Proceedings of the Seventh International Conference on Creationism.
Pittsburgh, PA: Creation Science Fellowship

THE FOSSIL RECORD OF ANGIOSPERM FAMILIES IN RELATION TO BARAMINOLOGY

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KEYWORDS: Angiosperms, flowering plants, fossils, baramins, Flood, post-Flood continuity criterion, continuous fossil record

ABSTRACT

To help estimate the number and boundaries of created kinds (i.e., baramins) of flowering plants, the fossil record has been analyzed. To designate the status of baramin, a criterion is applied that tests whether some but not all of a group's hierarchically immediate subgroups have a fossil record back to the Flood (accepted here as near the Cretaceous-Paleogene boundary). Because of the lag time in population size and dispersal immediately after the Flood, this record is considered established if the group has fossils in Lower Eocene or lower strata. The quality of the flowering plant fossil record was found to decrease significantly below a family size of 600 species. Therefore the criterion was modified to account for small families and groups that lack a fossil record but are sister groups of so designated baramins. Depending on the classification used, the method identified between 212 and 222 flowering plant baramins, mostly families and suborders but some orders. This corroborates other baraminological criteria and significantly lowers the taxonomic level designated in studies using the unmodified criterion. Different baramins appear to contain significantly different degrees of originally designed diversity versus post-Flood diversification.

INTRODUCTION

Created kind is central to an understanding of God's design in and His plan for the living creation through Biblical time. The term that creation biologists use to give greater precision to the concept of created kind is baramin, the study of which is called baraminology (Wise, 1990). Hence over a several year period, various criteria have been devised to differentiate baramins (e.g., suites of characters unique to different baramins; Wise, 1992) and recognize continuous variation within baramins (e.g., hybridization potential; Wood, 2006). For full discussion of the history and application of the baramin concept, see Wood *et al*. (2003). Statistical baraminology purports to detect both external discontinuity and internal continuity of baramins simultaneously from pairwise comparisons of morphological data of species, genera or other taxonomic entities (Robinson & Cavanaugh, 1998; Wood, 2002, 2005, 2006). Attempts are being made by creation biologists (Wise, 1992, 2008, 2009; Sanders, 2011) to use the fossil record to develop other criteria.

In addressing this question for mammals, Wise (2008, 2009) realized that, using fossils, one would have to document or, at least, provide adequate evidence that a baramin has existed since the time of the Flood. An example of such evidence would be fossils of baramin members either in Flood strata or in lowermost post-Flood strata (i.e., deposited a few years after disembarking) and is called a Continuous Fossil Record (CFR) with the Flood. A group for which evidence of a CFR is lacking might be a group derived within the baramin from an ancestor that did survive the Flood. That is, one must be aware that a group's fossil record might be incomplete. Wise described such a post-Flood descendant group as subbaraminic, and by necessity, its baramin would have to be a more inclusive group. Using this line of reasoning, Wise developed a criterion, the Post-Flood Continuity Criterion (PFCC), using fossils to approximate the mammals that were on the Ark. By the PFCC, a group is a baramin if it is the least inclusive taxonomic group that is represented with a CFR. Stated another way (Sanders, 2011), the taxon is a PFCC baramin if some but not all of its included taxa of next lower rank have a CFR. That is, if all of a group's included taxa extend back to the Flood, then each of the included taxa should be a baramin, not the larger group. However, if some of the included groups are subbaraminic, then clearly the more inclusive group (i.e., the least inclusive group represented as a whole by a CFR) is the baramin. See Figure 1 for a visual representation of the use of the PFCC criterion.

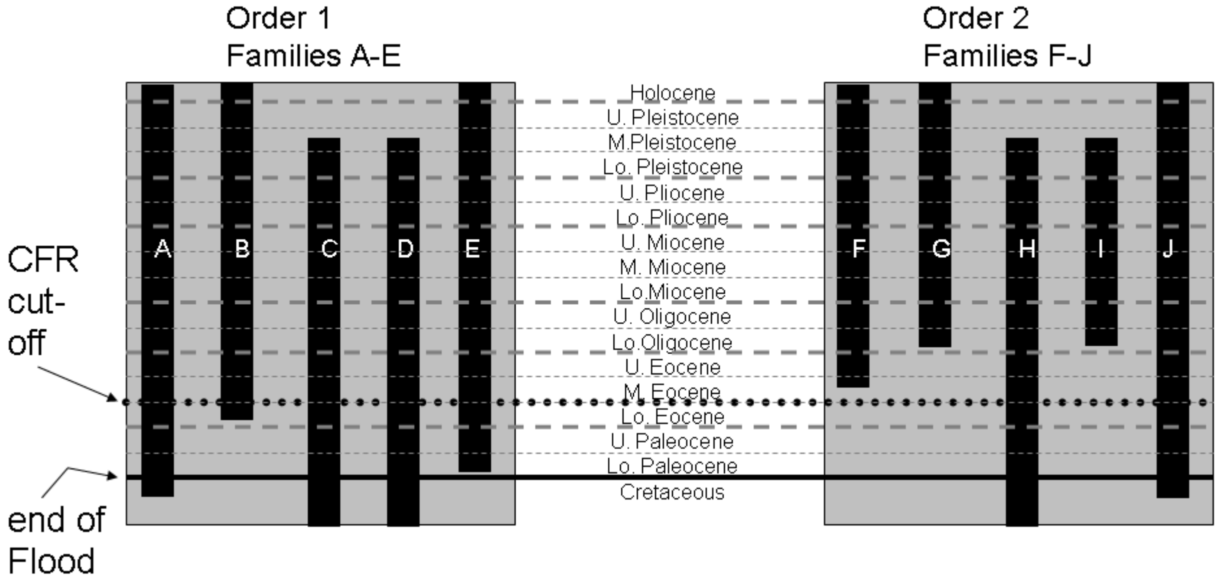

Figure 1. Examples of application of PFCC. The thick black horizontal line indicates the end of the Flood according to the K/Pg geological model. The black dotted horizontal line indicates the uppermost point where a group will be considered to have a fossil record back to the Flood (a CFR). Black columns are the fossil ranges of hypothetical families. In Order 1, all five families have a CFR and all five qualify as baramins under the PFCC. In Order 2, Families F, G and I lack a CFR. Therefore, only the order qualifies as a PFCC baramin; each family is subbaraminic, and F, G and I must have descended from the other one or two families.

For example, let's say that in the bittersweet order, the three families (hollies, icacinas, and bittersweets) each have fossils in Flood rocks or lowermost post-Flood rocks. Thus each of the families of the bittersweet order has a CFR. Let's further say that five extinct species of bittersweet are found in Flood rocks or lowermost post-Flood rocks. Thus, the bittersweet genus (*Celastrus*) also has a CFR. Let's further say that the other genera in the bittersweet tribe and the other tribes in the bittersweet family do *not* have a CFR. Whereas the bittersweet genus, bittersweet tribe, bittersweet family, and bittersweet order each have a CFR, the PFCC baramin is placed as the level of the bittersweet family, with the holly and icacina families also identified as PFCC baramins. In this particular case, the family level is the least inclusive group at which the subgroups of the bittersweet family become represented with a CFR. That is, either the five species are ancestral to the rest of the family, the five are representative of the variation existing before the Flood, or possibly the other members of the family failed to be fossilized, in which case, we would underestimate the number of baramins and place the baramin too high at the taxonomic level of family.

