IS EUCALYPTUS VARIABLE?

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SYNOPSIS:

I. The variability of characters considered seriatim.
II. Has variation in Eucalyptus now ceased?
III. Some studies in variation.
IV. Mannas, kinos, oils, etc. are accessory characters only.
V. Botanical classification for purposes of nomenclature of genera etc., is based upon morphological characters.

This Journal has been a medium for recording the theory that the genus Eucalyptus has now ceased to be variable. I propose to consider the question from various points of view.

I. THE VARIABILITY OF CHARACTERS CONSIDERED SERIATIM.

The genus Eucalyptus is such a large one that a number of schemes have been submitted for dividing it into sections with a view of associating those closely allied, or for arriving at the name of a species with facility. I propose to review each character, from timber to anther, to see if any satisfactory scheme can be evolved. In the Proc. Aust. Assoc. for Adv. of Science, Sydney Meeting, 1898, both Prof. Tate¹ and Mr. Luehmann² simultaneously gave prominence to the use of the fruit for purposes of classification. Both papers take cognizance of other characters as well. Both are the work of men who know the genus and are valuable contributions to knowledge.

¹ Tate, R.—"A review of the characters available for the classification of the Eucalypts, with a synopsis of the species arranged on a carpo-logical basis."
² Luehmann, J. G.—"A short dichotomous key to the hitherto known species of Eucalyptus."
Habit—Tate defines two habits of growth, viz:—trees, and shrubby, stocky trees, to which he applies the vernacular names of gums and mallees respectively, names well understood in Australia. He points out that in young plants of Eucalypts there is a large inflation of the base of the stem, either at the surface or just below the surface of the soil. In gums (*E. rostrata, leucoxylon, viminalis, etc.*) this is eventually outgrown, but in the mallees (*incassata, uncinata, etc.*) it persists, and increases in size proportionately with the development of the branches which are emitted from it—in the mallee this rudely globose bole is partly subterranean. "The umbrella-like disposition of the foliage of the taller mallees may be largely incidental to overcrowding, though it would seem to be an inherited character, as it is fairly pronounced in them when they are distinctly separated from one another." This classification is chiefly of practical use in Professor Tate's own State (South Australia) and in Western Australia.

It is however, very difficult to group the species according to habit. Some are dwarf in their typical forms, but under different circumstances they take on a larger growth. Then, speaking generally, such species as are found in damp situations in good soil are umbrageous trees; such for example are *stellulata, aggregata, Macarthuri*, but this character is largely a matter of environment. Then some species, *e.g.*, *viminalis*, have a more or less drooping habit as a rule, but this species is often nearly erect in less congenial soil. And, further, to show variation in habit, we have only to point to the Eucalyptus plantations of California and the South of France where the species are cultivated almost out of recognition.

Bark—Mueller (*Journ. Linn. Soc.*, III., 99, 1858) arranged the genus in the following six groups in respect to their barks. With the additional information we have obtained
since Mueller’s paper was published, we are able to recast his list of examples. It will be found, however, that no two botanists agree as to the sections in which to place some of the species, and as further field-knowledge is available and we know more about variation of bark in the same species, the same authority modifies his own lists.  

“1. Leiophloioae—Cortex post delapsum strati supremi undique lævis. (Vulgo, Flooded Gum trees, White Gum trees, Blue Gum trees partim, Red Gum trees partim, Yarra trees).”

Smooth barks (“Gums” we call them). Examples are E. hemastoma, rostrata, tereticornis, leucocxylon, viminalis, Gunnii, maculata, latifolia, aspera, stellulata, coriacea, saligna, Behriana, punctata, stricta, fasciculosa.

“Hemiphloioae—Cortex in trunci parte inferiore persistens rugosus et rimosus, in parte superiore ramisque delapsu strati superiores levigatus. (Vulgo, Moreton Bay Ash, Blackbutted gum tree, Box trees partim).”

Half-barks, the barks of the lower part of the trunk persistent and the upper part smooth. Examples are E. hemipholoa, pilularis, bicolor, longifolia, melliodora, amygdalina, dives. The Moreton Bay Ash (tesselaris) is better in section 3 or 6.

“3. Rhythphloioae—Cortex ubique persistens rugosus et rimosus intus solidus. (Vulgo, Bloodwood trees, Box trees partim, Peppermint trees partim).”

With wrinkled persistent bark, rather solid. This is an unsatisfactory group, including heterogenous barks. Mueller intended it to include the Bloodwoods (corymbosa, eximia, trachyphloia), also bicolor (which is better in 2) and E. microtheca; leptophleba, ferruginea. Odorata, robusta,

botryoides, may be added and also Stuartiana, pulverulenta, microcorys, acmenioides, resinifera, polyanthema, populinifolia, piperita.

Nos. 2 and 3 run into each other, and both of them into No. 4.

"4. Pachyphloioae—Cortex ubique persistens rugosus intus fibrosus. (Vulgo, Stringybark trees)."

"Stringybarks, with persistent, fibrous barks."

