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Ferdinand Mueller and the Shape of Nature: Nineteenth-century Systems of Plant Classification*

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In the nineteenth century, systematic botanists were preoccupied with the search for a so-called 'natural' system of classification, in which the names, order and rank of groups conveyed information about the relationships between plants. One such was Ferdinand Mueller who first identified this as a problem in which he was interested as a young man in Schleswig-Holstein. After moving to Australia in 1847, he encountered a flora so rich and diverse that he was emboldened to draw his own conclusions in systematics. These incorporated ideas originating in the previous century such as 'continuity' and the 'constancy' of species, evident in the work of Linnaeus and Jussieu, but also newer ideas, especially in relation to gymnosperms. Mueller met with resistance to his version of the natural system from Joseph Hooker and George Bentham at Kew Gardens in England, but received tacit support from colleagues in continental Europe who were busy making their own changes to classification. In Australia, Mueller was able to bring his influence to bear more successfully, and those who followed his version of the natural system helped him to establish a more independent local tradition in science.

Late in his life, Australia's most famous botanist, Baron Ferdinand von Mueller (1825–1896), made a casual remark about how he first began to learn about plants and their relationships to one another. It was with the help of two *Taschenbucher*, or pocket-books, of fellow-German botanists Wilhelm Koch (1771–1849) and Martin Kittel (1798–1885).[1] Mueller's personal copy of Kittel's *Taschenbuch der Flora Deutschlands* is still in the library of the Royal Botanic Gardens Melbourne, which houses the bulk of Mueller's surviving books and papers. The copy is a second edition, published in two volumes, 1843–1844, the first of which is inscribed 'Husum, December 1843. Ferd. Müller' indicating that Mueller obtained it as an eighteen-year-old pharmacy apprentice in the township of Husum in Schleswig-Holstein.[2] The volumes look well-thumbed, and at about 10 × 16 cm each, are just the right size to fit in a young man's pockets as he set out to explore and understand the plants of his homeland, and beyond.

The premise of books such as Kittel's was that names could be given to plants that revealed something about their relationships to each other. Kittel offered readers a choice of two systems of classification that listed, ordered and ranked those names. The first was developed by the Swedish botanist Carl Linnaeus (1707–1778) who also popularized binomial nomenclature, and the second was developed by the French botanist Antoine-Laurent de Jussieu (1748–1836). Both of these men believed that groups of related plants could be discerned in nature of which 'species' were the smallest and most fundamental.[3] Related species were called 'genera', and these in turn formed larger groups, ending with the plant 'kingdom' itself. Linnaeus only ever defined species and genera to his satisfaction, and regarded his supra-generic groups as arbitrary and therefore artificial.[4]

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Jussieu's system extended that of Linnaeus by identifying a series of naturally occurring 'orders' (also known as 'families'), made up of related genera; however, his next higher ranked groups, the 'secondary classes', were artificial.[5]

When Mueller came to write his own first botanical works in Schleswig-Holstein, he used Jussieu's system of classification, but after migrating to Australia in 1847 he switched to one devised by the Swiss botanist Augustin de Candolle (1778–1841). The arrangement of Candolle's system was similar to that of Jussieu's, although Candolle had a different way of understanding the relationships between groups.[6] As a result of on-going discoveries of new plants and new information about already-known plants, nineteenth-century botanists, including Mueller himself, continued to make refinements to what became known as the 'natural system' of classification. Mueller published some of his revisions in an exhibition catalogue in 1867,[7] and developed them in subsequent publications. His version of the natural system incorporated ideas of Linnaeus, Jussieu, Candolle and others, but in his own way. As well as using his system in his own floristic works, Mueller tried to get other botanists, both overseas and in Australia, to take it up, including in field-guides similar to those with which he initially began to learn about the shape of nature himself.

Linnaeus's System

According to Linnaeus, the author of the first classification system in Kittel's *Taschenbuch*, there were two kinds of natural groups in the plant kingdom. The first of these, 'species' and 'genera', were divinely created as discrete entities. That is, each one contained plants that were clearly related to each another, and not to plants in other similarly ranked groups. In the second kind of natural group — families, classes and so on — plants were also related to each other, but not in a clear-cut way. Linnaeus described the pattern they made as 'continuous'.[8] To help explain what this meant, he used the metaphor of a map of the world. Like countries, he believed that the boundaries of supra-generic groups were man-made and could be drawn to suit different purposes. Also like countries, supra-generic groups could share their boundaries with multiple other similarly ranked groups.[9] As has already been noted, Linnaeus did not describe any natural supra-generic groups himself, but he believed that botanists in the future would be able to do so.[10]

By the time Mueller started getting interested in botany in 1840, Linnaeus had been dead for over forty years and 105 years had elapsed since the publication of *Systema naturae*, which outlined his ideas on the relationships between plants.[11] Nevertheless, Linnaeus's system of classification was still being used in floras such as Kittel's. In fact this was true of all five floras known to have been in Mueller's library in Husum (Table 1).[12] Moreover, in three of them, Linnaeus's system was the only one used. In part, this may have been because the authors were all provincials who lived and worked remote from the main European centres of botanical research, but they were also probably influenced by practical matters. Because of the simplicity of Linnaeus's system, novices as well as experts were able to use it to make identifications more easily than by using alternative, 'natural' systems.[13] Kittel obviously tried to make the most of both kinds of systems in his *Taschenbuch*, using the so-called artificial system of Linnaeus as a key, and arranging the main body of text according to Jussieu's natural system.

Jussieu's System

As one of the leading botanists in the generation after Linnaeus, Jussieu took up the task of forming natural supra-generic groups. In 1789, he published his ideas in

Genera plantarum, which was republished posthumously in 1837.[14] Like Linnaeus, Jussieu used the metaphor of a map to explain continuity between plant groups, although he thought that this was a pattern that applied to genera as well as supra-generic groups, leaving only species as discrete entities.[15] Jussieu's most significant addition to Linnaeus's system was the definition of one hundred 'natural orders' (or families), which contained plants that were related to one another even if their boundaries were arbitrary. Each of these families was also intended to include an easily remembered number of genera. Jussieu's next highest ranked groups, the 'secondary classes', like Linnaeus's 'classes', remained artificial,[16] although in this, and in other ranks, Jussieu tried to place the most related groups next to one another, and in order from the most primitive (non-flowering plants) to the most highly developed (flowering plants).[17]