Wise (2008, 2009) based his analysis of mammals that fit the PFCC on the assumption that the Flood/post-Flood boundary is at or near the Cretaceous-Paleogene (K/Pg) boundary. This is the prevailing consensus of professional Flood geologists (Snelling 2009, ch.94) and derives from a series of criteria for distinguishing the Flood and post-Flood strata (Austin *et al*., 1994; Whitmore & Garner, 2008; Whitmore & Wise, 2008). Wise found that few mammal groups occur in Flood rocks. Those in early post-Flood rocks must therefore have survived the Flood via Noah's Ark; these now mostly extinct species gave rise or were part of the variation that gave rise within the same baramin to those fossil species in mid and late post-Flood rocks, as well as living species. Wise reasoned that the short time span of the early subseries of the Cenozoic (possibly few to tens of years each, following Whitmore & Wise, 2008), the expected life span of the Ark survivors, and the low population sizes during these early post-Flood years, would lower the chance of fossilization until the Lower Eocene. He also examined the quality of the fossil record of the entire Cenozoic and found that in 27% of the cases, a genus was missing from the middle subseries of a set of three subseries. In other words, there is a 27% chance for a fossil group to be missing from one subseries when, in fact, it actually existed during that subseries deposition. Squaring and cubing that, he calculated a 7% chance a group would be missing from two adjacent subseries, and a 2% chance they would be missing from three adjacent subseries. He concluded that at minimum there would be a 27% chance that a group would have first appeared in the Upper Paleocene and still have been on the Ark and a 7% chance for a group appearing in the Lower Eocene. Thus, he proposed that taxa should be considered to have a CFR if they were present in any strata up to and including the Lower Eocene subseries.

To argue that the fossil record is, in fact, complete enough to say that any given genus can be represented by fossils, Wise tallied the fossil record of living genera and found that it was between 80% and 99% complete for temperate continents and between 70% and 100% complete for dog-sized and larger mammals. Therefore, he proposed that the identification of baramins using the PFCC should be accurate or only slightly underestimated.

Plants present additional challenges because they survived the Flood largely outside the Ark and no set number of survivors can be known as for mammals. That is, one cannot assume that all living species descended from an Ark pair and that other variants of the baramin were lost. Sanders (2011) investigated the application of the PFCC to flowering plants by analyzing with Wise's methods a compilation of fossil pollen occurrences for all angiosperm families (Muller, 1981). The results were inconclusive but demonstrated two significant issues.

First, Sanders (2011) included three traditional classification systems (Dahlgren, 1975; Takhtajan, 1980; Cronquist, 1981) and one molecular system (Angiosperm Phylogeny Group [APG], 2003; Soltis *et al*, 2005) and found that different classifications can yield remarkably different results. This is because the fewer ranks nested in the classification, the higher the rank at which the baramin is designated. It takes just one small anomalous family with no fossil record to force the PFCC baramin to the rank of subclass or even class if the criterion is followed to its logical conclusion. Indeed, Sanders (2011) truncated the application by excluding subclass and higher ranks from consideration. As a result, Cronquist's system with only the ranks of family, order, and subclass left 161 families unassigned to any baramin; these Sanders referred to as "orphaned families."

Second, Sanders' study suggested that the quality of the fossil record should be assessed before applying the PFCC further. Obviously, macroscopically visible fossils (macrofossils), such as leaves, wood, flowers, and fruits, should be included in the study. Furthermore, preliminary surveys of the literature suggest that families with few living species are much less likely to be fossilized than families with many living species. Thus, the goal of this study is to add macrofossil data to the angiosperm data set, to provide a preliminary assessment of the quality of the angiosperm fossil record, and develop modifications of the PFCC that take that quality into consideration.

METHODS

The lowest taxonomic rank considered as baramin for this study is family for two reasons. 1) In the data sources consulted, the fossil record is not provided in the context of infrafamilial classifications, and, thus, the fossil ranges of tribes and subfamilies (and even genera) are not easily determined. 2) Statistical baraminology finds about 60% of baramins are at the family level (see Wood, 2008). Conversely as in Sanders (2011), the rank of subclass was considered too inclusive to be consistent with biblical kinds. The number of angiosperm families recognized is 316, including all the traditionally recognized multi- to monotypic families (consensus of sources e.g., Dahlgren, 1975; Takhtajan, 1980; Cronquist, 1981; Watson & Dallwitz, 1992; see also Sanders, 2010). Mono-or oligotypic families recognized on the basis of recent, especially molecular, studies are treated within the larger families to which they have affinity. Unlike that for mammals, there is no single compendium which summarizes all published occurrences by geologic subseries. In fact, only since the mid-1970s have methods been developed and standardized for correctly identifying angiosperm leaf fossils.

As in Sanders' (2011) study, Muller (1981) was consulted for the lowest stratigraphic occurrence of fossil pollen genera; Muller evaluated reports and related fossil form-genera to living genera where applicable.

Reports of macrofossils were compiled from four sources: 1) *The Paleobiology Database* (http://paleodb.org) contains reports submitted by volunteers and, thus, is incomplete with regard to the existing literature. Only reports of fossil identifications dating from 1980 were accepted from this source, except for reports dating to the mid-1970s by the two paleobotanists responsible for techniques of modern fossil leaf identification, Jack Wolfe and Leo Hickey.

Searches were conducted for entries fulfilling both the family name and the stratigraphic range of Lower Cretaceous to Lower Eocene. 2) *The Fossil Record* website (www.fossilrecord.net/fossilrecord/index.html) by Benton & Benton (1993-2006) records first, intermediate and last appearances by subseries of families tabulated by phyla or class. The occurrences are summarized from the literature but references to the original sources are not given to allow verification. At least questionable occurrences are noted; those questionable occurrences were not accepted for inclusion here. 3) Graham (1999) provides a careful evaluation of families and genera of Upper Cretaceous and Cenozoic fossils of the United States, Canada, and Greenland. His narrative is accompanied by numerous tables of data. 4) Graham (2010) is a companion volume covering Mexico southward but is more preliminary, consisting largely of extensive tables. Together his two books summarize what is known of the vascular plant fossil record of the Western Hemisphere.

Data from these sources were tallied in two ways. First, because Muller (1981) organized pollen data in Takhtajan's hierarchy, this system was used to arrange the generic (if known) and family fossil reports. The stratigraphic range of the report (for living genera and families, this includes the first occurrence to the Holocene) and the data source were tabulated. Stratigraphic ranges were also graphed by subseries and were color coded to indicate micro- vs. macrofossils. Second, Takhtajan's classification system (Takhtajan, 1980) was chosen to represent modern morphological, non-cladistic classifications because it is the most hierarchically structured with explicit listing of families, and the APG classification (APG, 2003 [supplemented with Stevens, 2001 onwards; Soltis *et al*, 2005; and Reveal, 2012]) was used to represent molecular, cladistic classifications. Spreadsheets were compiled for each, listing the families in the index column, with additional columns for names of suborders, orders, superorders, and subclass to which these families belong in the respective systems, as well as information on number of species, woodiness, presence of a CFR, etc. These spread sheets were manipulated for various analyses.

To estimate the quality of the fossil record, ten families from each of five size classes (0-150 species, 151-300 species, 301-500 species, 501-1000 species, and 1001+ species) were randomly sampled. For each sampled family, the occurrence of any fossil from Cretaceous to Pleistocene strata was scored as a positive fossil record. The average number of species in each size class and the frequency of positive scores for each size class were calculated.

A range of possible values for the number of baramins estimated by the PFCC criterion were determined. Using the available fossil record data, the minimal number of (but usually excessively large) PFCC baramins was estimated by strict application of the PFCC criterion in both the morphological (Takhtajan's) and molecular (APG) classifications. An estimate of the maximum number of baramins was obtained by modifying the PFCC as follows and applying it to both classifications: Based on the correlation of family size and fossil record quality (see results below) a size threshold was established, below which a family was considered unlikely to leave a fossil record. A family without a documented CFR and below the size threshold is considered to have a Potential CFR if at least one other sister family (in the same taxon of next higher level in Takhtajan's classification) or its sister clade (in the case of the APG system) possessed a documented CFR. On the other hand, families without a documented CFR and larger than the threshold were still considered to lack a CFR. This application of a potential CFR still leaves certain orders (or suborders) without any families with a CFR but whose sister order(s) is composed of multiple families with a CFR. Thus, the modified PFCC (MPFCC) applied here defines a baramin as a taxon at the lowest taxonomic level having a CFR (as in the original PFCC, but either documented or potential CFR qualifies) and any higher level taxon lacking such a CFR but whose sister taxon does possess a CFR (and hence qualifies as a baramin). Please note that, in orders or suborders qualifying as baramin by the latter application but containing a single family, the baramin is assigned to the family, not the higher rank.

