roof. This last tissue is the disc, derived from the nectary in the flower. It may descend vertically to the ovary and line the inner wall of the hypanthium as in the bloodwoods and ghost gums, or cross horizontally to the ovary roof, e.g. *E. regnans*, or be raised and ascend to an uplifted ovary roof, e.g. *E. tereticornis*. Some western species have a further development of the disc, e.g. in *E. coronata* and related species, in which the disc extends over the valves such that only the extreme tips of the valves are exposed.





Throughout the three genera fruit shape is difficult to categorise with certainty. One very distinctive fruit form, however, is seen in a few species endemic to southern Western Australia. In these, the numerous individual fruits in a single cluster are fused by the walls of the hypanthium from the time of [bud](#) formation onwards. The fused buds mature into a large, hard, woody cluster that is instantly recognisable, as in [E. lehmannii](#). These fruit are said to be syncarpous.

These fruits were originally considered to be so distinctive that on the discovery of the species, *E. lehmannii* was thought to belong to a different genus and was given this status in the newly coined name, *Symphyomyrtus*, meaning 'fused myrtle'. Later the fused character was considered to be somewhat superficial and the species was placed in the genus *Eucalyptus*. Fusion of organs is easily recognized and of great value in species recognition. Fusion of parts occurs elsewhere in the genus in other organs, e.g. opposite pairs of juvenile leaves of [E. uncinata](#) and the staminal filaments of [E. synandra](#).

For western species another useful aid to identification is found in part of the subgenus *Eudesmia*. The buds and fruit of many of the *Eudesmia* species are square in cross-section, the sepals being conspicuous on the rim at the tips of the sides of the square. 'Square' fruit are also seen in the widespread *E. calycogona*, and [E. prolixa](#), which is endemic to the goldfields of Western Australia. This is an interesting convergent character as the two groups are quite unrelated. Curiously the square fruit is also seen in some box species, clearly so in [E. froggattii](#), and less obviously so in *E. petraea* and *E. ochrophloia*, and some ironbark species, e.g. *E. tetrapleura*. The large urceolate fruits of the bloodwoods (e.g. [C. calophylla](#)) might also be regarded as quite distinctive fruits, but the great variety of fruit shapes seen throughout the eucalypts makes fruit shape a character for which words are rarely ideally descriptive. Further, categorizing fruits into separate shape descriptions is difficult given natural variation and general gradation between shape definitions/categories. Size of fruit is also very variable and within a species size may be affected by seasonal conditions, such as drought, and also by the numbers of fruit that may develop in relation to available resources. Therefore the shape of the fruit, should be used carefully in identification. Similarly when using fruit dimension, choose average sized fruit for the specimen, not extremes.

The roof of the ovary is 'free' and exposed and separates into [valves](#) which spread and allow the seeds to shed. The mature but unopened woody ovary may be deeply sunk in the fruit and not actually be visible below the rim; be more or less level with the rim; or in other species, the roof of the ovary may be raised above the rim. This latter character is seen most conspicuously in [E. coolabah](#) and the ovary is scarcely inferior, i.e. it is not well sunk into the hypanthium as it is in the vast majority of eucalypts.



Of considerable value in identification are the valves of the fruit. Their number and exertion can be characteristic of species and species groups, e.g. the red gums in which the ovary splits into 3 or 4 valves which are usually strongly exerted. The number of valves in the majority of eucalypt species is usually 3 or 4 with a few exceptions where the numbers are up to 6 or occasionally 7, as in the big-fruited *E. aquilina* and *E. preissiana* subsp. *lobata*. In one tropical species, *E. phoenicea*, the valve number is reduced to 2.



There is one valve character that requires qualification. In the large series *Subulatae* and to a lesser extent the series *Falcatae*, the ovary is sunk well below the rim of the hypanthium. The style surmounting the ovary splits into [three or four needle-like structures](#) (the number of the ovary chambers and therefore the valves). Despite their fragility they persist as the valves spread in dehiscence, and are conspicuously emergent above the rim of the fruit. Ultimately they break off but their early persistence is a feature of these two taxonomic series and may be regarded as a character of medium to high reliability bearing in mind that the 'valves' are finally lost from the fruit.