Mueller's preference in Husum for using a flora that followed a natural system was probably motivated by a desire to be, and be seen as, a forward-thinking botanist. Nevertheless, he may also have been attracted to the natural system because of its usefulness in pharmacy, which relied on plants for most of its drugs. As Jussieu himself observed: 'Plants of the same genus, which are almost alike in characters or organs, scarcely differ in virtue', by which he meant their medicinal properties.[18] In 1853, Mueller was to claim that the fact 'we may safely deduct [*sic*] the closest affinities of the medicinal properties of plants from their natural alliances' was 'a truth which achieved the most complete triumph of the natural system over all artificial classification'. 'By this guidance', he predicted that *Polygala veronicea*, a herb he had only recently discovered in Victoria, would be found to agree with the Austrian *Polygala amara* 'in those qualities, for which that plant has been administered in consumption'.[19] Moreover, this was of special interest to Mueller, who had already lost both parents and at least one sister to this illness.[20]

Using Jussieu's System

While Mueller went to Husum in 1840 to train as a pharmacist, he was soon occupied with obtaining 'a clear picture of the vegetation of the area in which I live'.[21] This was no small undertaking, because Husum was within walking distance of a surprising diversity of habitats, from coastal foreshore, heaths and marshes to sandy uplands, fields and woods. With floras like Kittel's *Taschenbuch* in hand, he used any time spare from his duties at the pharmacy to botanize around Husum, and to swap specimens and observations with other naturalists. By the end of 1843, he had written his own first floristic work which he called, rather grandly, 'Flora des Amtes Husum: 1 Heft',[22] although it lacked species descriptions and a key. The manuscript listed the names of 479 species of phanerogams, or flowering plants, with short notes on their frequency, and the

Table 1. Floristic works and their sytems of classification in Mueller's library at Husum

No.	Work	System used
1	J. R. Sickmann, *Enumeratio stirpium phanerogamicarum circa Hamburgam* ... (Hamburg, 1836)	Linnaeus
2	B. M. Kittel, *Taschenbuch der Flora Deutschlands* ..., edn 2 (Nürnberg, 1844)	Linnaeus, Jussieu
3	W. D. J. Koch, *Synopsis florae germanicae et helveticae* ..., edn 2 (Leipzig, 1843–1845)	Linnaeus, Candolle
4	E. F. Nolte, *Novitae florae holstaticae* ... (Kiel, 1826)	Linnaeus
5	G. Häcker, *Lübeckische Flora* (Lübeck, 1844)	Linnaeus

locations at which they could be found. Part two of the work, which presumably would have covered the cryptogams, or non-flowering plants, does not seem to have been written.

Although he did not say so in his flora, Mueller more or less followed Jussieu's system of classification. He used the same ranks, and names for groups, and placed them in order from least to most developed (Table 2). The manuscript, however, also included some changes to Jussieu's system. This was already evident from Mueller's use of 'phanerogam' in the title, a term originally coined by the French botanist Etienne Ventenat (1757–1808)[23] to distinguish two of Jussieu's three primary classes — the Monocotyledons and Dicotyledons (plants with one or two seed-leaves) — from the Acotyledons (plants with no seed-leaves). Moreover, in the body of the manuscript, Mueller moved the 'Diclines irregulars' (a group Jussieu placed at the end of the Dicotyledons) into the Apetalae, presumably because most of the plants in it lacked petals. The source of these changes was almost certainly Kittel's *Taschenbuch*, which also figured them in a list at the beginning of the main text. It is unlikely that Mueller came up with any original ideas about classification himself at this stage, although he may well have confirmed the usefulness of Kittel's in field-work around Husum.

In order to complete his pharmacy qualifications, in mid-1845 Mueller enrolled at Kiel University.[24] This also enabled him to take the courses of the then botany professor, Ernst Nolte (1791–1875). Unfortunately, Nolte was a disappointing teacher, and Mueller later asserted that he had 'sunk into obscurity ever since he acceded (and that before I was born) to his professorship'.[25] Nevertheless, Mueller was able to

Table 2. The highest ranked groups in Jussieu, Kittel and Mueller's systems

Jussieu, 1789	Kittel, 1843–1844 and Mueller, 1843
Acotyledones (1)	[not included] (1)
Monocotyledones	Phanerogamischen Pflanzen
hypogynae (2)	Monocotyledonen
perigynae (3)	bodenständige [hypogynae] (2)
epigynae (4)	kelchständige [perigynae] (3)
Dicotyledones	stempelständige [epigynae] (4)
Apetalae	Dicotyledonen
epigynae (5)	blumenlose [apetalae]
perigynae (6)	zweilagerige [diclines] (5)
hypogynae (7)	stempelständige [epigynae] (6)
Monopetalae	kelchständige [perigynae] (7)
hypogynae (8)	bodenständige [hypogynae] (8)
perigynae (9)	röhrenblumige [monopetalae]
epigynae	bodenständige [hypogynae] (9)
Synanthereae (10)	kelchständige [perigynae] (10)
Corisanthereae (11)	stempelständige [epigynae]
Polypetalae	synanthereae (11)
epigynae (12)	corisanthereae (12)
hypogynae (13)	freiblumige/ polypetalae
perigynae (14)	stempelständige [epigynae] (13)
Diclines irregulars (15)	bodenständige [hypogynae] (14)
	kelchständige [perigynae] (15)

use the university library, herbarium and botanic garden to continue his botanical studies. In September 1846, he also attended the 23rd annual *Versammlung Deutscher Naturforscher und Ärzte*, the pre-eminent scientific gathering in German-speaking Europe, which was held in Kiel. This gave him an opportunity to hear and meet botanists who were actively engaged in the foremost research questions of the day including Matthias Schlieden (1804–1881), professor of botany at Jena and a leading supporter of experimental research, and Moritz Willkomm (1821–1895), a botanist from Leipzig, not much older than Mueller, who presented a report on an expedition to Spain and Portugal.[26]

Mueller summarized the botanical results of his university studies in a doctoral thesis. Its subject was the phanerogams of south-west Schleswig, which suggests that it was little more than an expansion of the Husum manuscript. In an introduction of about 1300 words, however, he revealed how he begun to think of botany as a grand natural science to which he could himself contribute.[27] In regard to classification this was most evident in his allocation of species to ten families not used in Kittel's *Taschenbuch* (Table 3). These families all presumably came from other botanical works that Mueller read at university. He also introduced the names of eighteen varieties that he discovered himself,[28] and one unattributed variety of the water-weed *Potamogeton pectinatus*, which he later suggested was probably a new species. 'Consideration for Nolte', Mueller explained, 'with whom I corresponded from 1841, prevented me from bringing this species before the public independently of the *then* best Potamogeton specialist in the world'.[29]