RESULTS

All families in the random sample with over 700 species are known from fossil species in Pleistocene or lower strata (Figure 2). Below 600 species there is a rapid decrease in the frequency of families with fossil records. When the sample is further divided into families that are primarily woody versus herbaceous, the size at which there is a rapid decrease below 100% of families with a fossil record is 400 and 635 species, respectively. Based on the results, it was determined that predominantly woody families with less than 400 species and herbaceous families with less than 635 species are too small to be expected to have a fossil record.

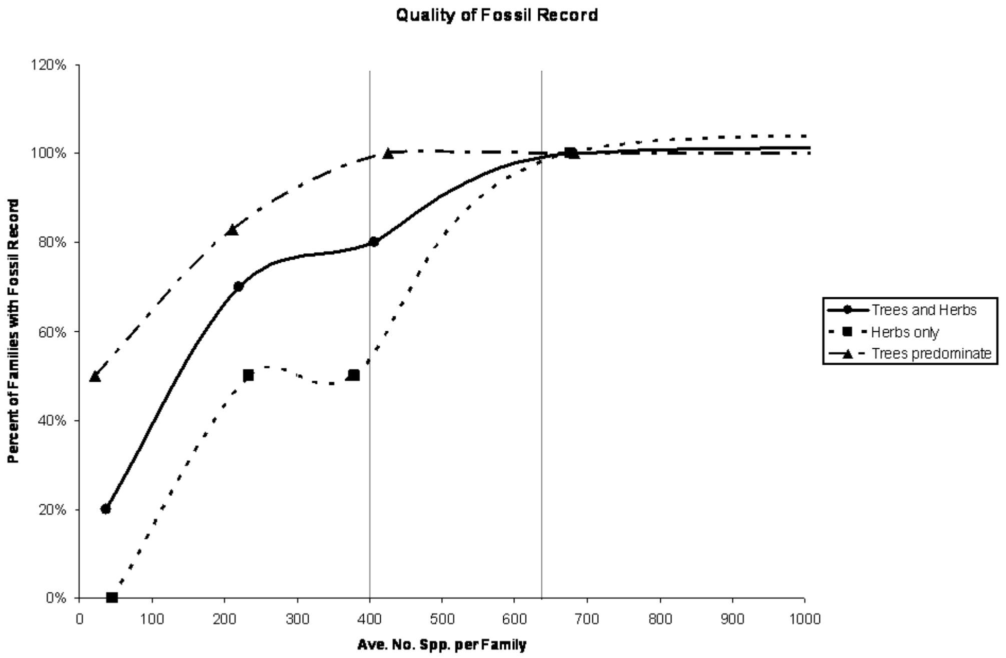

Figure 2. Quality of the angiosperm fossil record. Ten randomly selected families in each of five size classes were averaged to give the number of species and the percent with a fossil record. The average values are shown for the ten families by the dots. The line shows the interpolated values. The value diminishes rapidly below 100% for families with fewer than 600 species. The broken line and triangles give the same information of the subsample comprised of only predominantly woody families, and the dashed line and squares gives that for the predominantly herbaceous families. These values provide the basis for assigning a potential but undocumented CFR to small families that are sister to families (or in the APG system, sister to clades) with a documented CFR. Please note that the size class of greater than 1000 species lies far to the right of the portion shown and has a 100% fossil record in all three sample categories.

Data in this study produced 130 angiosperm families with a documented CFR, which constitute 41% of angiosperm families (Table 1). Within these families, the sources listed 129 genera occurring in Lower Eocene or lower strata. Strict application of the PFCC yields between 33 and 44 baramins for the molecular and morphological classifications systems, respectively, in which the number of families as baramins was 12 in both cases (Table 2). Very large inclusive baramins at the ordinal and superordinal levels dominate. A small number of families remain orphaned in both systems.

When the MPFCC is applied, 120 families have a potential CFR in Takhtajan's system, while the APG system yields 96 such families (Table 1). Recalculation of baramins using the MPFCC leaves no families orphaned in either system; it yields for Takhtajan's system 212 baramins and

	Previous Study (Sanders 2011)	Present Study Takhtajan system (1980)	Present Study APG (Stevens 2001+; Reveal 2012)
Families with documented CFR	58	130	130
Families with potential but undocumented CFR	0	120	96
Total Families for which a CFR is accepted	58	250	226
Percent of families with accepted CFR	18.4	79.1	71.5

Table 1. Families with a Continuous Fossil Record with the Flood (CFR) as determined by a documented fossil record, by a potential fossil record for small families in the context of sister groups in their respective classification systems, and by combining the two categories for use with the modified PFCC.

	Baramins identified by strict application of the PFCC		Baramins identified by modified application of the PFCC (MPFCC)	
	Takhtajan	APG	Takhtajan	APG
Families	12	12	186	191
Suborders	1	2	8	13
Orders	18	11	18	18
Superorders	13	8	0	0
Total	**44**	**33**	**212**	**222**
Orphaned Families	2	3	0	0

Table 2. Comparison of taxonomic distribution of baramins in Takhatajan's system (1980) and the APG system (Stevens, 2001 onwards; Soltis *et al*., 2005; Reveal, 2012) using both the strict PFCC and the modified PFCC in each system.

for the APG system 222 baramins. In both cases, the vast majority of baramins are at the rank of family with no superorders treated as baramins (Table 2). The families identified as baramins account for approximately 2/3 of living families in both systems. The remaining families are subbaraminic in suborder or order level baramins. A complete list of MPFCC baramins is given for both the Takhtajan and APG systems in the Appendix.

DISCUSSION

Comparison of strict and modified application of the PFCC. Strict application of the PFCC to flowering plants results in baramins at a much higher taxonomic level than that estimated using statistical baraminology. For example, Wood (2008) obtained support for three families as holobaramins (Olacaceae, tallow-wood family; Poaceae, grass family; Nymphaeaceae, waterlily family). In stark contrast, these families are placed in much more inclusive baramins using the strictly applied PFCC—superordinal in the case of the former two families and ordinal for the Nymphaeaceae. Sanders (2011), also using a strict PFCC, obtained the same very inclusive baramins for these three families with data from fossil pollen only. Therefore, even though the present addition of macrofossils increased the number of CFR families significantly over that with just pollen data, the expanded data did not change the baramin designations significantly under the strict PFCC. Note, however, in the Appendix that, when the MPFCC is applied, the baramin shifts to the family level for these three families as in Wood's statistical baraminology.

Furthermore as noted by Sanders (2011), differences in classification systems have dramatic effects on the identification of baramins when these are determined using the strict application of the PFCC. This is closely related to the distinctness of the major families and superfamilies (i.e., groups of closely related families) in contrast with the obscurity of many ordinal and higher order affinities that have plagued angiosperm systematics since the early 1800s. Although conventional systematics has embraced molecular phylogenies to resolve the enigmatic higher order affinities, molecular-based classifications separate at a distance groups that otherwise are similar on morphological grounds. Within a baramin one would expect a single underlying genomic background paralleling morphological similarity. Therefore as one moves up the taxonomic hierarchy, the level at which the morphological similarities becomes disconnected from or conflicts with the genomic similarities strongly suggests that discontinuities between baramins has been reached. In this study, as well as that by Sanders (2010), this level is commonly at the family or superfamily.