A good natural group, including eugenioides, capitellata, macrorrhyncha, obliqua, pilularis, var. Muelleriana, tetrodonta.

"5. Schizophloioae—Cortex ubique persistens profunde sulcatus intus solidus. (Vulgo, Ironbark trees)."

"Ironbarks with hard, deeply furrowed barks."

Perhaps the best of all groups. Examples E. siderophloia, paniculata, crebra, sideroxylon, melanophloia.

"6. Lepidophloioae—Cortex saltem in trunco persistens lamellaris friabilis. (Vulgo, Melaleuca Gum trees, Mica trees)."\(^1\)

With persistent bark on the trunk only, and forming scaly separate pieces. Mueller’s examples are miniata (aurantiaca) phoenicea, peltata (melissiodora), to which I would add tessellaris.

The Revd. Dr. Woolls\(^2\) ignores section 6, and it certainly cannot be separately maintained as a section.

The cortical classification separates trees that are closely allied, e.g., hemiphloia and Baueriana, the first being a

\(^1\) The meaning of this, which is not quite clear as it stands, is explained by the following passage: "The bark of both is very lamellar and friable, outside of a yellowish- or greyish-brown, on fracture partly glittering, and somewhat resembling mica-schist."—Eucalyptographia under E. phoenicea.

\(^2\) Proc. Linn. Soc., N.S.W., vi., 709.
half bark and the latter having rough bark to the branchlets. Similarly *E. pilularis*, in its normal form has smooth, while its variety *Muelleriana* has rough branchlets.

It places in juxtaposition those that are not closely related, as will be observed from the examples given under each section. Prominent examples are (a) *E. paniculata*, Sm., and *E. fasciculosa*, F.v.M., and (b) *E. sideroxylon*, A. Cunn. and *E. leucoxylon*, F.v.M., respectively nearly alike in leaves, flowers and fruits, but utterly dissimilar in bark and wood.

Absolute anomalies as regards barks are those of Ironbark for *E. stellulata*, *Sieberiana*, and *viminalis*; a box-like bark for *E. tereticornis*, and observers will note many other anomalies within their own experience. At the same time, in careful hands, the bark is the most useful character the forester can employ.

**Timber**—While the character of a timber is a matter of economic importance, its use in botanical diagnosis is very often overlooked. For many years I have insisted on the examination of the timber wherever possible, and recognition of this character has undoubtedly led to a better understanding of the genus.

Timbers can be classified in different ways, *e.g.*,

1. **Fissility**—Some are fissile, such as Stringybarks (*E. eugenioides*, etc.), Mountain Ash (*E. Sieberiana*), Victorian Blackbutt (*E. regnans*) etc. Others are short in the grain, such as many gums, snapping off like a carrot, while others are tough and interlocked like boxes and ironbarks.

2. **Colour**—In a lecture delivered in 1891 before the Sydney Architectural Association of N.S.W., I divided many of the Eucalyptus timbers into pale hardwoods, subdividing them into three groups, (a) hard, interlocked, (b) fissile,

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3 See Luehmann, *op. cit.* page 524.
(c) inferior, such as gums,—which is a useful practical classification. In my "Notes on the Commercial Timbers of New South Wales" (1895), I submitted the classification (1) ironbarks, (2) pale hardwoods, (3) red hardwoods.

1. **Gums**—These timbers are short in the grain, dry to a brown or reddish colour, crack radially in drying, have many gum veins and, as a rule, lack durability. Their barks are smooth, and more or less ribbony. Examples—*stellulata, coriacea, haemastoma, viminalis, Gunnii*. They connect with the "Boxes" (Bastard), and also with the smooth barked members of the Jarrah Group.

2. **Mallees**—Examples—*oleosa, Behriana, incrassata*. This is a group based on geographical considerations. They are arid country species and connect the "Gums" and "Red Boxes."

3. **Ironbarks**—These are fully described in my "Notes on the Commercial Timbers of New South Wales." They consist of (a) True Ironbarks, viz., *paniculata, siderophloia, crebra, sideroxylon*; (b) Bastard Ironbarks, timbers very similar to ironbarks, but the barks belonging to the "Box" Group. They consist of *Boormani* and *affinis*. *Melanophloia* (and perhaps *microtheca*) connects the two groups.

4. **Boxes**—These are tough, interlocked timbers, usually with fibrous bark on the trunk, and may be sub-divided into:—(a) Pale, Examples—*hemiphloia, melliodora, Bosistoana, Baueriana, populifolia, quadrangulata, Cambagei, goniocalyx, tesselaris, leucoxylon, corynocalyx, globulus*. (b) Red, Examples—*bicolor, microtheca, polyanthema, odorata, fusciculosa*. These two groups include some smooth barks or "gums" but their timbers are provisionally classified with the "Boxes."

(c) Bastard, Examples—*Stuartiana, pulverulenta, Macarthur, aggregata*. The timber of (c) is inferior and closely resembles that of the gums.
5. Stringybark Group—This includes a number of fissile timbers that pass into each other and may be sub-divided as follows:—

(a) True Stringybarks—Examples, _eugenioides_, _macrorrhyncha_, _capitellata_, _obliqua_, Baileyana.