Candolle's System

In March 1847, Mueller passed his final pharmacy examinations, and it seemed he was destined for the life of an amateur botanist. Several months earlier he had turned 21 and come into an inheritance that was probably equivalent to several thousand English pounds. Around the same time his sister Bertha (1826–1861) began exhibiting symptoms of tuberculosis. Mueller decided to use some of their inheritance to take Bertha and his other surviving sister Clara (1833–1901), for the sake of their healths, on a sea-voyage to a country with a warm climate.[30] He selected South Australia because that was 'where the stream of German emigrants then mainly flowed'.[31] It was also as yet little known botanically.[32] To help him distinguish between already-named species in the flora and novelties he took copies of Robert Brown's *Prodromus florae Novae Hollandiae* of 1810 (the first attempt at a flora of Australia), which more

Table 3. Family names in Mueller's and Kittel's systems

Family in Mueller, 1843	Species	Family in Kittel, 1843–1844
Potamogetoneae Lk	Potamogeton natans L.	Najades Juss.
Lemnaceae Duby	Lemna triscula L.	Pistiaceae Rich.
Compositae Adans.	Hieracium Pilosella L.	Synathereae Rich.
Stellatae L.	Sherardia arvensis L.	Rubiaceae Juss.
Corneae Cand.	Cornus sanguinea L.	Araliaceae
Hederaceae Mart.	Hedera Helix L.	Araliaceae
Lineae Cand.	Linum usitatissimum L.	Geraniaceae A. St. Hil.
Sileneae Cand.	Silene inflata Sm.	Caryophylleae Juss.
Alsineae Cand.	Cerastium triviale Lk	Caryophylleae Juss.
Papilionaceae L.	Ononis spinosa L.	Leguminosae Juss.

or less followed Jussieu's system of classification, and J. G. C. Lehmann's *Plantae Preissianae* of 1844, which was based on a collection of plants made in Western Australia in the early 1840s and followed Candolle's system.[33]

After a voyage of four months, Mueller and his sisters arrived in South Australia in December 1847. Wasting no time in familiarizing himself with the local flora, he scooped up his first specimens, of algae, over the side of his ship as it prepared to dock.[34] He continued to botanize at every opportunity, although these were somewhat limited after he secured a position in an Adelaide pharmacy. In five years in South Australia he collected plants, on foot, along the Adelaide coastline, on its plain and in the nearby hills, and made two substantial journeys by horse. The first of these was overland through scrub country to Rivoli Bay on the south-east coast of the colony in October 1848. It was part of an unsuccessful investigation into a disease that was afflicting the sheep of a local pastoralist, Samuel Davenport (1818–1906).[35] The second and more substantial expedition was to the Flinders Ranges in October–November 1851. This took Mueller 375 km north of Adelaide through only recently settled country that was also botanically unexplored, and into the interior of the colony on the margins of the dry salt-bed of Lake Torrens.[36]

Even with the books by Brown and Lehmann in hand, Mueller struggled to distinguish known and unknown species and urgently sought additional information.[37] In 1849, he acquired a copy of Walpers' *Repertorium botanices systematicae* (1842–1847), a digest of species descriptions extracted from a range of botanical literature, arranged according to Candolle's system.[38] Nevertheless, Mueller remained unsure of his identifications and sent his manuscripts on the South Australian flora for editing to a fellow botanist and pharmacist in Hamburg, Wilhelm Sonder (1812–1881), who had access to a well-stocked herbarium of named Australian specimens. Mueller's first manuscript was published in the Halle-based botanical journal *Linnaea* in 1853 under the title: 'Diagnoses et descriptiones plantarum novarum, quas in Nova Hollandia australi praecipue in regionibus interioribus detexit et investigavit'.[39] It included the descriptions of eleven new genera, 103 new species, and one new variety. Although it is not clear whose idea this was, this article was also arranged according to Candolle's system of classification.

The career of Augustin de Candolle overlapped that of Jussieu, although he was really a member of the next generation of botanists who tried to perfect the natural system. In 1813, his first version was published in *Théorie élémentaire de la botanique*, which he updated in two more editions, the final one appearing posthumously in 1844.[40] Unlike Jussieu and Linnaeus, Candolle did not believe that nature was continuous, and he revisited their analogies of a map to explain what he meant.[41] Gaps between plant groups could occur, he argued, 'because Nature has really left in the order of beings, here and there, empty spaces, as well as she has left on the globe uninhabitable marshes and deserts'.[42] Like Jussieu and Linnaeus, however, Candolle placed his groups in a ranked hierarchy, including a series of 'sub-classes' that were more or less the same as Jussieu's 'secondary classes' and Linnaeus's 'classes' and remained artificial.[43] Candolle also reversed the order of the groups, starting each rank with the most developed and ending with the least.[44]

Using Candolle's System

In 1851, gold was discovered in the colony of Victoria, and in the following year Mueller moved to Melbourne to get his share of the profits by opening a pharmacy.

Once again, however, fate intervened to steer him back to botany. Somehow he managed to meet the head of the Victorian government, Charles La Trobe (1801–1875), who, recognizing his talent, took advantage of the boom times to appoint him the first Government Botanist of Victoria.[45] In this capacity, Mueller was able to make three substantial botanical expeditions around the colony in three years. These exposed him to more habitats than he had ever seen before, including heathland, forests, wet-lands, desert and, for the first time in his life, alpine peaks, many of which were little- or uncollected.[46] Then in 1855–1856, Mueller served as botanist on a major exploring expedition across the north of Australia led by Augustus Gregory (1819–1905). This took him to the other side of the arid interior he had first encountered in South Australia, to the alternately wet and dry country near the Gulf of Carpentaria and in Arnhem Land, and through the wet tropics in north Queensland.[47]

The importance of these travels to Mueller's understanding of the shape of nature was immense. They enabled him to see continuities and discontinuities between plants on a vast scale, and to observe new species and genera (although no new higher-ranked groups), all of which suggested connexions between groups in the natural systems of Jussieu and Candolle, or new divisions within the groups. As Mueller later told the British botanist George Bentham (1800–1884):

> I think I had in Australia, where physical conditions are more widely different within limited space than perhaps in most parts of the globe, an opportunity to study the laws of variation of species more carefully in the field & under the most varied circumstances, than any other or at least than most Botanists.[48]

By 1865, Mueller claimed to have botanized in Australia along lines of over 25,000 miles (40,000 km). He had also built up a vast network of collectors who were sending him specimens from places that he was not able to see for himself.[49]

Mueller's first publication as a professional botanist came out in 1853 and included a systematic index of the Victorian flora.[50] In this, he continued to use Candolle's version of the natural system but, as when he was using Jussieu's system, not faithfully (Table 4). At the highest rank of classification he retained Jussieu's three 'primary classes' (Acotyledons, Monocotyledons and Dicotyledons) although, as Candolle had done, he reversed their order and began with the most rather than the least developed. Within the Dicotyledons, Mueller adopted Candolle's four 'sub-classes' distinguished on the basis of the disposition of their petals (Thalamiflorae, Calyciflorae, Corolliflorae and Monochlamydeae), but he used neither of Candolle's 'classes' in the Acotyledons. Moreover, in the first part of the index alone, Mueller already recognized about 23 families that were not in the final version of Candolle's system,[51] all of which undoubtedly came from other botanical works known to Mueller. He also made changes to the sequence of families in Candolle's system, and these may well have reflected his own observations on the relationships between plants.