Recognition of the poor quality of the fossil record of small families and applying that information in the MPFCC bring both 1) the taxonomic level of baramin closer to the family rank and 2) the estimates of baramins from divergent systems into closer correspondence (Table 3, Appendix). These two are related in that, given the family concepts used in this study are applied to both systems, the sister families relationships are similar in both systems resulting in baraminic status of the families without a documented CFR; whereas, higher level relationships, though divergent in the two systems, are, thus, less important in resolving family level baraminic status. One must realize, however, that the MPFCC is only one possible criterion (Wise, 1992; Wood, 2002, 2005) and, hence, may produce biased results.

Quality of the fossil record. If one multiplies the number of all families in each size class times the average chance of fossilization for that size class obtained from the random sample of families shown in Figure 2, then about 200 of the 316 families recognized here should have a known fossil record (Cretaceous to Holocene). Based on the data sources in this study, one can estimate that an average of 5 extant genera per family and an average of 5 extant species per genus are part of that record. This gives an estimate of 1,000 extant genera and 5,000 extant species with a fossil record. Thus, the living genera and species that have a fossil record compose approximately 7% of the roughly 14,000 living genera and about 2% of the living 250,000 species of flowering plants. This is in stark contrast to the quality of the mammal and mollusk fossil record. In well studied areas such as Europe and North America, about 75% to 90% of living species have a fossil record and up to 99% of living genera have a fossil record (Wise, 2009). Given that lignin (wood and venation) and sporopollenin (walls of spores and pollen) are expected to be as resistant to decay as are bones, this low percentage of living plant species and genera is quite unexpected. This is especially true for trees with woody fruits and sclerified leaves and inflorescences. However, the lignin in the cell walls of herbaceous plants is usually more weakly developed and becomes fragmented or dispersed quickly upon decay of the organs. This would be expected for pre-Flood herbs that were being buffeted by the Flood waters and winds. For post-Flood environments, except for aquatic sites where anaerobic conditions can develop, herbaceous plants would be expected to occur in dryer habitats that are more subject to wind and herbivore destruction, as they are today. This would also apply to less sclerified woody plants in forests where fungal growth is rampant, as in tropical rain forests. The fragmentary nature of any potential fossils of herbs and soft woody plants is comparable to that of mammals of small body size such as bats and shrews, which Wise (2009) noted have a poorer fossil record than do larger mammals. So whether the scant record is a result of poor fossilization, actual absence, or too few researchers to find fossils remains to be investigated.

Of course, using the number of current species to understand the fossilization potential of a group has its own problems. Obviously the lack of a record could mean the group truly originated post-Flood. However, it could also mean that the population size of the baramin was much smaller pre-Flood and diversified into numerous species after the Flood. Conversely, a group, such as *Cercidiphyllum* with a single species today, may have had more species growing in extensive pre-Flood habitats. Thus, the former would be accurately reflected in the analysis of the plant fossil record (Figure 2), whereas the latter would have a better fossil record than that expected for a group with few extant species.

With regard to the selection of the number of species to establish the cut-off for accepting a potential CFR, why was a value of approximately 98% frequency of families chosen? Certainly one could use the 50% frequency line and obtained cut-off values of about 20 species for woody families and 300 species for herbaceous families. A 5% frequency line would result in a cut off of zero species for woody families and 80 for herbaceous one. However, using these cut-offs would have simply moved the estimates closer and closer to that of the strict application of the PFCC. Using the 98% frequency line, therefore identifies a maximum number of families as baramins to contrast with the minimum number resulting from a strict PFCC.

An issue related to the quality of the fossil record is whether the Lower Eocene is as an appropriate upper boundary for determining a CFR for plants as it is for mammals. Certainly the life span of woody plants would be as long as or longer than that of mammals disembarking the Ark. However, plants shed organs—leaves, pollen, flowers, fruits, twigs—long before their life span ends. This should certainly be true during stormy climatic conditions prevailing immediately after the Flood. On the other hand, the conditions limiting fossilizations would include, at least, the small numbers of propagules that survived to form centers of dispersal and the time it would take to re-establish vegetal cover over extensive areas of decimated landscape, especially given the cloud of ash and aerosols blocking sunlight in the years immediately following the Flood. Indeed, the issue of numbers of survivors, the pre-Flood intrabaraminic diversity they represent, and the number of sites in which they landed and revegetated the earth's surface may prove to be nearly intractable problems.

Evolutionary assumptions of conventional classifications. Likewise, using sister group relationships of the conventional classifications is a double-edged sword. Having a phylogeny available, such as that upon which the APG classification is based, makes determining sister-groups relationships straightforward, regardless of whether any of the clades are named using a formal rank. No comprehensive cladogram exists for any morphological classification system, and sister group relationships have to be inferred from the formally named, internested ranks. The reasoning is that, if the DNA similarity of a small family without a CFR suggests it is equivalent to a sister family/clade that does have a CFR, then it would be expected have been on the earth at the same time. Of course, the sister-group relationships are determined by phylogenetic techniques with the assumptions that similarities are homologies that demonstrate common ancestry. That is, the classification is based on a phylogeny. Though the morphological classification systems are not based on explicit phylogenies, they are based on evolutionary assumptions that morphological similarities are homologies. Because of the disconnect between morphological and molecular homologies, these different systems yield different sister-group relationships. This explains why different systems yield different assessments of baramins using the PFCC. However, given the present data, the assessment of a small family with out a CFR has three possibilities: 1) it is just a subbarminic group related to its molecular sister group; 2) it is a subbaraminic group related to its morphological sister group; or 3) it is a distinct baramin. If it truly is a separate baramin, whether we determined that by the molecular or morphological classification is irrelevant. That is, it was created separately with created morphological similarity to some groups and created molecular similarity to other groups, and its sharing a common ancestor with any other group is an illusion. See also comments in section above.

Geologic context of the Flood/post-Flood boundary. Oard (2007, 2010a, 2010b, 2011) has championed the "late Cenozoic" (roughly Pliocene/Pleistocene to mid Pleistocene depending on locality) as the end of Noah's Flood with a nearly immediate development of the ice advance followed by establishment of "uniformitarian" conditions. Although he has advanced 11 criteria to differentiate inundatory, transgression, regression, and post-Flood geological signatures, he has not recognized potential flaws in those criteria as Whitmore and Garner (2008) have done with their criteria. His primary criticism of the Cretaceous/Paleogene adherents is that they do not provide mechanisms for large-scale post-Flood geological processes required by that position. Nevertheless, Whitmore and Garner's criteria and their application generate clear patterns that support their position. It seems to me that pattern determination must come first. Once the patterns are known, then attention can be spent on developing hypotheses regarding mechanisms responsible for those patterns.

Oard points out two shortcomings of the K/Pg hypothesis that are perhaps the most difficult to address. 1) He argues that Whitmore and Garner (2008) do not account for the massive amount of sediment eroded from the Eocene Green River Formation (Oard, 2010a), and 2) Wise (2002, pp173-174) does not account for the mammals that should have been buried in the Flood (Oard, 2010b). However, if Wise's later conclusions (2008, 2009) are correct, currently recognizable mammal families are mostly subbaraminic and had not yet diversified at the time of the Flood.

Of course, all models proposed for the end of the Flood have short comings, and I see three short comings, among others, in Oard's position. 1) He assumes very rapid resumption of normal conditions after the Flood (Oard, 2007, 2010a), which *a priori* precludes potential mechanisms to explain the patterns demonstrated by Whitmore and Garner (2008) and Whitmore and Wise (2008). 2) He does not account for stratomorphic series in Cenozoic fossils leading to living species (Oard, 2010b). 3) He does not account for the continuity of the North American mammal fauna or the Australian endemic biota across the proposed "late Cenozoic" Flood/post-Flood boundary (Oard, 2010b; see criticism by Ross, 2012). I believe that the K/Pg hypothesis leads to a greater consilience of data in geology and biology and, therefore, adopt that position in this study.