(b) Blackbutts—Examples, _pilularis_, (which absolutely connects with the Stringybarks through its variety _Muelleriana_), _aemenioides_. The most valuable timbers of the group.

(c) Peppermints—Examples, _amygdalina_, _regnans_, _dives_, _piperita_; these timbers have gum-veins and are altogether inferior in quality.

Allied to these is the—

6. Mountain Ash Group—Fissile timbers usually pale in colour, and with bark not so fibrous as the preceding. Examples, _Sieberiana_, _Planchoniana_, _virgata_, and its varieties _Risdoni_, _cordata_.

7. Tallow-wood and Spotted Gum—_E. microcorys_ and _E. maculata_, two valuable pale coloured timbers, _sui generis_.

8. Bloodwoods—These have gum-veins and are coarse grained; _corymbosa_ is red, and _eximia_ and _trachyphloia_, which are pale, connect with _maculata_.

9. Jarrah Group—Containing a number of heterogeneous species, and which I name after the best known member. Some have fibrous barks, others are smooth, but they are all deep-red, durable timbers. Examples, _marginata_, _resinifera_, _diversicolor_, _propinqua_, _punctata_, _saligna_, _botryoides_, _robusta_, _tereticornis_, _rostrata_, _longifolia_. This group connects with the Red Boxes.

The timber of the same species varies a good deal according to soil and situation, and our knowledge does not yet enable us to discriminate between some timbers not closely
allied botanically. In other words, a man who professes to discriminate between all species of timber attempts the impossible.

**Exudations**—In *Proc. Linn. Soc., N.S.W.*, 1890 I proposed examination of the kinos as an aid in the diagnosis of Eucalypts, and I divided them into three groups according to their behaviour in water or alcohol (spirit).

1. **Ruby Group**—Consisting of ruby coloured kinos, soluble in water and alcohol in all proportions. Examples are, all Renantherae except *microcorys*.

2. **Gummy Group**—Soluble in water, but insoluble in alcohol owing to the gum they contain. Examples, the Ironbarks.

3. **The Turbid Group**—These kinos are soluble in hot water or hot alcohol but deposit sediment on cooling. Examples, most of the Parallelantherae. This section, however, includes heterogeneous substances and brings together species little allied. It is doubtless capable of further elaboration, but only serves to accentuate variation in the genus.

Some kinos e.g., *E. maculata*, are characteristic in appearance, having an olive-green colour; perhaps also that of *E. corymbosa*, of an intense, almost vermilion colour.

An exudation of less importance is that of *Manna*. A number of species exude saccharine substances from the leaves and, a very few, from the trunk. The list is being added to slowly, but in most cases the mannas are mere scientific curiosities and of little value in a scheme of classification. They include *viminalis*, *Gunnii*, *punctata*, *pulverulenta*, *Stuartiana*.

The method of classification on the comparatively few experiments made is ingenious but of little practical value to us for diagnosis, thousands of sections being required in order to obtain data for generalisation. The paper is however, of more than ordinary value and is well worthy of perusal.

Leaf—(a) Suckers—De Candolle (Prodromus Vol. III., 1828) classified Eucalypts according to the opposite or alternate character of the leaves, a character of special importance at that time since species were often described from seedlings grown in pots. Field observations have, however, shown that all species have opposite leaves in at least an early stage. In seedlings this is best observed, but in many cases suckers show the character quite as well. In a few species e.g., _gamophylla_, this opposite-leaved character persists through life. In many cases the young leaves are broad and become alternate and narrower, with a lanceolate or falcate shape as maturity is reached. Often these young leaves are glaucous, becoming glabrous as growth proceeds. But there is a group in which the seedling and sucker leaves are narrow. Such species include _amygdalina_, _pilularis_, _viminalis_.

The list is however so incomplete that it is impossible at present to use it as a broad basis of classification. For diagnostic purposes I personally use the shape of the young leaf wherever possible; it is an atavistic character and data are accumulating by which we shall be in a better position to interpret it.

The difference between suckers and mature leaves has been studied in Europe for many years, although in Eucalyptus the systematic comparison of such forms is of comparatively recent date. It is of practical importance to the Australian forester, for the reason that the occur-
rence of these young or sucker leaves is so very frequent in the bush.

"When a trunk is injured new shoots make their appearance either from the "eyes" in the stem or from reserve buds of the branches and twigs, or by buds produced from the roots below the ground. The leaves of these shoots or suckers, as they are called, differ very much from the stems or branches which have been broken, eaten, cut or frozen off." .