Table 4. Comparison of the highest ranked groups in Candolle's and Mueller's systems

Candolle, 1844	Mueller, 1853
Végétaux vasculaires	Dicotyledoneae
Dicotylédones	Thalamiflorae
Thalamiflores	Calyciflorae
Calyciflores	Corolliflorae
Corolliflores	Monochlamydeae
Monochlamydées	Monocotyledoneae
Monocotylédones	Acotyledoneae
Végétaux celluleux	
Semivasculaires	
Cellulaires	

As to Candolle's ideas on continuity, it is not clear if Mueller was aware of them but, if so, he seems to have rejected them. His few surviving references in the 1850s to the shape of nature suggest that he thought it was continuous. For example, in 1857 he told the Director of Kew Botanic Garden, William Hooker (1785–1865), that 'Nature, with an easy pace transgresses always the artificial boundaries, into which we endeavour to ennarrow her'.[52] Moreover, in his botanical report on the North Australian Exploring Expedition, published in 1858, Mueller suggested that the new genera he had found would be 'a valuable contribution towards the botanical system'. This was because 'the discovery of new generic types assists in disclosing the laws of affinity in nature, connecting often those forms which are isolated by wide chasms'. In other words he was filling in gaps that otherwise might lead botanists to conclude that genera could be discrete groups, and 'aiding thus in the advancement and accomplishment of a truly natural system of the whole existing vegetation'.[53]

Darwin and Classification

Mueller's first decade in Australia came to a close with the publication of Darwin's *Origin of Species*. perhaps the most famous book ever written that discussed relationships between organisms (including plants). While this book did not critique existing natural systems of classification, it did redefine what they meant by 'natural'.[54] Instead of seeing God as responsible for creating relationships between organisms, Darwin used *Origin of Species* to contend that these were the result of 'the propinquity of descent — the only known cause of the similarity of organic beings'.[55] He also suggested that in so far as relationships between groups of organisms could be distinguished, it was only through the degree of modification that their characters had undergone through natural selection. 'I believe', he wrote in *Origin of Species*, 'that the *arrangement* of the groups within each class, in due subordination and relation to the other groups must be strictly genealogical in order to be natural'.[56]

Darwin sent Mueller a copy of *Origin of Species* that probably reached him early in 1860.[57] Just how much Mueller read is not clear, but thereafter he felt knowledgeable enough about what he called the 'transmutation theory' to reject it.[58] In the 1860s, he reaffirmed his view of species as 'special creations' — discrete and unalterable — above which the pattern of relationships in nature was continuous. This also led him to wonder if it was worth distinguishing supra-specific groups at all. 'To me', he suggested to the Munich-based botanist Carl von Martius (1794–1868) in 1864, 'the colourful world of forms in nature appears solely as a complex of species'. Mueller boldly concluded that a proposal by the German botanist Johann Ehrhart (1700–1756) 'to give a name only to species is, strictly speaking, the only tenable one'. Nevertheless, Mueller admitted to Martius that 'in its execution we would lose the important points of reference, which support particularly our memory', and that therefore it was probably still worthwhile combining species into groups of 'never precisely definable genera', and so on.[59]

Arguing for Significant Change

Mueller continued to follow Candolle's system in the 1860s, but he became increasingly dissatisfied with it.[60] After all, the final version of *Théorie élémentaire* was now over fifteen years old, and much new information about plants had been discovered, in no small part by himself. Unwilling, as yet, to tackle substantial reform of the natural system on his own, in 1862 he wrote to George Bentham about the matter. Along with Joseph Hooker (1817–1911), then Assistant-Director at

the Kew Botanic Garden, Bentham was working on a new 'Genera plantarum'.[61] It would be only the second such work to be published since Jussieu's *Genera plantarum* in 1789 [the other being by the Austrian botanist Stephan Endlicher (1804–1849)].[62] Given Kew's pre-eminence as a centre of botanical research in the British Empire, Mueller anticipated that Bentham and Hooker's 'Genera plantarum' would likely be very influential, and that it would therefore provide an excellent opportunity to introduce large-scale changes to Candolle's system of classification.[63]

In particular, Mueller was unhappy with the distribution of families in Candolle's four sub-classes in the Dicotyledons — Thalamiflorae, Calyciflorae, Corolliflorae and Monochlamydeae (Table 4). As early as 1826, the British botanist Robert Brown (1773–1858) had observed that the floral structure of some species in the Monochlamydeae was fundamentally different from that of the others.[64] These species came to be called 'Gymnospermae', which means 'naked seed'. In contrast, the seeds of the other species in Monochlamydeae, and the other sub-classes, were enclosed in an ovary until they were fertilized.[65] In Australia, Mueller was able to observe the differences for himself in a series of gymnospermous genera including *Cycas*.[66] 'But it would undoubtedly be a good work', Mueller somewhat awkwardly told Bentham in 1862,

> if with the exception of Amentaceae Cycadeae & Coniferae all the Monochlamydeae of DC [i.e. Candolle] (or the apetalous Dicotyledonae of Jussieu) were distributed over the petaliferous divisions of the system, whereby the most artificial portion of Candolles & Jussieus classification would be render [*sic*] natural.[67]

Three months later, Joseph Hooker responded to Mueller on behalf of Bentham. He thanked Mueller for his hints but declared they were easier said than done. He and Bentham had spent days trying to improve Candolle's system but had found it utterly impossible. They regarded all his sub-classes as artificial, not just Monochlamydeae: 'We therefore keep all 4,' Hooker told Mueller, 'as confessedly artificial groups, but absolutely necessary for practical purposes.'[68] In another letter he added that everyone should follow Candolle's system, 'not because it is necessarily the best, but because most do follow it, & all know how to find the orders by sequence without referring to the index'.[69] Hooker also had a suggestion of his own to give Mueller, which was that botanists who only dealt with local floras (presumably including Australia) were out of their depth in suggesting substantial changes to systems of classification, and ought to leave it to experts who dealt with world floras, such as himself and Bentham at Kew.[70]

Mueller, however, did not give up. In 1863, Bentham published the first of seven volumes of a flora of Australia, which was based substantially on specimens and notes contributed by Mueller.[71] The Monochlamydeae would not be dealt with until later volumes, but Mueller argued that meanwhile non-gymnospermous families in this group, like Euphorbiaceae (which included genera such as *Euphorbia* and *Phyllanthus* in Australia), should be redistributed into sub-classes in earlier volumes.[72] 'I shall certainly not include Euphorbiaceae in Calyciflorae', Bentham replied tartly in 1865, ' — we [i.e. the Kew botanists] follow in the main the arrangement of De Candolle who with the greater number of botanists place Euphorbiaceae amongst Monochlamydeae'.[73] Mueller continued to nag Bentham about Euphorbiaceae (and also Laurineae, which included genera such as *Cinnamonum* and *Cryptocarya* in Australia) in another three letters.[74] Bentham refused to be worn down, but clearly grew ever more tired of the subject. 'Euphorbiaceae and Lauri-

neae', he declared emphatically in 1866, 'under our arrangement cannot possibly come into the third volume',[75] and indeed they did not.