Consider the implications for the angiosperm fossil record of the biblical record. As the Flood waters transgress the continents to higher elevations, we should see an increasing diversity in the macrofossils as increasing numbers of plant communities or biomes were dislodged and the often dismembered plants settled out or were trapped in falling sediments. There should be some turn over as earliest flooded communities were completely destroyed and later flooded ones took their place or were added to the mix. By the time all communities were dislodged, there should have been a gradual tapering off and stasis of diversity of fossils. Pollen fossils should show a lower diversity but higher amounts per genus because few groups are wind pollinated and only part of those would have been releasing pollen at the time of inundation. The end of the Flood should show a bottle-neck of diversity as the remnant survivor plants sprouted at scattered locations in the fresh surfaces of sediment after regression of the waters. From this point there should have been increasing diversity as new species diversified from ancestors that sprouted after the Flood (even in the face of some extinction in rapidly changing environments). If the regressing flood waters washed much late-Flood sediment onto the continental shelves (as in Oard's position), we would expect the drop in diversity across the Flood/post-Flood boundary to be even more dramatic.

I contend that the expected pattern of diversity above corresponds more closely to fossil patterns seen across the K/Pg boundary rather than a Pliocene/Pleistocene or pre-glacial/glacial boundary. Many extant angiosperm genera (and even species) have a continuous fossil record from at least Pliocene and Upper Miocene strata. For example, Amazonian diversity is continuous from the Miocene to the Upper Pleistocene and Holocene (Colinvaux & De Oliveira, 2001). Furthermore, most of the Cenozoic extinctions of plant genera occur prior to the "late Cenozoic" (e.g., Carrión & Fernández, 2009). If the Miocene and Pliocene represent middle Flood sediments, the minimal extinction and high rate of survival of these mid-Flood fossil groups as living post-Flood groups is problematic. Given the cataclysmic nature of the Flood, it seems unlikely that a majority of genera should have been able to survive it. However, if the Miocene and Pliocene are post-Flood, the data are more easily explained.

As a consequence of a K/Pg end of the Flood, the data suggest complex patterns of pre-Flood diversity and post-Flood survival and diversification for flowering plants. Trees thought by evolutionary biologists to be primitive, such as those in tropical forests and temperate wind-pollinated ones, are in surprising diversity in Flood rocks, as well as early post-Flood strata. For example, several modern genera of Betulaceae, Fagaceae, Juglandaceae, Ulmaceae, Sterculiaceae, Euphorbiaceae, Rosaceae, Icacinaceae, Proteaceae, and Palmae have a CFR. Moreover, a number of small families such as Cercidiphyllaceae and Platanaceae had greater diversity of genera before the Flood that did not survive (Paleobiology Database Website). Predominantly herbaceous families conventionally thought to be advanced mostly do not have a CFR, being subbaraminic in suborders or orders that are represented in Flood or early post-Flood strata by one genus or a few genera that are often extinct. Many other CFR families are represented by a single CFR genus or likewise are in a suborder or order that is represented by a single CFR genus.

CONCLUSIONS

There are a number of problems encountered when estimating limits of flowering plant baramins by applying the PFCC as developed for use with mammals. As a result, the criterion was modified by incorporating a better understanding of 1) the fossilization potential of angiosperms in relation to size of families in number of species and 2) sister-group relationships in recent classifications. This lowers the level of baramin to mostly families (and suborders) from superorders and orders that are obtained using the strict application of the PFCC. Thus, the MPFCC corroborates baraminic analyses using other methods, including hybridization potential and statistical morphometric baraminology. These results also support the suggestion that the taxonomic level at which a group's genomic similarity and morphological similarity become discordant is likely the boundary of that baramin. Even so, there still remain a number of uncertainties, such as 1) whether the consulted sources sufficiently and accurately represent the known fossil record, 2) why the fossil record of angiosperms is so meager at the species and generic level, 3) whether species numbers is an appropriate index of fossilization potential, and 4) whether means other than relying on evolutionarily based classifications can be found. These uncertainties make it clear that the data presented here are insufficient to draw baraminic boundaries without corroboration with other lines of baraminic analysis. Also the application of the MPFCC is influenced by the geologic placement that one accepts for the end of the Flood. Stratigraphic positions of discontinuities versus continuities in the angiosperm fossil record appear to support the K/Pg boundary, which as been developed on geologic criteria, as the model for the Flood/post-Flood boundary. Thus, the results based on the MPFCC and this geologic model suggests that baramins vary as to their taxonomic level and to the degrees of intrabaraminic diversity prior to and diversification since the Flood. Future work will seek to improve the compilation of fossils from the literature and include subfamilies and tribes to determine if there is evidence that the PFCC/MPFCC should apply below the family level. The baramins identified in this way should also be compared to data from the discordance of genomic similarity with morphological similarity.

ACKNOWLEDGMENTS

I thank Todd C. Wood for encouragement to pursue this study, students in Bryan College's introductory research course for compiling much of the data into analyzable form, and three anonymous reviewers for suggesting improvements.

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APPENDIX

Living angiosperm MPFCC baramins (those identified using a Modified Post-flood Continuity Criterion) are listed with bold font in Takhtajan's (1980) and the APG (Stevens, 2001 onwards; Soltis *et al*., 2005; Reveal, 2012) classification systems. The list for each system provides a maximum number of baramins that can be tentatively identified with the data readily accessible currently. Underlined taxa have a documented CFR. Small families lacking a documented CFR but that are sisters to families with a documented CFR are assumed to have a poor fossil record and assigned a potential CFR; if qualifying as a baramin (see text), they are marked in bold but not underlined; if they are subbaraminic, they are in normal font marked with a tilde. Baramins marked with an asterisk lack a CFR but are accepted because their sister-groups (within their respective systems) qualify as baramins by having a CFR. In orders or suborders qualifying as baramin in this way but containing a single family, the baramin is assigned to the family, not the higher rank. The gaps in the APG system are intended to allow for closer alignment with comparable groups in Takhtajan's system

Takhtajan (Morphological) System

- **Subclass**
  - **Superorder**
    - **Order**
      - **Suborder**
        - **Family**

- Magnoliidae
  - Magnolianae
    - Magnoliales
      - Magnoliineae
        - **Degeneriaceae**
        - **Eupomatiaceae**
        - **Himantandraceae**
        - **Magnoliaceae**
      - Annonineae
        - **Annonaceae**
        - **Canellaceae**
        - **Myristicaceae**
      - Winterineae
        - **Winteraceae**
    - Illiciales
      - **Illiciaceae**
      - **Schisandraceae**
    - Laurales
      - Monimineae
        - **Austrobaileyaceae**
        - **Amborellaceae**
        - **Trimeniaceae**
        - **Monimiaceae**
        - **Gomortegaceae**
        - **Calycanthaceae**
        - **Idiospermaceae**
      - Chloranthineae
        - **Chloranthaceae**
        - **Lactoridaceae**
      - Laurineae

APG (Molecular) System

- **Superorder**
  - **Order**
    - **Suborder**
      - **Family**

- Amborellanae
  - Amborellales
    - **Amborellaceae**
- Nymphaeanae
  - Nymphaeales
    - **Cabombaceae**
    - **Nymphaeaceae**
- Austrobaileyanae
  - Austrobaileyales
    - **Austrobaileyaceae**
    - **Trimeniaceae**
    - **Illiciaceae**
    - **Schisandraceae**
  - Chloranthales
    - **Chloranthaceae**
- Magnolianae
  - Magnoliales
    - **Myristicaceae**
    - **Magnoliaceae**
    - **Degeneriaceae**
    - **Himantandraceae**
    - **Eupomatiaceae**
    - **Annonaceae**
  - Laurales
    - **Calycanthaceae**
    - **Idiospermaceae**
    - **Gomortegaceae**
    - **Hernandiaceae**
    - **Monimiaceae**
    - **Lauraceae**