Instances of differences are given and it is added, "Hundreds of trees and shrubs might be mentioned in which there is a distinct difference between the foliage of the suckers and of the normal branches of the crown."1

Nor has the description of species and varieties from suckers or seedling leaves been confined to writers on Eucalyptus:—

"Gardeners and descriptive botanists have frequently determined and described mutilated plants as other species, hybrids, or varieties. They are neither the one nor the other. The peculiar appearance of the altered members resulting from mutilation is exactly determined beforehand in each species; it is due to the specific constitution of the species, and thus is part of its being. It is not produced by the external influences which lead to the formation of the varieties, but is brought about by the inherent necessity quite independent of the influence of climate and soil."2

Practically all the researches on the anatomy of Eucalyptus leaves have been made on those of the readily available E. globulus, in which species both sucker and mature leaves are readily available.

The most complete research is the masterly paper of G. Briosi.3 See also a study by H. Pocklington.4

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1 Kerner and Oliver, ii., 515, 6. 2 Op. cit., 518.
3 Ricerche intorno all' anatomia delle foglie dell' Eucalyptus globulus, 23 pl. Milano, 1882.
4 The Microscope in Pharmacy, Eucalyptus globulus, Pharm. Journ. (3) III., 990; iv., 549. A useful histological study of bark, leaves, etc.
Then Henslow\(^1\) says:—"The chief difference between the two forms of leaves I find to be as follows:—In the horizontal leaf the upper epidermis is composed of small cells, and there are no stomata. There is a palisade tissue of one layer of cells, with lax mesophyll below the lower epidermis. This latter has larger cells than the upper and is provided with stomata. The pendulous leaf is a good deal thicker than the horizontal. Both epidermides are provided with a very dense cuticle in which the stomata are deep-seated. There are four rows of palisade cells on both sides with a chlorophyllous mesophyll between them. The petiole is flattened so that the leaf can swing much in the same way as that of the Poplar."

A useful paper by Dr. Albert Schneider\(^2\) speaks of the sucker ("dorsiventral") leaves with palisade cells on the upper side and stomata on the under side only. The mature leaves "isolateral leaves or phyllodes" take a vertical position with the convex edge directed upward. The epidermis is alike on both sides. It will be observed that his results do not agree with those of Henslow,—evidence of variation.

The anatomical characters of the leaves of Eucalyptus offer, however, much room for research. See "stomata" p. 327.

(b) Cotyledon leaves—The shape of the cotyledon leaves we know less about, and data are being collected. The work has been hindered because of the difficulty of obtaining seed from certain interesting forms. Mueller's *Eucalyptographia* and Lubbock's "A contribution to our knowledge of seedlings," form the basis of our present available information on the subject.

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\(^1\) Origin of Plant Structures, p. 68 (note). His "horizontal" are sucker leaves and "pendulous" the mature foliage.

Other characters of Eucalyptus leaves we require to know more about, are their size, texture and prominence of venation. They are minor characters, and some species present much variation in this respect.

(c) Venation—Messrs. Baker and Smith have grouped certain Eucalyptus leaves into sections in regard to the disposition of their veins, pointing out that the oil-content of the leaves can in a measure be gauged from the venation. The suggestion is ingenious but as the venation is, like other characters, variable within such large limits, (e.g., in the same twig the lower leaves may have spreading veins, while the upper ones may have a nearly pinnate venation), the method will only be practically useful in the hands of experts.

(d) Young stems—Some Eucalypts have marked quadrangular stems. E.g., globulus, Maidenii, goniocalyx, quadrangulata, tetragona, and many others, but, as a rule this quadrangular appearance, often well marked at an early stage of growth, passes away as growth proceeds.

(e) Essential oil—The perfume of Eucalyptus leaves is owing to the presence of an oil. It varies in different species in regard to both character or amount. In young it is commonly more abundant than in mature foliage, the high proportion of resinous matter in the young foliage being, however, a drawback to distillation. In some cases the perfume is not easy to define, but the crushing of the fresh or even dried leaves in the warm hand has been used as a diagnostic character for many years. It affords a rough but ready test, which is always available, and really valuable in skilled hands. Incidentally it may be mentioned that some few leaves, e.g., corymbosa, contain a substance allied to caoutchouc in their tissues especially in their young state.

1 This Journal, xxxv., p. 116.
Some years ago, when Superintendent of Technical Education, I determined to ascertain whether this qualitative test of Eucalyptus odour was capable of leading up to further results. Accordingly I obtained samples of commercial Eucalyptus oils and also watched their distillation in the country, but found, as a general rule, that the various kinds of leaves were not rigidly kept apart. I therefore resolved, with the advice of Dr. T. L. Bancroft of Brisbane and the active co-operation of Mr. Owen Blacket, C.E., Lecturer in Engineering at the Technical College, to erect a model still capable of holding large charges of leaves, and to distil only those leaves obtained by my own collector or through agencies which permitted the origin of the leaves to be precisely checked from a botanical point of view. In this way, and in this way only, could Eucalyptus oils of many species, absolutely true to name, be obtained for research. My transfer to the Botanical Gardens removed me from this domain of botanical technology and the work, thus initiated has been continued and extended by my late assistants Messrs. Baker and Smith.