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## ■ Seed

One useful feature that is not immediately available in the field is the seeds. Until the vascular connections between the individual fruits held in the crown and the parent tree are broken, the valves will not open. Otherwise, eucalypt fruit are held on the branchlets often for years. Seed from detached fruits, however, can be ready for inspection after about 24 hours by placing unopened fruits in a paper bag where they dry out quickly and shed [the seeds and the thinner chaff particles](#). There is a great number of seed forms and these can be seen either with the naked eye or with a lens. Fortunately, related species have identical seeds and the character is therefore one of high reliability. Because words do not adequately convey the actual seed shape for most species, experience is needed to educate the user who will ultimately find the seeds to be an invaluable aid in discriminating species and groups of related species. We suggest the following terms as a guide.



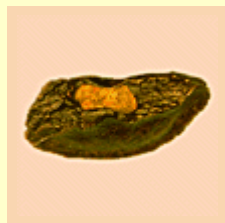
### Flattened or saucer-shaped

The seed is somewhat flattened with a distinct upper (dorsal) and lower (ventral) side. The ventral side may be somewhat concave, with the hilum in the centre. [Angophora](#) and the ghost gums have this type of seed.



### Pyramidal or obliquely pyramidal

The seed is pyramid shaped with a relatively smooth or lacunose, flat or rounded dorsal side. The ventral side is usually ribbed, wrinkled or angled and is surmounted by a narrowed face at the summit where the hilum is (e.g. [E. acmenoides](#)). This is the seed type in most of the monocalypts although there is a great amount of variety in their seed form. Perhaps the most extreme seed shape in the monocalypts is seen in some western endemics, e.g. [E. buprestium](#) and [E. todtiana](#), in which the body of the seed is small in comparison to the grossly extended curved lateral wings.



### Boat-shaped

The seed is elongated and strongly keeled dorsally with a large, conspicuous hilum in the middle of the flat underside. The edges may be flanged or narrowly winged. [C. gummifera](#) and [C. calophylla](#) notably have this type of seed.



### Cuboid

The seed is chunky, often with a smooth, shiny or somewhat granular, sometimes slightly rounded, dorsal side. The hilum is situated on a smaller terminal face separated from the dorsal side by the side walls of the seed. These walls are often angular. The chaff is usually similar to the seed, but somewhat smaller and lighter coloured (e.g. [E. seeana](#)).

### Ellipsoidal with terminal wing

The flattened-ellipsoidal body of the seed occurs at the lower end (considering the disposition of

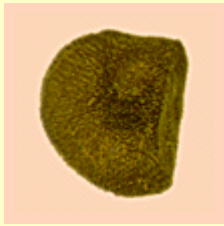


the ovule on the placenta in the intact bud), with a transparent wing as long as the body of the seed at the top end. The wings may be seen, just before seed shed, emerging from the top of the ovary. The hilum is usually positioned near one edge not far from the start of the wing. The wing is purely a descriptive morphological term and the structure has no apparent aerial function. Most of the bloodwoods have this type of seed (e.g. [C. chippendalei](#)).



#### Pointed at one end

The seed is somewhat flattened, usually rounded at one end and pointed at the other. It may be described as teardrop-shaped (e.g. [E. conica](#)).



#### D-shaped

The seed is roughly disc-like with a short straight side and a longer connecting curved side. The hilum is towards the narrowed end (e.g. [E. porosa](#)).



#### Spherical

The seed is more or less spherical (e.g. [E. desmondensis](#)).