- **Lauraceae**
- **Hernandiaceae**
- **Piperales**
- Saururaceae
- Piperaceae
- Aristolochiales
- **Aristolochiaceae**
- Rafflesianae
- **Rafflesiales***
- Hydnoraceae
- Rafflesiaceae

- Nymphaeanae
- Nymphaeales
- Nymphaeineae
- **Cabombaceae**
- **Nymphaeaceae**
- Ceratophyllineae
- **Ceratophyllaceae**
- **Nelumbonaceae**
- Alismatidae
- Alismatanae
- Alismatales
- Alismatineae
- **Butomaceae**
- **Limnocharitaceae**
- **Alismataceae**
- Hydrocharitineae
- **Hydrocharitaceae**
- Najadales
- Aponogetonineae
- **Aponogetonaceae**
- Scheuchzeriineae
- **Scheuchzeriaceae**
- Potamogetonineae
- **Juncaginaceae**
- **Potamogetonaceae**
- **Zannichelliaceae**
- Zosterineae
- **Zosteraceae**
- Najadineae
- **Najadaceae**
- Liliidae
- Triuridanae
- Triuridales
- **Triuridaceae**
- Lilianae
- **Liliales**
- Liliineae
- Melanthiaceae~
- Liliaceae
- Amaryllidaceae~
- Phormiaceae~
- Agavacea~
- Asphodelineae
- Asphodelaceae

- Canellales
- **Winteraceae**
- **Canellaceae**
- **Piperales**
- Saururaceae
- Piperaceae
- Lactoridaceae
- Aristolochiaceae
- Hydnoraceae~

- Lilianae
- Arales
- **Araceae**
- **Lemnaceae**
- Alismatales
- **Alismataceae**
- **Limnocharitaceae**
- **Butomaceae**
- **Hydrocharitaceae**
- **Najadaceae**
- Potamogetonales
- **Scheuchzeriaceae**
- **Aponogetonaceae**
- **Juncaginaceae**
- **Zannichelliaceae**
- **Zosteraceae**
- **Potamogetonaceae**
- **Dioscoreales***
- Taccaceae
- Burmanniaceae
- Thismiaceae
- Dioscoreaceae
- Pandanales
- **Triuridaceae**
- **Velloziaceae**
- **Stemonaceae**
- **Cyclanthaceae**
- **Pandanaceae**
- Liliales
- Alstroemeriineae
- **Melanthiaceae**
- Liliineae
- **Liliaceae**
- **Trilliaceae**
- Smilacineae
- **Philesiaceae**
- **Smilacaceae**

Asparagineae
Asparagaceae
Nolinaceae
Iridineae
Iridaceae
Haemodorineae
Haemodoraceae
Velloziaceae
Pontderiineae
Pontederiaceae
Philydrineae
Philydraceae
Smilacales
Philesiaceae~
Stemonaceae~
Trilliaceae~
Smilacaceae
Dioscoreaceae
Taccaceae~
Burmanniales*
Burmanniaceae
Thismiaceae
Orchidales
Orchidaceae*
Bromeliales
Bromeliaceae*
Juncanae
Juncales
Juncaceae
Cyperales
Cyperaceae
Commelinanae
Commelinales*
Xyridineae
Rapateaceae
Xyridaceae
Commelinineae
Commelinaceae
Mayacaceae
Eriocaulales
Eriocaulaceae*
Restionales
Flagellariaceae
Joinvilleaceae
Restionaceae
Poales
Poaceae/Gramineae
Zingiberanae
Zingiberales
Strelitziaceae
Musaceae
Heliconiaceae
Zingiberaceae
Cannaceae
Marantaceae
Arecidae

Orchidales
Orchidaceae*
Asparagales
Iridineae
Iridaceae
Asphodelineae
Phormiaceae
Asphodelaceae
Hyacinthineae
Amaryllidaceae
Agavaceae
Asparagineae
Asparagaceae
Nolinaceae
Bromeliales
Bromeliaceae*
Rapateales
Rapateaceae
Xyridales*
Eriocaulaceae
Xyridaceae
Mayacaceae
Juncales
Juncaceae
Cyperaceae
Restionales
Restionaceae
Poales
Flagellariaceae
Joinvilleaceae
Poaceae/Gramineae
Commelinales*
Commelinaceae
Philydraceae
Haemodoraceae
Pontederiaceae
Zingiberales
Strelitziineae
Strelitziaceae
Musineae
Musaceae
Heliconiineae
Heliconiaceae
Cannineae*
Cannaceae
Marantaceae
Zingiberineae
Zingiberaceae
Arecales
Arecaceae/Palmae
Typhales
Typhaceae
Sparganiaceae

- Arecanae
  - Arecales
    - **Arecaceae/Palmae**
  - Cyclanthales
    - **Cyclanthaceae**
  - Pandanales
    - **Pandanaceae**
  - Typhales
    - **Typhaceae**
    - **Sparganiaceae**
- Aranae
  - Arales
    - **Araceae**
    - **Lemnaceae**

- Ranunculidae
  - Ranunculanae
    - **Ranunculales**
      - Lardizabalaceae~
      - Menispermaceae
      - Berberidaceae
      - Ranunculaceae
    - **Papaverales***
      - Papaveraceae
      - Fumariaceae
    - Sarraceniales
      - **Sarraceniaceae**
- Hamamelidae
  - Hamamelidanae
    - Trochodendrales
      - **Trochodendraceae**
      - **Tetracentraceae**
    - Cercidiphyllales
      - **Cercidiphyllaceae**
    - Eupteleales
      - **Eupteleaceae**
    - Didymelales
      - **Didymelaceae**
    - Hamamelidales
      - Hamamelidineae
        - **Hamamelidaceae**
        - **Altingiaceae**
        - **Platanaceae**
        - **Daphniphyllaceae**
      - Buxineae
        - **Buxaceae**
    - Eucommiales
      - **Eucommiaceae**
    - Urticales
      - Ulmineae
        - **Ulmaceae**
      - Urticineae
        - **Moraceae**
        - **Cannabidaceae**
        - **Urticaceae**
    - Barbeyales
      - **Barbeyaceae**

- Ceratophyllanae
  - Ceratophyllales
    - **Ceratophyllaceae**
- Ranunculanae
  - Eupteleales
    - **Eupteleaceae**
  - Ranunculales
    - **Ranunculineae**
      - Lardizabalaceae~
      - Menispermaceae
      - Berberidaceae
      - Ranunculaceae
    - **Papaverineae***
      - Papaveraceae
      - Fumariaceae
- Proteanae
  - Sabiales
    - **Sabiaceae**
    - **Meliosmaceae**
  - Proteales
    - Nelumbonineae
      - **Nelumbonaceae**
    - Platanineae
      - **Platanaceae**
    - Proteineae
      - **Proteaceae**
  - Trochodendrales
    - **Trochodendraceae**
    - **Tetracentraceae**
- Buxanae
  - Buxales
    - **Didymelaceae**
    - **Buxaceae**
- Myrothamnanae
  - Gunnerales
    - **Gunneraceae**
- Dillenianae
  - Dilleniales
    - **Dilleniaceae**
- Saxifraganae
  - Peridiscales
    - **Medusandraceae**
  - Hamamelidales
    - Paeoniineae
      - **Paeoniaceae**

- Casuarinales
      - **Casuarinaceae**
- Fagales
  - Fagineae
      - **Fagaceae**
  - Betulineae
      - **Betulaceae**
- Balanopales
      - **Balanopaceae**
- Leitneriales
      - **Leitneriaceae**

Juglandanae

- Myricales
      - **Myricaceae**
- Juglandales
      - **Rhoipteleaceae**
      - **Juglandaceae**