The 1867 Exhibition Catalogues

Frustrated in his attempts to get Kew to reform Candolle's system, Mueller finally decided to undertake the task himself, although initially he did so rather quietly. As a Commissioner of an international exhibition held in Melbourne, 1866–1867, he contributed an essay on Australian vegetation to the official catalogue.[76] The essay did not discuss systems of classification, but in an attached list of about 950 trees Mueller divided the Dicotyledons into three sub-classes instead of four. The first he called 'Choripetalae' which included plants without or with separate petals, and more or less equalled Jussieu's 'Polypetalae'. The second he called 'Synpetalae' which included plants with united petals, and more-or-less equalled Jussieu's 'Monopetalae'. The third group, 'Amentaceae', included plants without regular flowers. It included four families — Casuarinae, Cupuliferae, Coniferae and Cycadeae — the rump of Jussieu's 'Apetalae' (as defined by Kittel), or Candolle's Monochlamydeae. Mueller redistributed the rest of Candolle's Monochlamydeae into his two other new groups: Choripetalae and Synpetalae.

Aware that an exhibition catalogue could easily be overlooked by other botanists, Mueller placed notices about it in the London-based *Journal of Botany* and *Gardeners' Chronicle*. Once again, however, these did not actually discuss systems of classification.[77] Mueller gained further publicity for his essay when it was republished by the commissioners of an international exhibition in Paris held in 1867,[78] and sent a copy directly to Kew. In June 1867, George Bentham said he was looking forward to reading the essay,[79] but in subsequent surviving letters there is no suggestion that he did so. It seems possible, therefore, that in 1867, at least, no other botanists noticed Mueller's attempts to improve the natural system. Moreover, this seems to have been confirmed by Mueller himself in later years when he felt obliged to inform critics such as Hooker and the American botanist Asa Gray (1810–1888) that he was a veteran in the field of systematics.[80] He went so far as to point out that while his first article about it was published in 1867, it was actually written a full year earlier.[81]

Flora australiensis

In 1868, Bentham finished the fourth volume of *Flora australiensis* and began to ready himself for the Monochlamydeae. Mueller duly shipped collections of relevant specimens,[82] but could not resist another dig about their classification. 'When you come to vol. V', he told Bentham, 'you will regret, that the very dissimilar orders of Monochlamydeae were not distributed among Thalamifl[orae] and Calyciflorae. *Then* we would get a real good natural system.'[83] In reply, Bentham thanked Mueller for his letter but dismissed it, saying, 'I see nothing requiring special answer'. As if to soften this rebuff, however, he added: 'I get so tired of writing that I have not patience to enter into long correspondence'.[84] Indeed, it took Bentham another two years to issue the fifth volume of the flora, and then it only included the non-gymnospermous families of the Monochlamydeae.[85] When Mueller received his copy in November, he said nothing about its system of classification, and merely looked forward to the next volume and the rest of the Monochlamydeae.[86]

Bentham, however, was in no hurry to press on, and three years passed before he finished the sixth volume.[87] Moreover, despite everything he had said about upholding Candolle's version of the natural system, when the volume appeared, altera-

tions had been made to the Monochlamydeae. Instead of including gymnospermous families in this group, as Candolle had done, Bentham put them into their own sub-class which he called 'Gymnospermeae'.[88] In accompanying notes, he openly acknowledged the distinctiveness of these plants, and contrasted them with what he called the 'Angiospermeae', or plants with seeds that were covered in some way. He said nothing directly about having changed Candolle's system, although he indicated that the classification of gymnosperms was a matter of controversy that would not be finally settled until the structure and development of their 'flowers' was more completely understood.[89] Mueller received his copy of the volume in November 1873 but once again said nothing about its arrangement.[90]

Mueller's Student Floras

With Bentham controlling the flora of Australia, Mueller turned his attention to other works. In 1875, he floated the idea of a Victorian flora, but one for students and field-naturalists rather than botanists — in other words, his own version of Kittel's *Taschenbuch*. Initially the government was willing to support the project, but when Mueller calculated that the finished product would run to 800 pages with 150 engravings (Kittel was 848 pages, without illustrations), it baulked at the cost. The Chief Secretary also disapproved of Mueller's use of scientific language in the text.[91] In August 1877, Mueller managed to publish a cut-down version of 150 pages called *Introduction to Botanic Teachings* that provided simply worded information on familiar Australian plants like Gum-trees and Wattles.[92] Of course he did not give up on his larger student flora, and in 1879 the government allowed him to publish the first part of *Native Plants of Victoria*, *Succinctly Defined*.[93] This consisted of 190 pages and 44 illustrations, and at about 14 × 21 cm was portable,[94] if not exactly pocket-sized, but no other parts were published.[95]

Although he was restricted in what he could say in *Botanic Teachings*, Mueller appended a systematic list of families. It included his first published reference to the word 'Gymnospermae'.[96] The *Native Plants of Victoria* offered Mueller more scope to explain himself, and in the preface he at last made up for his previous silence on systems of classification:

> The systematic arrangement adopted is that of the Candollean or reversed Jussieuan natural system, with this important change variously suggested before, that the monochlamydeous or apetalous division has been restricted to the Coniferae and orders very closely allied to them.