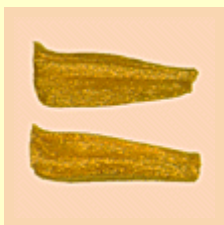
#### Ovoid or depressed-ovoid

The seed is ovoid or elliptical in outline but flattened with the hilum on the more or less concave ventral side (e.g. [E. aggregata](#)). A large number of species have this type of seed. Examples are the section *Maidenaria*, endemic to eastern Australia, in which the dorsal surface is often lacunose, and a large number of mallees occurring across southern Australia. These seeds have very smooth dorsal sides with two or three shallow longitudinal grooves. This is seen particularly in series *Subulatae* and *Calycogonae*.



#### Obliquely elongated

The seed is like a narrowly drawn-out pyramid with the dorsal face curved and prolonged into a thin 'tongue'. The terminal face is small, flat and oblique on the seed with the hilum in the middle. The sides are ridged (e.g. [E. burracoppinensis](#)).



#### Linear

The seed is narrow and elongated, with a very small dorsal surface, long sides and terminal hilum (only [E. curtisii](#)).

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## ■ Pith

Once a specimen has been taken, a very handy and accessible feature is the pith of the branchlets. In the southern half of the country about half of the dry country mallees have a line of clear-coloured or [brown oil glands in the pith](#) usually visible to the naked eye, while the remaining species have a [white or uniformly coloured, undifferentiated pith](#). This character is easily assessed in the field by [pulling a side branchlet away](#) from the main axis. Pith glands, if present, will be most conspicuous at the nodes so this is where the character should be sought for its presence or absence. The developmental origin of these discrete rounded pith glands is unknown.



Pith gland absence or presence is a character of moderately high, not absolute, reliability and is a particularly useful character to help identify South Australian and southern Western Australian species.

This, however, is not true in all areas of the country. Many, perhaps all, species of *Corymbia* (bloodwoods and ghost gums) and *Angophora* have obvious short or elongated duct-like spaces in the pith of the branchlets. These are not as easily seen in the field as the discrete round pith glands but can be seen with a 10X lens, especially at or near the leaf bases. These ducts may be filled with a sticky brown substance (?oil or resin) or the contents may be crystalline but they are not round pith oil glands as described above. Only one species of ghost gum, *C. kumbolgiensis* has been observed with discrete round brown pith oil glands. In EUCLID we have scored this character when we have seen it in *Corymbia* and *Angophora* species, however when identifying these species it should be used with caution or avoided.

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## ■ A brief history of *Eucalyptus*, *Angophora* and *Corymbia*

Although eucalypts must have been seen by the very early European explorers and collectors, no botanical collections of them are known to have been made until 1770 when Joseph Banks and Daniel Solander arrived at Botany Bay with James Cook. There they collected specimens of *C. gummifera* and later, near the Endeavour River in northern Queensland, they collected *E. platyphylla*; neither of these species was named as such at the time.

In 1777, on Cook's third expedition, the botanist David Nelson collected a eucalypt on Bruny Island, southern Tasmania. This specimen was taken to the British Museum in London, where it was named *Eucalyptus obliqua* by the French botanist, Charles-Louis L'Héritier de Brutelle, who was working in London at the time. He coined the generic name from the Greek roots *eu* and *calyptos*, meaning 'well' and 'covered', in reference to the operculum of the flower bud. This organ protects the reproductive structures during their development and sheds under pressure from the emerging stamens at flowering. The name *obliqua* was derived from the Latin, *obliquus*, meaning 'oblique', describing a leaf base where the two sides of the leaf blade are of unequal length and do not meet the petiole at the same point.

In the publication of *Eucalyptus obliqua*, L'Héritier recognized in the generic name a feature common to all eucalypts - the operculum. In his choice of specific name, he recognized not only a characteristic feature of *E. obliqua* but one that occurs in most other eucalypts as well. *E. obliqua* was published in 1788 and coincides with the date of the first official settlement of Australia.

Between 1788 and the beginning of the nineteenth century several more species of *Eucalyptus* were named and published. Most of these were by the English botanist James Edward Smith and most were, as might be expected, trees of the Sydney region. They include the economically valuable *E. pilularis*, *E. saligna* and *E. tereticornis*, each of which also occurs in Queensland, with the distribution of *E. tereticornis* extending to the island of New Guinea.