Rosidae

- Rosanae
  - Saxifragales
    - **Cunoniineae**
      - Brunelliaceae~
      - Cunoniaceae
      - Eucryphiaceae~
    - **Pittosporineae***
      - Escalloniaceae
      - Brexiaceae
      - Iteaceae
      - Hydrangeaceae
      - Roridulaceae
      - Pittosporaceae
      - Bruniaceae
      - Alseuosmiaceae
    - **Saxifragineae**
      - Saxifragaceae
      - Crassulaceae
      - Grossulariaceae~
      - Droseraceae
      - Gunneraceae
  - Rosales
      - **Rosaceae**
      - **Chrysobalanaceae**
      - **Fabaceae/Leguminosae**
  - Connarales
      - **Connaraceae**
  - Podostemales
      - **Podostemaceae**
  - Nepenthales
      - **Nepenthaceae**
- Myrtanae
  - Myrtales
    - Myrtineae
      - **Crypteroniaceae**
      - **Lythraceae**
      - **Melastomataceae**
      - **Myrtaceae**

- Hamamelidineae
  - **Altingiaceae**
  - **Hamamelidaceae**
  - **Cercidiphyllaceae**
  - **Daphniphyllaceae**

Saxifragales

- Crassulaceae
- Haloragidaceae
- Iteaceae~
- Grossulariaceae~
- Saxifragaceae

Rosanae

- Vitidales
      - **Vitaceae**
      - **Leeaceae**
- **Zygophyllales***
      - Krameriaceae
      - Zygophyllaceae
- Fabales
      - **Fabaceae/Leguminosae**
      - **Surianaceae**
      - **Polygalaceae**
- Rosales
      - **Rosaceae**
- Rhamnales
      - **Barbeyaceae**
      - **Rhamnaceae**
      - **Elaeagnaceae**
- Urticales
      - **Ulmaceae**
      - **Cannabidaceae**
      - **Moraceae**
      - **Urticaceae**
- Juglandales
      - **Fagaceae**
      - **Myricaceae**
      - **Juglandaceae**
      - **Rhoipteleaceae**
      - **Casuarinaceae**
      - **Betulaceae**
- Cucurbitales
  - Cucurbitineae
      - **Coriariaceae**
      - **Cucurbitaceae**
  - **Begoniineae**
      - Datiscaceae
      - Begoniaceae
- Celastrales
      - **Brexiaceae**
      - **Celastraceae**
- Oxalidales
      - **Connaraceae**
      - **Oxalidaceae**
      - **Cunoniaceae**
      - **Eucryphiaceae**
      - **Elaeocarpaceae**
      - **Brunelliaceae**

- **Combretaceae**
- **Onagraceae**
- **Trapaceae**
- Haloragineae
  - **Haloragidaceae**
- Rhizophorineae
  - **Rhizophoraceae**
- Lecythidineae
  - **Lecythidaceae**
- Rutanae
  - Rutales
    - Rutineae
      - **Rutaceae**
      - **Simaroubaceae**
      - **Surianaceae**
      - **Zygophyllaceae**
      - **Meliaceae**
      - **Burseraceae**
      - **Anacardiaceae**
      - **Julianaceae**
    - Coriariineae
      - **Coriariaceae**
  - Sapindales
    - **Staphyleaceae**
    - **Sapindaceae**
    - **Aceraceae**
    - **Hippocastanaceae**
    - **Batidaceae**
    - **Sabiaceae**
    - **Meliosmaceae**
  - Geraniales
    - Linineae
      - **Ctenolophaceae**
      - **Linaceae**
      - **Erythroxylaceae**
    - **Geraniineae**
      - Oxalidaceae
      - Geraniaceae
    - **Balsaminineae***
      - Balsaminaceae
      - Tropaeolaceae
    - Limnanthineae
      - **Limnanthaceae**
  - **Polygalales**
    - Malpighiaceae
    - Vochysiaceae~
    - Polygalaceae
    - Krameriaceae~
- Aralianae
  - Cornales
    - **Nyssaceae**
    - **Alangiaceae**
    - **Cornaceae**
    - **Garryaceae**
  - Araliales
    - **Araliaceae**

- **Violales**
  - Violaceae
  - Turneraceae
  - Passifloraceae
  - Flacourtiaceae
  - Salicaceae
- Rhizophorales
  - **Ctenolophaceae**
  - **Erythroxylaceae**
  - **Rhizophoraceae**
- **Linales***
  - Linaceae
  - Pandaceae
- **Ochnales***
  - Ochnaceae
  - Medusagynaceae
  - Quiinaceae
- Hypericales
  - **Clusiaceae**/**Guttiferae**
  - **Podostemaceae**
- **Malpighiales***
  - Elatinaceae
  - Malpighiaceae
- Euphorbiales
  - **Rafflesiaceae**
  - **Euphorbiaceae**
  - **Picrodendraceae**
- **Chrysobalanales***
  - Balanopaceae
  - Dichapetalaceae
  - Chrysobalanaceae
  - Caryocaraceae
- Geraniales
  - **Geraniaceae***
- Myrtanae
  - Myrtales
    - Onagrineae
      - **Combretaceae**
      - **Onagraceae**
      - **Lythraceae**
      - **Trapaceae**
    - Myrtineae
      - **Vochysiaceae**
      - **Myrtaceae**
    - Melastomatineae
      - **Melastomataceae**
      - **Crypteroniaceae**
  - **Crossosomatales***
    - Staphyleaceae
    - Stachyuraceae
    - Crossosomataceae

Apiaceae/Umbelliferae

- Celastranae
  - Celastrales
    - Icacinineae
        - **Icacinaceae**
        - **Aquifoliaceae**
        - **Medusandraceae**
    - Celastrineae
        - **Celastraceae**
  - Santalales
    - Santalineae
        - **Olacaceae**
        - **Santalaceae**
    - Loranthineae
        - **Loranthaceae**
        - **Viscaceae**
  - Balanophorales
        - **Balanophoraceae**
  - Rhamnales
        - **Rhamnaceae**
        - **Vitaceae**
        - **Leeaceae**
  - Elaeagnales
        - **Elaeagnaceae**
- Proteanae
  - Proteales
        - **Proteaceae**
- Caryophyllidae
  - Caryophyllanae
    - Caryophyllales
      - **Phytolaccineae**
        - Phytolaccaceae
        - Nyctaginaceae
        - Aizoaceae
        - Cactaceae
        - Portulacaceae~
        - Basellaceae~
        - Didiereaceae~
      - **Caryophyllineae***
        - Molluginaceae
        - Caryophyllaceae
      - Chenopodiineae
        - **Amaranthaceae**
        - **Chenopodiaceae**
    - Polygonales
        - **Polygonaceae**
    - Plumbaginales
        - **Plumbaginaceae***
- Dilleniidae
  - Dillenianae
    - Dilleniales
        - **Dilleniaceae**
        - **Crossosomataceae**
    - Paeoniales
        - **Paeoniaceae**
    - Sapindales
      - Sapindineae
        - **Anacardiaceae**
        - **Julianaceae**
        - **Burseraceae**
        - **Hippocastanaceae**
        - **Aceraceae**
        - **Sapindaceae**
      - **Rutineae**
        - Rutaceae
        - Meliaceae
        - Leitneriaceae
        - Simaroubaceae
    - Malvales
      - Thymelaeineae
        - **Thymelaeaceae**
      - Cochlospermineae
        - **Cochlospermaceae**
        - **Bixaceae**
      - Cistineae
        - **Cistaceae**
        - **Dipterocarpaceae**
      - Malvineae
        - **Sterculiaceae**
        - **Tiliaceae**
        - **Bombacaceae**
        - **Malvaceae**
    - **Capparales**
        - Tropaeolaceae~
        - Moringaceae
        - Caricaceae
        - Limnanthaceae~
        - Koeberliniaceae
        - Batidaceae
        - Resedaceae~
        - Capparaceae
        - Brassicaceae/Cruciferae
  - Berberidopsidanae
    - Berberidopsidales
        - **Aextoxicaceae**
  - Santalanae
    - Santalales
        - **Olacaceae**
        - **Loranthaceae**
        - **Santalaceae**
        - **Viscaceae**
    - Balanophorales
        - **Balanophoraceae**
  - Caryophyllanae
    - **Polygonales**
        - Plumbaginaceae
        - Polygonaceae
    - Nepenthales
        - **Droseraceae**
        - **Nepenthaceae**