He also reminded readers that 'the progress of discovery' had made 'the artificial separation of monochlamydeous orders... more and more untenable'. As an example of the 'disruption of affinities' caused by retaining this group, he rather pointedly referred to Bentham's *Flora australiensis* in which 'we have the extremely natural row of amyliferous (or curvembryonate) orders distributed … through all the five volumes of dicotyledenous plants'.[97]

A review of *Botanic Teachings* in the *Gardeners' Chronicle* described it as an excellent introduction to botany for young children, and the *Journal of Botany* added that 'it is natural and right that our colonies should make their own textbooks'. Neither review mentioned Mueller's systematic index which, after all, occupied only two pages.[98] Reviews of *Native Plants of Victoria*, however, took up Mueller's own cues as to the importance of his systematic changes. 'In classification', wrote the *Gardeners' Chronicle* of this book, 'the author follows those botanists who intercalate the apetalous families with their polypetalous allies, instead of grouping them below the gamopetalae'.[99] The *Journal of Botany* made a similar observation, in only slightly

less neutral language: '[T]he [work] now before us, contains the polypetalous Orders, among which are intercalated in their supposed places the apetalous or monochlamydeous ones.'[100]

By the 1870s, Mueller was only one of an increasing number of botanists to dismantle Candolle's Monochlamydeae, a fact of which he was himself aware. Since Brown's observations on 'Gymnospermeae' in 1826, this group had been adopted in systems of plant classification created by Adolphe Brongniart (1801–1876) at the Muséum d'histoire naturelle in Paris,[101] Alexander Braun (1805–1877), professor of botany in Berlin (who also moved the Gymnosperms out of the Dicotyledons completely),[102] and, of course, Bentham. Moreover, in 1875, the professor of botany at Mueller's old university in Kiel, August Eichler (1839–1887), adopted the terms 'Choripetalae' and 'Sympetalae' [*sic*] alongside 'Gymnospermeae', apparently unaware that Mueller had already coined the first of these ten years earlier.[103] In the 1880s, Mueller was able to add Jean Müller (1828–1896) at Geneva to his list, Théodore Caruel (1830–1898) at Florence, and Elias Fries (1832–1913) at Uppsala, and these names by no means exhausted the possibilities.[104]

First Use of Mueller's System

Given the plethora of natural systems in circulation overseas, it is not surprising that the first botanist to use Mueller's version lived in Australia. This was William Woolls (1814–1893), a teacher and Anglican clergyman at Parramatta in New South Wales; the work concerned, *Species plantarum Paramattensium*, was published in 1871. In a preface, Woolls admitted 'I am not a Botanist by profession', and he obviously looked to others for direction on botanical matters that he did not have the time, or opportunity, to master. Thus, it was from *Flora australiensis* that he took the names of species, but it was from Mueller that he took advice on how to dispose of them in supra-specific groups.[105] Woolls had been a friend and correspondent of Mueller's for fifteen years, and clearly regarded him as more of an authority on the Australian flora than Bentham.[106] As Woolls revealed on a personalized copy of *Species plantarum Paramattensium*, his feelings for Mueller were ones of 'deep affection & devotion'.[107]

Woolls also used Mueller's version of the natural system in his next botanical work, *Plants Indigenous in the Neighbourhood of Sydney*, which was published in 1880. This time, however, he relied on Mueller for both the names of species and their arrangement, cutting Bentham out altogether.[108] He also replaced the term 'Amentaceae' with 'Apetalous Gymnosperms', and resurrected two of Jussieu's terms 'hypogynae' and 'perigynae' in a series of extra subdivisions in the Dicotyledons and Monocotyledons (Table 5). Although he attributed all these names to

Table 5. Mueller's system, 1882

Dicotyledonae Ray (1703)
Choripetaleae Hypogynae F.v.M. (1879)
Choripetaleae Perigynae F.v.M. (1880)
Synpetaleae Perigynae
Synpetaleae Hypogynae F.v.M. (1880)
Apetaleae Gymnospermeae F.v.M. (1880)
Monocotyledoneae Ray (1703)
Calyceae Perigynae F.v.M. (1880)
Calyceae Hypogynae F.v.M. (1880)
Acalyceae Hypogyneae F.v.M. (1880)
Acotyledoneae Jussieu (1789)
Characeae Richard (1815)
Filivalos Berkeley (1857)
Musci Linné (1737)
Jungermannieae Mathieu (1853) from Gray (1821)
Lichenes Hoffmann (1795)
Fungi B. de Jussieu (1728)
Algae Roth (1800)
Fucoideae J. Agardh (1842) from Agardh (1817)
Florideae J. Agardh (1842) from Lam. (1813)
Zoospermeae J. Agardh (1842)
Diatomaceae Agardh (1830)

Mueller, they had not yet in fact been used by Mueller himself. The most likely explanation for this situation is that Mueller developed them for *Native Plants of Victoria* in 1879, but because only the first part of this work was printed, the rest remained in manuscript. As Woolls was writing up his Sydney flora, also in 1879, he must have had access to this manuscript, or at least details of the complete system of classification that Mueller intended to use in *Native Plants of Victoria*.

Genera plantarum

In the same year as Woolls's book on the Sydney flora was published, Bentham and Hooker finally issued their treatment of the Monochlamydeae in *Genera plantarum*.[109] They followed the lead of *Flora australiensis* and created a new sub-class for the Gymnospermeae alongside the Monochlamydeae. Compared with what Mueller had done, this was a relatively conservative reform of Candolle's system.[110] In an associated conspectus, Bentham and Hooker acknowledged that the Monochlamydeae used to include the Gymnospermeae but admitted that now most botanists recognized them as a group in their own right. They added, however, that, in their opinion, the final rank and position of the Gymnospermeae was still to be fully worked out.[111] Mueller received his copy of *Genera plantarum* in April and predicted that it would be 'a treasure for all times' although he was too busy to look at it. In another somewhat ambiguous remark, he marvelled over Bentham's unflagging 'mental power', thereby drawing attention to his old age (80), and hoped that he and Joseph Hooker would soon be able to bring the work to a conclusion.[112]

The Censuses

Mueller's seeming lack of interest in *Genera plantarum* was probably due to his being now actively involved in two grand systematic works of his own. The first of these, a census or systematic list of Australian genera, was issued in 1882,[113] and contained the most complete outline of his version of the natural system to be published (Table 5). As in previous works, Mueller in this census initially divided the plant kingdom into three groups — the Dicotyledons, Monocotyledons and Acotyledons — the first of which he subdivided as in Woolls's publication of 1880. Now, however, he also divided the Acotyledons into seven groups, with the seventh, the algae, sub-divided into a further four groups, the names of which had all been circulating in the botanical literature for at least twenty-five years. Mueller also used his census to redraw the boundaries of genera, thereby reducing the total number found in Australia, and applied a rule of 'strict priority' to their nomenclature, which meant attributing all names to the botanists who first coined them, even if these botanists were not currently the ones most commonly cited.

Mueller's second grand systematic publication was a partial census of Australian species that came out in 1883.[114] The only new feature it added to his system was the use of the terms 'vasculares' to describe the species it included and 'evasculares' to describe those yet to be enumerated. In a lengthy preface, however, Mueller gave his most detailed explanation of his views on systematics, and answered possible criticisms.[115] First of all, he argued that his censuses were needed because the first volume of Bentham's *Flora australiensis* was now twenty years old and many new species had been described since then. Secondly, Mueller emphasized his qualifications to write them, including extensive field experience, access to research materials, and links with other botanists. Finally, he reminded readers that he had been using his own version of Candolle's system since the exhibition catalogue of 1867, and that similar reforms had been made by other botanists 'from the time of the earlier

writings of Brogniart to that of the latest essays of Jean Mueller'.[116] In short, there was nothing to make a fuss about.