(f) Stomata—Mueller, in Eucalyptographia under E. pachyphylla and E. phoenicea, has classified some of the Eucalypts according to the number and distribution of the stomata. He styles the leaves,—

1. Hypogenous according to the presence of stomata on the under surface only.

2. Heterogenous according to their presence on both surfaces, but less numerous above than below.

3. Isogenous, when they are present on both surfaces, but approximately equal in number above and below. "This almost equal distillation of the stomata coincides with the similarity of the colour of both sides of the leaves."

Examination of the stomata cannot, however, be used for diagnostic purposes with any degree of certainty, because of the variation in the distribution of the stomata even in the same tree.
Galls—At one time I inclined to the opinion that the shapes of the leaf-galls in Eucalyptus would be a useful character for classification. Mr. W. W. Froggatt, who has of late years been giving special attention to Brachyscelidæ, finds that the same insect frequents so many species that no general grouping of the trees based on their galls can be made.

Inflorescence—Professor Tate points out that the usual form of inflorescence is an umbel which by lengthening of the axis passes to the panicle or corymb. The transition from one to the other is so easy, he goes on to remark, and often exemplified on the same tree, that it is obvious the form of the inflorescence is not reliable as a specific character. Bentham had previously drawn attention to the unsatisfactory character of the arrangement of the inflorescence from the point of view of the systematist.

Naudin’s grouping (second memoir) of 56 species (or reputed species) known to him as growing in the gardens of Provence, is mainly based on the inflorescence, but also depends on the fruits and leaves. It doubtless was of local value, but it is based on characters which present so much variation as to preclude its general application. Following is an abstract in Gardeners’ Chronicle, 7th February, 1891:

Section I. Inflorescence in cymes or axillary umbels.

Capsules longer than the calyx tube.
Capsules shorter than the calyx tube.

(a) Cymes three flowered.
   Leaves uniform, opposite.
   Leaves uniform, alternate.
   Leaves of two shapes.

(b) Cymes of 3 to 7 or more flowered.
Cymes 7 flowered.
   Leaves uniform opposite.
   Leaves of two shapes, opposite at first.
   Leaves uniform, always alternate.
(c) Cymes or umbels, axillary, more than 7-flowered. Leaves uniform.
Leaves of two shapes.

Section II. Flowers in terminal panicles or corymbs.

Flowers—With reference to individual flowers there is much variation in the number of flowers in an umbel, and to a less extent in the colour of their filaments. The colour in the vast majority of species is white or cream, but in a few species e.g., leucoxylon, sideroxylon, viminalis, ficifolia, calophylla, pyriformis, it may be pink also. In some species, e.g., ficifolia, miniata, phoenicea, it may be red, even a vermillion or orange-red. In a few species (e.g., pilularis) the filaments of dried flowers turn red in course of time.

The pedicel is normally rounded, but owing to compression it is very often strap-shaped as in botryoides, and extreme cases are afforded by obcordata, and occidentalis.

Flower-bud—The shape of the operculum was first used as a classification character by Willdenow in his *Species Plantarum*, 1799. He divided the twelve species then known into two groups, "operculo conico," "operculo hemisphaerico." It is undoubtedly a useful character for the purpose, but variable like everything else about Eucalyptus. *E. tereticornis* is usually looked upon as a species to be diagnosed by its operculum but (Bull. Herb. Boissier, 1902, 579), I have shown that this character breaks down completely as between that species and *E. rostrata*. *E. capitellata*, and *E. macrorrhyncha* were at one time separated by their opercula, but they pass into each other as regards those organs. At the same time it will always remain, in the hands of a judicious observer, one of the most practically useful diagnostic characters we have.
Some species possess a double operculum or membraneous bract enveloping the whole of the young inflorescence. It was first observed by Robert Brown (see his description of *Eudesmia tetragona*), but a few years ago it was only recorded from a very few species. In some it is very early deciduous and, in others infrequent, but I have observed it in such a large number of species that I am inclined to the opinion that extended research will show that it occurs in all. Brown's and Jussieu's interesting observations on the single and double operculum will be found supplementary to the former's description of *Eudesmia tetragona* (*Bot. App. to Flinders' Voyage*).

**Anther**—Bentham (*Flora Australiensis*) first grouped species according to the shape and mode of dehiscence of the anthers. He made five groups, but laid no stress on the importance of the dehiscence of the top on the anther. He however, alludes (B. Fl. iii. 186) to "truncate" anthers, and at page 189 to the truncate anthers of *E. leueoxygen*. Mueller, finding that Bentham's five groups could not be separately maintained, reduced them to three, viz:—

(a) *Renantherae*, the anthers large and the cells divergent at the base.

This section mostly includes the Stringybarks, although it includes several White Gums, plants otherwise very different.

(b) *Porantherae*, the anthers small an opening in pores.

This section mostly includes Boxes and some Mallees, and includes the Silver-leaved Ironbark (*melanophloia*), while *E. crebra* which is very closely allied to it is placed in another section.

(c) *Parallelantherae*, the cells parallel, and the longitudinal slits consequently parallel.