Also in this period the genus *Angophora* was published, in 1797, by the Spanish botanist Antonio Jose Cavanilles, based on specimens collected at Port Jackson by Frenchman Luis Née in 1793. Née was botanist with the Alejandro Malaspina expedition. Various authors have considered *Angophora* to be sufficiently distinctive that it should be maintained as a separate genus. Others believe it is a 'eucalypt'. We recognize both *Eucalyptus* and *Angophora* in EUCLID, reflecting results of recent research and usage by the general community.

The nineteenth century was a period of extensive land exploration. This resulted in the discovery of many new eucalypts and their subsequent naming by several of the great botanists in Australian history, particularly Ferdinand von Mueller, whose work on eucalypts contributed greatly to the first comprehensive account of the genus in George Bentham's *Flora Australiensis* (1867). Bentham never visited Australia, but his account is the most important early systematic treatment of the genus *Eucalyptus*.

Some earlier authors had constructed classifications, but the distinctions they used - for example, shape of the operculum and the juvenile leaf arrangement - were only applicable to far fewer species than were known to Bentham; they were of little use when applied to a much larger number of species. One useful study before that of Bentham, however, was Mueller's description of different bark types (Mueller, 1858). These still have relevance in distinguishing between, for example, groups that shed or retain dead bark and, in the latter case, between ironbark and other types of rough bark.

Bentham divided the genus into five series whose distinctions were based on characteristics of the stamens, particularly the anthers. Categories within each series were based largely on the leaves, and on bud and fruit shape.

He was obviously working with limited botanical specimens, and field characters were not available to him unless communicated by others from Australia.

Mueller, working in Australia, devised another classification based on the anthers (Mueller, 1879-84), while Joseph Henry Maiden (1924) elaborated on the anther system, which was taken even further by William Faris Blakely (1934). By this time, classification based on the anther system had become too complex to be workable.

Other more consistent characters have been sought in recent years to aid in the construction of classifications. Of these, leaf venation, the nature of bristle glands, the morphology of the seeds, nature of the operculum and the structure of the inflorescence are fundamental. More sophisticated equipment has usually enabled the examination of these leaf and floral structures early in and during their development. Similarities thus recognised usually provide the evidence of natural affinity between species and groups of species. In other words, botanists became better equipped to decide whether these similarities noticed in different species and groups were the results of inheritance from a common ancestor or if they had independently evolved, in many cases as an adaptive necessity such as lignotuber formation or salt tolerance.

A comprehensive but informal classification of all known eucalypt species was published in 1971 by the late L.D. Pryor and L.A.S. Johnson. It comprised seven major groups based on the association of many morphological characters and suggested by the breeding incompatibility between them. Their system has been subjected to close scrutiny in the past 30 years. Many improvements to this classification were proposed by Johnson himself and by others, although he never formally published a system of classification.

Briggs and Johnson (1979) contributed a major advance in the botany of the whole family Myrtaceae, in which they outlined for the first time a comprehensive analysis of inflorescence structure in all genera and its indication of evolutionary trend.

In Volume 19 of the 'Flora of Australia', all eucalypts published to 1988, were comprehensively treated (Chippendale, 1988). This work includes 513 species of *Eucalyptus* arranged in 92 series, many of which were published formally in this volume. This is not a structured classification as there are no subgenera or sections. The work is of particular value for its typology and erection of many new taxonomic series.

The decade after 1988 saw the application of advanced methodology in the study of the genus *Eucalyptus*, especially in phylogenetic analyses of taxonomic series (e.g. Ladiges *et al.*, 1987; Hill and Johnson, 1995) and in the use of molecular techniques in the estimation of infra-generic relationships within the genus and between cognate genera (Ladiges *et al.*, 1995; Ladiges and Udovicic, 2000).