Reviews of the two censuses appeared in the *Journal of Botany* and the *Gardeners' Chronicle*. The former acknowledged but did not critique Mueller's version of the natural system, observing only that 'An index would have added to the usefulness of the Census [of genera], as the sequence of orders adopted is not that usually followed.'[117] The latter was preoccupied with criticizing Mueller's genera and nomenclature and ignored his higher-ranked groups.[118] Mueller also received feedback in letters, although few of these survive. Henri Baillon (1827–1895), professor of botany at the École de médecine in Paris, apparently wrote approving the dismantling of the Monochlamydeae. 'From *him*,' Mueller declared, 'who has seen so much from all parts of the world, who dissects so accurately and observes so well microscopically, any opinion on systematic arrangement comes with the greatest authoritative force.'[119] On the other hand, it seems that Asa Gray, professor of botany at Harvard University, disapproved of Mueller's changes to Candolle's system.[120]

The botanists at Kew also noticed Mueller's censuses. In fact, Bentham wrote an angry letter to him about the one on species, although afterwards he seems to have thought the better of sending it.[121] Rather like a teacher marking a poor essay, this letter began by praising the appearance and documentation of Mueller's census. '[B]ut', Bentham concluded abruptly, 'all that is not botany':

> With regard to that science, it grieves me to think that you should have devoted so much of your valuable time to a work which, botanically speaking, is not only useless but worse than useless.

As well as rejecting Mueller's genera and nomenclature, Bentham declared that 'interfering with established sequences of orders [i.e. families] without discussing in each instance the reasons for and against the doing so, is only producing confusion in the minds and collections of systematic botanists'. In this regard, however, Mueller was no more negligent than most other botanists who introduced variations to the natural system, including Bentham himself.[122]

In another letter that does not survive, Kew's Assistant-Director, William Thiselton-Dyer (1843–1928), reproached Mueller for not following *Genera plantarum*. 'I am free to steer my own course', Mueller replied, pointing out again that he was doing so long before this work was published.[123] Mueller also attacked the refusal of Bentham and Hooker to reform Candolle's system: 'If we are to have no changes of any kind', he declared, 'then there can be no progress.' 'As regards Monochlamydeae', he added, 'there is no doubt on my mind that they should be inserted, each order, where its *real affinity* lies; otherwise we can have *no natural system*.'[124] To Asa Gray, he wrote more of the same, arguing that if Candolle was the last botanist allowed to change plant classification, then Linnaeus's system 'should never have been abandoned'. Nevertheless, Mueller was ultimately confident about the future of his reforms. 'The Monochlamydeae may still drag on 'til the end of the century', he predicted to Gray, 'but will not likely be maintained far into the next secular epoch!'[125]

Getting Others To Use His System

At Mueller's request, the government of Victoria printed 1000 copies of his census of species, which was a standard number for his botanical works.[126] Of these, 250 copies were to be distributed among members of parliament, the Trustees of the Melbourne Public Library, and mechanics' institutes and free libraries around Victoria. Mueller was allowed another 250 copies for distribution to 'Academies and other learned Unions as well as leading men of science',[127] which was more than

double the number he was granted for most of his other botanical works,[128] and confirms how much he wanted this census to register in the botanical community. Only 28 of the recipients have so far been identified (Table 6),[129] including Bentham and Hooker, but the census clearly went well beyond Kew into continental Europe, North America and around Australia. In fact, by May 1885 Mueller had run out of copies, and had to renege on a promise to Jean Müller in Geneva to send him one. 'However, if it matters particularly to you about it,' he told the apparently disappointed Müller, 'I will send you a reprint for your private library.'[130]

Despite this effort at publicity, Mueller's census of species seemed to have little impact overseas. Kew's botanists of course stuck to Bentham and Hooker's system of classification, as did Asa Gray in the United States.[131] Other botanists continued to use their own systems, adopted other European botanists' systems, or developed their own. Nevertheless, there may have been at least one exception. In a letter to the director of the Sydney Botanic Garden, Charles Moore (1820–1905), in 1887, Mueller asserted:

> The idea of keeping the Monochlamydeae by themselves, becomes more and more discarded; — even by last mail the leading

Table 6. Recipients of Mueller's census of species, 1883

Country	Recipient
Australia	1. Georgina King, Sydney
	2. Linnean Society of NSW
	3. Arthur Lucas, Melbourne
	4. Joseph Maiden, Sydney
	5. Royal Geographical Society of Australasia, Qld
	6. Royal Society of SA, Adelaide
	7. Royal Society of Tas., Hobart
	8. School of Mines & Industries, Ballarat
	9. Ralph Tate, Adelaide
	10. Otto Tepper
	11. William Woolls, Sydney
Denmark	12. Kongelige Danske Videnskabernes Selskab, Copenhagen
France	13. Henri Baillon, Paris
Germany	14. Adolf Engler, Berlin
	15. Freie Deutsche Hochstift für Wissenschaften, Künste und allgemeine Bildung in Goethe's Vaterhause, Frankfurt
	16. Ferdinand Krauss, Stuttgart
	17. Gesellschaft zur Beförderung der gesammten Naturwissenschaften, Marburg
	18. Naturhistorische Gesellschaft, Hannover
	19. Naturwissenschaftliche Gesellschaft Isis, Dresden
India	20. Agricultural and Horticultural Society of India, Calcutta
Switzerland	21. Alphonse Candolle, Geneva
United Kingdom	22. George Bentham, Kew
	23. James Britten (*The Journal of Botany*)
	24. Joseph Hooker, Kew
	25. Linnean Society, London
	26. Maxwell Masters (*The Gardeners' Chronicle*)
United States of America	27. Asa Gray, Harvard
	28. George Engelmann, St Louis

> Botanist of Western North-America expresses himself on his own accord bound, to adopt my alteration of the DC system.[132]

The identity of this botanist is uncertain but he may have been Sereno Watson (1826–1892), an assistant of Gray's at Harvard University who travelled in north-western America in 1880. If so, he did not live to use Mueller's system in any substantial publications.[133]

In Australia, it was a different story. About fourteen major floristic works were published by local botanists between 1871 (when Woolls first adopted Mueller's system) and 1903 (when the last work that Mueller tried to influence was published)[134] (Table 7).[135] Of these, half used his system, while most of the rest followed *Flora australiensis*, even after the issue of *Genera plantarum*. Having once selected a system, botanists tended to remain loyal to it, with only one, Charles Moore in Sydney, switching sides. In 1884, he used Bentham's system and in 1893, Mueller's. The reasons probably lie in a letter from Mueller to Moore where Mueller argued that all Australian floras should follow his arrangement of species for the sake of consistency (the same as Hooker said about Candolle), because Bentham's system was 'behind the times' and, most importantly, because this would secure his co-operation.[136] Moore's co-author in 1893, Ernst Betche (1851–1913), also supported using Mueller's system and told Moore, with unfounded confidence, that if Bentham were still alive that he too would now agree with this decision.[137]