This section comprises the remainder of the Eucalypts, and a most heterogeneous and extensive collection they
are, variable in many ways. As a matter of fact the anthers refuse to be rigidly marshalled into sections. They sometimes display such variation of divergence of cell, size, and mode of dehiscence that classification on the anthers alone becomes a matter of difficulty. In the old collections the difficulty is enhanced through the partiality of insects for these organs. Nevertheless examination of the anthers is always carried out by me, and it is a most useful character.

**Pollen-grains**—Mueller (Eucalyptographia, under *E. erythrocorys*), has shown that the size of pollen-grains varies in different species, but we require very many more measurements than are available to be in a position to place any interpretation upon the results. The shape of the pollen-grains also varies, but we have few data on the subject.

**Calyx**—The calyx, "cupula" of De Candolle and other botanists, the "hypanthium" of Schauer, is no longer used for classification purposes, having been proved to be so utterly variable. De Candolle (and his translator G. Don) offered a classification of the Eucalypts consisting of opposite or alternate leaves combined with a comparison of the size of operculum with the cupula.

**Fruit**—While many botanists have more or less used the fruit as a diagnostic character in Eucalyptus, and it is undoubtedly the best character we have, it is due to Professor Tate to say that (*op. cit.*) he was the first to submit a scheme for classification of the genus based on the fruits alone. He deals with (a) shape; (b) external sculpture and ornament; (c) capsular-teeth; (d) capsule-cells; (e) fertile seeds. But examination of Professor Tate's scheme shows (through no fault of his) how very imperfect and full of exceptions it is. Taking item by item we find the shape in each species to vary within wide limits. Per-
sonally I very largely use the fruit (unripe fruits may be very misleading), for diagnostic purposes, but in many cases it must be carefully used for it displays an enormous amount of variation. This much is proved, and I go further and say that some fruits only appear to have an approximately constant shape because we have so much to learn in regard to the range of the species and consequent possibilities of variation. Of course I at once admit the fact that some species are "stronger" than others. To sum up, for herbarium work the anthers and fruits are the best characters to go by; for the scientific forester, the bark and the timber, but all characters display a puzzling amount of variation.

II. HAS VARIATION IN EUCALYPTUS NOW CEASED?

Bentham (B. Fl. iii. 186—188) shows the variability of the various characters of the genus, and notes on variation are given to nearly all his groups and series.

At p. 186, he says:—

"It must be admitted, indeed that these groups, distinct as they may be in the typical species, pass very gradually into each other through intermediate forms, but I have endeavoured to supply cross-references to facilitate the determination of dried specimens in doubtful cases."

And again:—

. . . "but to the botanist who is unable to compare them in a living state, the due limitation and classification of their species presents almost insuperable obstacles. The extraordinary differences in the foliage of many species at different periods of their growth add much to the ordinary difficulties arising from the gradual transition of varieties, races, or species one into the other."

Mr. R. T. Baker however, holds a different opinion. For example:—
"This constancy is accounted for by the author on the geological age of this continent, for whilst other continents have undergone subsidences and upheavals, Australia has stood still or remained stationary, thus giving the plants enormous periods of time for differentiation, so that the "missing links" naturally are wanting."

And again:—

"In this paper the author endeavours to show that much of the hitherto supposed variability of specific characters of our Eucalyptus trees is the result of various artificial classifications applied to the species in the past, whereas, if classified on what appears to be a natural basis, the species possess very little, if any, variability, and retain in a marked degree individual character through their whole area of distribution. Each species is taken seriatim to prove a want of variation in its specific characters." (The italics are mine).

Further:—

"By following a natural classification, that is, one founded on a long and intimate acquaintance with the trees in nature, their habits and places of growth, the form and qualities of their seed, the manner of their elevation, increase and reproduction, the peculiarities of their radication, their interior substances, the infinitely varied formation of their vascular system (by which the plant is not only enabled to circulate the juices necessary to its support), the peculiar qualities of seeds, salts, gums, resins, oils by which they are distinguished, and all other constituents on which their natural combination so ultimately depends, almost all traces of variability disappear, and the above anomaly or difficulty in timber identification would be obviated."

Messrs. Baker and Smith further state:—

"We are now able to demonstrate most fully that of all the numerous peculiarities of the Eucalypts not one is of greater value

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4 This Journal, xxxv., 121.
in indicating differences in the several species or that is more con-
clusive in its results, than is the practical constancy of chemical
constituents in identical species, a fact of the greatest scientific
and economic importance."

By "identical species" it is not certain whether botanical
or chemical species are referred to. And again:—

"That the constituents have been fixed and constant in the oils
of the several Eucalypts for a very long period of time."

It is added that the venation of the leaves and their
botanical characters "show also a marked constancy."

All this comparative constancy is probably accounted for
by the long period of time that must have elapsed before
a particular species could have established itself as such
over so extensive a range as we find species to-day.

"The chemical and botanical peculiarities must also have been
fixed primarily, because we do not find the differences in characters
one might expect by environment. Our researches seem to show
that the species are only well marked varieties in which the dis-
tinctive characters have become permanent." 1 (The italics are mine).

These statements are quite definite. The authors state
that the genus Eucalyptus has now become fixed.