- **Theales**
  - Ochnaceae
  - Theaceae
  - Caryocaraceae~
  - Marcgraviaceae~
  - Quiinaceae~
  - Medusagynaceae~
  - Clusiaceae/Guttiferae
  - Elatinaceae~
- Violales
  - **Violineae**
    - Flacourtiaceae
    - Passifloraceae
    - Stachyuraceae~
    - Violaceae
    - Bixaceae~
    - Cochlospermaceae
    - Cistaceae~
    - Turneraceae~
    - Caricaceae~
  - Cucurbitineae
    - **Cucurbitaceae**
- **Begoniales**
  - Datiscaceae
  - Begoniaceae
- **Capparales**
  - Capparineae
    - Capparaceae
    - Koeberliniaceae~
    - Brassicaceae/Cruciferae
  - Resedineae
    - Resedaceae
  - Moringineae
    - Moringaceae
- **Tamaricales***
  - Tamaricineae
    - Frankeniaceae
    - Tamaricaceae
  - Fouquierineae
    - Fouquieriaceae
- Salicales
  - **Salicaceae**

Ericanae

- Ericales
  - **Actinidiaceae**
  - **Clethraceae**
  - **Ericaceae**
  - **Empetraceae**
  - **Epacridaceae**
  - **Diapensiaceae**
  - **Cyrillaceae**
- Ebenales
  - Styracineae
    - **Styracaceae**
    - **Symplocaceae**
  - Ebenineae

- **Tamaricales***
  - Frankeniaceae
  - Tamaricaceae
- Caryophyllales
  - Caryophyllineae
    - **Caryophyllaceae***
  - Chenopodiineae
    - **Chenopodiaceae**
    - **Amaranthaceae**
  - **Nyctagininеae**
    - Aizoaceae
    - Nyctaginaceae
    - Phytolaccaceae
  - **Portulacineae***
    - Molluginaceae
    - Basellaceae
    - Didiereaceae
    - Portulacaceae
    - Cactaceae

Cornanae

- Cornales
  - **Nyssaceae**
  - **Alangiaceae**
  - **Cornaceae**
  - **Hydrangeaceae**
  - **Loasaceae**
  - **Hydrostachydaceae**

Ericanae

- Ericales
  - **Balsamininеae***
    - Balsaminaceae
    - Marcgraviaceae
  - **Polemoniineae***
    - Polemoniaceae
    - Fouquieriaceae
  - Scytophtalineae
    - **Lecythidaceae**
  - **Primulineae**
    - Sapotaceae
    - Ebenaceae
    - Theophrastaceae~
    - Myrsinaceae
    - Primulaceae
  - Theineae
    - **Theaceae**
    - **Symplocaceae**
    - **Styracaceae**
    - **Diapensiaceae**
  - Sarraceniineae
    - **Sarraceniaceae**
    - **Actinidiaceae**
    - **Roridulaceae**
  - Ericineae
    - **Clethraceae**
    - **Cyrillaceae**
    - **Ericaceae**

- **Ebenaceae**
- **Sapotaceae**
- **Primulales**
  - Myrsinaceae
  - Theophrastaceae~
  - Primulaceae
- Malvanae
  - Malvales
    - **Elaeocarpaceae**
    - **Tiliaceae**
    - **Sterculiaceae**
    - **Bombacaceae**
    - **Malvaceae**
    - **Dipterocarpaceae**
  - Euphorbiales
    - **Euphorbiaceae**
    - **Picrodendraceae**
    - **Pandaceae**
    - **Dichapetalaceae**
    - **Aextoxicaceae**
  - Thymelaeales
    - **Thymelaeaceae**
- Asteridae
  - Gentiananae
    - **Gentianales**
      - Loganiaceae
      - Rubiaceae
      - Theligonaceae~
      - Apocynaceae
      - Asclepiadaceae
      - Gentianaceae
      - Menyanthaceae~
    - Oleales
      - **Oleaceae**
    - Dipsacales
      - **Caprifoliaceae**
      - **Adoxaceae**
      - **Valerianaceae**
      - **Dipsacaceae**
    - Loasales
      - **Loasaceae**
  - Lamianae
    - Polemoniales
      - Convolvulineae
        - **Convolvulaceae**
      - Polemoniineae
        - **Polemoniaceae**
      - Boraginineae
        - **Hydrophyllaceae**
        - **Boraginaceae**
        - **Lennoaceae**
    - **Lamiales**
      - Verbenaceae
      - Avicenniaceae~
      - Phrymataceae~
      - Lamiaceae/Labiatae

- **Empetraceae**
- **Epacridaceae**
- Lamianae
  - Garryales
    - **Garryaceae**
    - **Eucommiaceae**
    - **Icacinaceae**
  - **Gentianales**
    - Rubiaceae
    - Theligonaceae~
    - Gentianaceae
    - Loganiaceae
    - Apocynaceae
    - Asclepiadaceae
  - Solanales
    - **Solanineae**
      - Convolvulaceae
      - Solanaceae
      - Nolanaceae~
    - Boraginineae
      - **Hydrophyllaceae**
      - **Boraginaceae**
      - **Lennoaceae**
  - Lamiales
    - Oleineae
      - **Oleaceae**
    - **Gesneriineae***
      - Tetrachondraceae
      - Gesneriaceae
    - **Lamiineae**
      - Callitrichaceae
      - Globulariaceae
      - Plantaginaceae
      - Hippuridaceae
      - Buddlejaceae
      - Scrophulariaceae
      - Myoporaceae
      - Lamiaceae/Labiatae
      - Phrymataceae
      - Orobanchaceae
      - Verbenaceae
      - Pedaliaceae~
      - Martyniaceae~
      - Bignoniaceae
      - Avicenniaceae~
      - Acanthaceae
      - Lentibulariaceae~

- Tetrachondraceae~
- Callitrichaceae~
- **Scrophulariales**
  - Solanineae
    - Solanaceae
    - Nolanaceae
  - Scrophulariineae
    - Buddlejaceae~
    - Scrophulariaceae
    - Globulariaceae~
    - Bignoniaceae
    - Pedaliaceae~
    - Martyniaceae~
    - Orobanchaceae~
    - Gesneriaceae
    - Plantaginaceae~
    - Lentibulariaceae~
    - Myoporaceae~
    - Acanthaceae
    - Hydrostachydaceae~
  - Hippurineae
    - Hippuridaceae~
- Asteranae
  - **Campanulales***
    - Campanulineae
      - Campanulaceae
    - Goodeniineae
      - Goodeniaceae
      - Brunoniaceae
  - Calycerales
    - **Calyceraceae**
  - Asterales
    - **Asteraceae**/**Compositae**

- Asteranae
  - Aquifoliales
    - **Aquifoliaceae**
  - Asterales
    - Alseuosmiineae
      - **Alseuosmiaceae**
    - Campanulineae
      - **Campanulaceae***

    - Asterineae
      - **Menyanthaceae**
      - **Goodeniaceae**
      - **Brunoniaceae**
      - **Calyceraceae**
      - **Asteraceae**/**Compositae**
  - Escalloniales
    - **Escalloniaceae**
  - Bruniales
    - **Bruniaceae**
  - Apiales
    - **Pittosporaceae**
    - **Araliaceae**
    - **Apiaceae**/**Umbelliferae**
  - **Dipsacales**
    - Adoxaceae~
    - Caprifoliaceae
    - Dipsacaceae
    - Valerianaceae