Mueller's Own Field-guide

Just as it seemed that Mueller had finally established his authority to write on classification, one last twist occurred. In 1884, the President of the Field Naturalists Club of Victoria, Frank Dobson (1835–1895), asked him to write a field-guide to the colony's flora in the form of a dichotomous key. While having long wished to write such a field-guide, Mueller did not want to do it in this way. A dichotomous

Table 7. Systems used in floristic works on Australian plants, 1871–1903

No.	Work	System
1	W. Woolls, *Species Plantarum Paramattensium* ... (Göttingen, 1871)	Mueller
2	R. Schomburgk, *The Flora of South Australia* ... (Adelaide, 1875)	Bentham
3	W. W. Spicer, *A Handbook of the Plants of Tasmania* (Hobart, 1878)	Bentham
4	W. Woolls, *Plants Indigenous in the Neighbourhood of Sydney* (Sydney, 1880)	Mueller
5	R. Tate, 'A census of the indigenous flowering plants and ferns of extra tropical South Australia', *Trans. Roy. Soc. SA,* 3 (1880), 46–90	Mueller
6	F. M. Bailey, *A Synopsis of the Queensland Flora* (Brisbane, 1883)	Bentham
7	C. Moore, *A Census of the Plants of New South Wales* (Sydney, 1884)	Bentham
8	W. Woolls, *The Plants of New South Wales* (Sydney, 1885)	Mueller
9	R. Tate, *A Handbook of the Flora of Extratropical South Australia* (Adelaide, 1890)	Mueller
10	C. Moore and E. Betche, *Handbook of the Flora of New South Wales* (Sydney, 1893)	Mueller
11	D. McAlpine, *Systematic Arrangement of Australian Fungi* (Melbourne, 1895)	McAlpine
12	F. M. Bailey, *The Queensland Flora*, 6 vols (Brisbane, 1899–1902)	Bentham
13	J. Stirling, 'Notes on a census of the flora of the Australian Alps', *Trans. & Proc. Bot. Soc. Edinburgh*, 67 (1903), 319–395	Mueller
14	L. Rodway, *The Tasmanian Flora* (Hobart, 1903)	Bentham and Hooker

key identified specimens by successively contrasting alternative states of simple characters but, rather like Linnaeus's artificial system of classification, it also tended to disrupt the natural sequence of groups that Mueller had spent a life-time trying to reveal. Dobson, however, was a politician as well as a president, and Mueller felt obliged to do as he asked.[138] In 1886, he published the so-called 'second' part of a *Key to the System of Victorian Plants*, which was mainly taken up with illustrations but also included a 55-page list of plants arranged according to his version of the natural system.[139] Two years later he published the 'first' and main part of the field-guide, which contained the dichotomous key itself in a bulky 559 pages.[140]

Mueller almost apologized for his work in a preface,[141] but he need not have been so defensive. The *Gardeners' Chronicle* considered that he had combined the dichotomous format and the revelation of natural relationships 'with great skill', which it assumed 'must have been a tedious and difficult task'.[142] Moreover, the *American Journal of Science* pointed out that the dichotomous key (just like Linnaeus's system) was extremely convenient, enabling 'a student to trace out the name of a plant with great rapidity'.[143] Perhaps, however, the most important measure of the success of Mueller's *Key* lay in its usage. Although it is not known how many were printed, the *Key* remained the standard field-guide for the Victorian flora for over forty years. Its successor volume, Ewart's *Flora of Victoria* of 1931, was arranged according to the natural system of the German botanist Adolf Engler (1844–1930), which contrasted the gymnosperms with the angiosperms.[144] Even so, the link with Mueller's system was not entirely broken, because Engler was a correspondent of Mueller's and a recipient of his census of species (Table 6).

Conclusion

In his *Key to the System of Victorian Plants*, Mueller encouraged readers to go out and collect specimens. '[T]hey may add to the objects for mental training', he declared, 'and joyous engagements far beyond what by the youthful observer could be surmised playfully at the outset'. In fact, he added autobiographically, 'they may exercise indeed an influence on a whole life'.[145] As a young man in Schleswig-Holstein, he was fascinated by the plants around him, and soon wanted to know their names and to understand what these revealed about their relationships. The classification systems of Linnaeus and Jussieu were early guides, and remained the foundation for his belief that the shape of nature was continuous. Nevertheless, through the work of Kittel, other botanists, and perhaps his own observations, Mueller became aware that plant classification could be made more natural. It was with this knowledge that he set off for Australia in 1847, where the variety and novelty of the flora was such as to give him the necessary experience to continue to make a contribution to the development of such a classification system himself.

Mueller's first decade in Australia left him one of the most widely travelled individuals in the country, and he published his botanical findings in a series of articles. Initially these were more or less arranged according to Candolle's version of the natural system, but Mueller was never completely satisfied with it, and by 1860 he believed it needed substantial reform. The botanists at Kew declined his suggestion that they be the ones to undertake this, arguing that a stable system of classification was more practical than a constantly changing one. Mueller disagreed, and when he dismantled Candolle's Monochlamydeae and segregated the gymnosperms in 1867, he was among the first botanists to do so. Moreover, by defying

Bentham and Hooker at Kew and continuing to develop his version of the natural system in subsequent publications, Mueller helped to create a more independent tradition of scientific work in Australia. The opinion of the Kew botanists did matter to him, but he refused to accept that he had any less right than they did to undertake independent research, and to draw original conclusions based upon it.

By the 1880s, Mueller felt vindicated in his position on the Monochlamydeae, because an increasing number of botanists overseas reached similar conclusions, although they did so in their own versions of the natural system. In Australia, as a lone worker in classification, he was able to bring his influence to bear on fellow botanists much more successfully. In fact, his greatest competition came from Bentham's *Flora australiensis*, which also eventually recognized the gymnosperms as a separate group. Mueller's sense of triumph locally would almost have been complete, if not for the insistence of a politician in 1884 that he write a field-guide to the Victorian flora in the form of a dichotomous key. The resulting work was in effect the reverse of Kittel's *Taschenbuch*. It included Mueller's natural system at the beginning as a 'sub-key', and arranged the main text according to an artificial one. This field-guide, however, did fulfil Mueller's wish to introduce others to botany, and it did so unchallenged for a generation, which was about as long as the works of Linnaeus, Jussieu and Candolle also held sway.

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