By what authority can anyone venture to say that
variation has ceased in the genus? I regret that such a
statement has been made, as it seems to be specially
unfortunate. In view of the evidence I have already
adduced, I imagine most botanists will agree that the genus
is as variable as Rubus, Rosa, Hieracium, Cinchona, or
Salix.

A friend humorously expressed the situation by saying,
"There is so much variation that there is really but one
species, and its name is Eucalyptus australis." The late
Rev. Dr. Abbott made a somewhat similar utterance when,

1 Baker and Smith, this Journal, xxxv., 122, 123.
speaking of the English language and of its marvellous flexibility, he declared that "Any part of speech may be used as any other part of speech."

My studies of this genus have shown me that variation exists in every species with which I am acquainted. Some species are undoubtedly "stronger" than others, but the more we collect and the more we observe, the more we find old barriers between old species break down. With some species one is inclined to say, "What character is constant! there is no safety unless one keeps the type in sight just as the mariner does the light of the light-house." To pursue the simile further I am sure that the only way to avoid botanical shipwreck is to stick to the type.

III. SOME STUDIES IN VARIATION.

We have now arrived at the point when it will be profitable to consider specific instances of difficulties of classification through variation. I would invite attention to a paper\(^1\) I have recently written to illustrate this point. In summing up, I show that we have the following names for the Gum-topped Stringybarks of Tasmania (which extend into Victoria and Southern New South Wales), that is to say for practically the same tree:—

4. *E. regnans*, F.v.M.
7. *E. haemastoma*, Sm.
10. *E. Sieberiana*, F.v.M.

\(^1\) The Gum-topped Stringybarks of Tasmania; a study in variation.—Read before the Roy. Soc., Tasmania, 1902.
The Gum-topped Stringybark has therefore been duly named, and has been given ten synonyms in addition,—not hastily, but by men who have worked on the genus, and who have given reasons for their determinations. The great majority of the determinations can still be defended, and may be looked upon as indicating forms of the species referred to. Study of the Gum-topped Stringybarks presents one of the best instances of variation in the genus that I have met with, and affords a most instructive example of the necessity, in this protean genus, of endeavouring to ascertain what is the type, and of bearing it closely in mind.

Again, who will have the temerity to define the boundaries between the Stringybarks, *Eucalyptus eugenioides, capitellata* and *macrorrhyncha*, and between all of them and *E. pilularis*? I could give dozens of specific instances in which species run into each other, showing that we are striving after a wrong ideal when we endeavour to stereotype them.

IV. MANNAS, KINOS, OILS, ETC., ARE NON-ESSENTIAL BUT ACCESSORY OR ADAPTIVE CHARACTERS AND EXAMINATION OF THEM MUST BE SIMPLY LOOKED UPON AS AIDS TO DIAGNOSIS.

Volatile oils (e.g., of Eucalyptus) are what are termed accessory substances, that is to say, they are not essential to the plant. They probably have various functions, e.g.,

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1 This is of course following Tyndall, who showed that an envelope of aromatic air around a plant is less pervious to heat rays than is ordinary atmosphere.—Kearney, "Report on a botanical survey of the Dismal Swamp region."—(Contrib. U.S. Nat. Herb., v., 6, p. 392), says, "How effective this may be is yet very doubtful, but it is not to be denied that such aromatic plants are much more abundant in dry soils and climates, where the water supply of the plant needs to be jealously guarded than where other conditions prevail." He quotes Pfeffer (Pflanzenphys. 2te Auflage, 1., 501) who considers that this exhalation is "hardly of high importance" for protection against loss by water.
(1) to create a halo of vapour which checks transpiration, (2) to attract, by their odour insects necessary for fertilizing the plant, and (3) render the plant nauseous to some insects and animals which would otherwise prey upon it.

Such accessory characters cannot obviously be other than variable, yet Messrs. Baker and Smith say "that the constituents have been fixed and constant . . . . "their botanical characters show a marked constancy" . . . "the chemical and botanical peculiarities must also have been fixed primarily."

The key to the oil question has less to do with the determination of species, but depends on examination of the minute morphology (anatomy) of the leaf.

V. BOTANICAL CLASSIFICATION FOR PURPOSES OF NOMENCLATURE OF GENERA, SPECIES, AND VARIETIES IS BASED ON MORPHOLOGICAL CHARACTERS.

It is the object of botanists to construct a Natural System. Linnaeus in proposing his artificial system, which met the requirements of his day, still looked upon a truly natural system as the ideal of botanists. As time has rolled on we have steadily approached this ideal. Jussieu, DeCandolle, Bentham, Hooker, and others have made marked progress in perfecting the natural system, and Engler in his Pflanzenfamilien and now his Pflanzenreich, is, with the assistance of coadjutors, showing the latest progress in this direction. All these authorities base their systems on morphological characters, and it is of course their object to associate closely related forms.  

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1 This Journal, loc. cit.