Most notably in 1995 K.D. Hill & L.A.S. Johnson published a monograph on the bloodwoods and ghost gums in which they described the genus *Corymbia*, with species grouped in seven sections which intentionally follow from the earlier work of Pryor & Johnson (1971). This grouping at section, and at series and subseries rank is, according to the authors, intentionally informal, i.e. outside the International Code of Botanical Nomenclature (Hill & Johnson, 1995, p. 186)

In 2000, M.I.H. Brooker published a formal classification of the genus, which is a synthesis in the form of an updated taxonomy to accommodate the numerous taxa published since Chippendale's 1988 treatment. While based conceptually on the work of Pryor & Johnson, it recognizes one genus, *Eucalyptus* and includes *Angophora* and *Corymbia* as 2 of a total of 13 subgenera, and assigns all species known to the year 2000 to a hierarchical system of subgenera, sections, subsections, series, subseries and supraspecies (Brooker 2000).

The 5 years following Brooker's 2000 classification has seen further systematic and phylogenetic investigations of the eucalypts. Increasingly, molecular data are incorporated into studies of the relationships between the subgenera recognised by Brooker, and this is reflected in ongoing refinements to eucalypt systematics. The various concepts proposed from those studies are discussed in the accompanying section "[Evolutionary Relationships in \*Eucalyptus sens. lat.\*](#)".

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■ **Evolutionary Relationships in *Eucalyptus sens. lat.***

## Hybrids

Whilst hybridism has been frequently reported between species in *Corymbia*, and also between species from within the same subgenus of *Eucalyptus*, rarely are hybrids between species from different subgenera of *Eucalyptus* seen in the field. An example of the latter is hybrids between *E. cloeziana* (subgenus *Idiogenes*) and *E. acmenoides* (subgenus *Eucalyptus*) (see Stokoe *et al.*, 2001). Manipulated hybrids between species from different subgenera have never been successful.

Hybridism requires genetic compatibility and synchronous flowering times (unless manipulated). Hybrids between species within a subgenus are rare in natural forests or scrubs. They are more likely to be seen as regrowth trees or mallees in disturbed areas where changed environmental conditions may be more amenable to the success of the hybrid combination. Hybrids in stands appear to be selected against in favour of the parent species.

Many reported hybrids are better interpreted as natural intergrades between closely related species. e.g. *E. burgessiana* and *E. stricta* in eastern New South Wales, *E. dalrympleana* subsp. *dalrympleana* and *E. viminalis* subsp. *viminalis* in Tasmania, *E. angulosa* and *E. incrassata* in coastal South Australia and Western Australia, *E. brownii* and *E. populnea* in Queensland.

Hybrids can complicate the identification of specimens and there are a couple of ways of investigating more closely whether the problem specimen is a hybrid. Firstly, close observation of the features of eucalypts in the stand where you collect the specimen may indicate that some trees appear intermediate in some features such as bark type or crown colour. Secondly if there is seed on your specimen you may be able to raise a moderately large number of seedlings (say 10-20) and look for gross variation in seedling leaf shape and other characteristics, and compare these with similarly grown seedlings raised from individuals of the purported parents. This is of course a lengthy business but can give good information.

There are a few well-known formally named hybrids where both parents have been identified and are seen in the field, e.g.

[\*E. brachyphylla\*](#) (*E. kruseana* × *E. loxophleba* subsp. *lissophloia*)

[\*E. erythrandra\*](#) (*E. incrassata* or *E. angulosa* × *E. tetraptera*)

[\*E. missilis\*](#) (*E. cornuta* × *E. angulosa*)

and possibly [\*E. balanites\*](#) (*E. lanepolei* × *E. decipiens*).

In another example, [\*E. annuliformis\*](#), only one parent is evident, [\*E. drummondii\*](#), the other being a mystery.

Many presumed hybrids have been formally named by botanists of the eucalypts over the last 200 years. The most recent annotated list of many of these names can be found in Chippendale (1988, pp. 428–442). Hill & Johnson (1995) list, in an appendix, hybrids and intergrades they have observed in *Corymbia*.

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