2 I do not lose sight of the fact for one moment that, in the discrimination of genera and species we should call to our assistance any characters that can be employed to that end. Prof. John M. Coulter in his Vice-Presidential Address, Section F. (Biology) Amer. Assoc. Adv. Science, 1891, p. 300, eloquently pleads for a philosophical conception of a species in V—Dec. 3, 1902.
Mr. Baker however, contends that, at all events as regards the genus Eucalyptus, this method of classification is wrong. Following are some of his statements.

"And all this is due to our having classified in the past our Eucalypts on what the author contends is an artificial basis, namely, morphological characters."

And again:—

"In many instances it is impossible to classify Eucalypts on the shape of fruits, anthers, buds, and leaves, and in this connection is mentioned the case of *E. bicolor* and *E. pendula*, of A. Cunningham. It has been customary in recent times to synonymise these species under the name of *E. largiflorens*, F.v.M. Now Cunningham, who was a field botanist and who was familiar with these trees, named the bastard box of Cabramatta *E. bicolor*, a tree with a dark box bark on the stem, and with clear white limbs, and having a lightish brown coloured timber, whilst the "Coolabah" of the interior he named *E. pendula*, from its drooping habit. This tree has a red coloured timber, and a bark extending to the ultimate branches. The oils of the two trees are quite distinct. The economic and systematic materials of *E. pendula* having been obtained from many parts of the Colony, and show the usual constancy of specific characters which the author has found to hold in almost all other Eucalyptus species. This also applies to *E.*

the following passage:—"The character of a species is an extremely composite affair, and it must stand or fall by the sum total of its peculiarities and not by a single one. A specific character in one group may be a generic character in a closely related one, or no character at all. Therefore, there is nothing that involves a broader grasp of facts, the use of an inspiration rather than a rule, than proper discrimination of species. I have a belief that the arbitrary, rule-of-three mind will never make a successful taxonomist; and that there is a sort of instinct for specific limitations which the possessor cannot communicate to another. This taking into account the total character of a plant, from facies to minute characters, will furnish the basis of future descriptive work. The more obstacles that can be put in the way of hasty determination the better."

bicolor, and on these grounds it is contended that the two trees should be regarded as distinct species. The only resemblance is the venation of the lanceolate form of leaf. If placed under E. largiflorens, then there would be the anomaly of having under one species a tree with two kinds of timber, two kinds of oil, and a variation in leaves."1

This argument is, however based on wrong determinations. I have shown, on morphological grounds and reference to the actual types, (Proc. Linn. Soc. N.S.W., 1902), that the E. bicolor referred to above is E. Bosistovana, F.v.M., and that the E. pendula referred to is really E. bicolor, A. Cunn., thus some of the deductions based on the assumption that his determinations are correct, fall to the ground.

Again Messrs. Baker and Smith have in this Journal added a new species to science (Eucalyptus apiculata, Baker and Smith), in the following words:—

"The oil obtained from a Mallee known as E. stricta was different from that obtained from the supposed E. stricta growing around Berrima and Mittagong, but it was not possible to separate them on any known botanical characters, as no morphological differences could be detected, but the fact remained that the oils were different and always so ... thus we propose to make the Berrima form distinct, and give it specific rank under the name of Eucalyptus apiculata."2

Surely this cuts at the very foundations of systematic botany. If two plants are morphologically identical one may be substituted for the other.

The plants to which Mr. Baker refers have been known to botanists for many years and they have agreed with Mr. Baker that "no morphological differences can be detected" between E. stricta, Sieb., and E. apiculata, Baker and Smith. As Mr. Baker has stated that the two plants

1 Op. cit.  2 It is not a true Mallee.  3 This Journal, xxxv., 121, 122.
yield different oils, botanists will (as I have already done) still further examine them to see if they possess morphological differences that are at present not obvious to our own eyes. When any differences are detected surely it will be then time enough for a new name to be proposed, for at present it is obviously impossible for the botanist, unless he subjects the plant to distillation, to say whether he has collected *E. stricta*, Sieb. or *E. apiculata*, Baker and Smith.

Messrs. Baker and Smith's statement that there is no morphological difference between the plants and yet the oils vary, may surely be interpreted as evidence in favour of the view that the oils in plants vary according to environment. It is a matter of common experience in Europe that the same plant, cultivated in different soils and situations, yields oils varying much in quantity and character. Acting on that experience cultivators only attempt to grow oils of certain grades in special soils and situations. I think I have shown, beyond doubt, that all other characters of Eucalyptus vary. There seems to be no evidence why the oil should present a remarkable exception to the general rule.

It seems strange to me that with evidence (as I contend), simply inexhaustible, of variation in Eucalyptus, both as regards spontaneous and cultivated plants, where it is sometimes necessary (I believe) to name a plant with the qualifying note that another botanist may have good grounds for placing it in an allied species, this doctrine of variation apparently does not command universal acceptance. It seems to me that the "non-variation" theory runs counter to some of the most generally accepted sets of practical observations on which the doctrine of evolution of species is based, and there is just a little danger of what Darwin terms "arguing in a circle" in presenting the observations that are interpreted to destroy the dogma which many of us look upon as built on unassailable facts.