Supplementary Materials for

Reproductive innovations and pulsed rise in plant complexity

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Supplemental Materials and Methods

Data collection and sampling

We scored extant and well-preserved fossil reproductive structures for a set of complexity characters (full list provided in 'Character Data Analysis' below) based on personal observations from herbarium specimens housed at Kew Gardens, Harvard University Herbaria, and Brown University, and published literature. To compile this data set, we typically sampled one representative species per genus; we used this approach to maintain more consistent sampling across fossil and extant groups, as the fossil record includes many monotypic and singleton genera. Exceptions to this include genera with a long stratigraphic range (where we sampled one representative species per geologic epoch in order to build a more complete time series), paleobotanical form genera (which are morphologically similar but do not necessarily belong to the same biological lineage), and genera with known variation in morphology; in each of these cases, we included multiple representatives of genera in our data set. For taxa that produced separate microsporiangiate/pollen and megasporangiate/seed structures (e.g., staminate and pistillate flowers), we scored each structure individually. In total, our fossil dataset includes 930 reproductive structures from 866 taxa spanning the Middle Silurian to the Pliocene, although we focused our attention on Paleozoic and Mesozoic taxa as most Cenozoic taxa belong to extant genera and their complexity is captured by the modern data set. The Cenozoic plant fossil record is also generally poorer with regards to well-preserved flowers than the Cretaceous, reflecting the general absence of charcoalified specimens which provide much of the well-preserved record in earlier time periods.

For extant vascular plants, we included representative species from nearly all genera except those from two highly diverse clades, filicalean ferns (~10,000 species [*36*]) and angiosperms (~350,000 species [*37*]). For angiosperms in particular, our sampling scheme was more targeted than that of other clades because of the difficulty in fully sampling such a diverse group; we included representative species from early diverging ANA-grade angiosperms at the genus level and from magnoliids at the family level using a variety of sources (full sources provided in data available on Dryad: https://doi.org/10.5061/dryad.w0vt4b8qx), but for hyperdiverse monocot and eudicot clades we primarily used a taxonomic compilation (*38*) that illustrates relevant aspects of floral morphology from selected major families. In some cases, we supplemented this source with personal observations and more focused studies on gynoecium/ovule structure. We also specifically sampled major wind-pollinated clades (e.g., Fagaceae, Poaceae) among monocots and eudicots to assess if complexity varied with pollination syndrome, although for consistency with angiosperm sampling in general we sampled only one representative species per family. We also scored extant seed plants, whether gymnosperm or angiosperm, as exhibiting either strictly abiotic (wind or water mediated) or biotic (partially or fully mediated by animal vectors) pollination. In all, we analyzed 574 extant reproductive structures from 472 taxa.

Complexity Characters

Character Scoring

We analyzed morphological complexity by scoring reproductive structures for two basic components: the number of types of sporangia (including the sporangia of homosporous plants, microsporangia in heterosporous free-sporing plants and pollen sacs in seed plants, and megasporangia heterosporous free-sporing plants and the nucellus+megagametophyte in seed plants]) and the number of morphological element types (METs), which is our method of defining the types of basic parts in a reproductive structure. We then scored each of these components for six additional characters (full list provided in the following section) that record the degree to which these elements are reiterated to form the total reproductive structure. Given that our scoring and analysis of METs are the key feature of this study, we first discuss our approach to scoring METs.

We define METs as basic geometric elements that can be combined to form a reproductive structure. A reproductive structure is here defined as consisting of various kinds of sporangia and all METs that occur between them and vegetative tissue such as leaves or vegetative axes. We consider supporting axes such as cone axes, flower stalks/pedicels, or inflorescence axes to be part of the reproductive structure, even if they are continuous with vegetative branches, if they strictly produce fertile organs and are not interspersed with vegetative organs. To tally the number of METs, we begin by identifying the basic reiterated organ-level structures that are present (such as bracts, sporophylls, cone scales, ovules, carpels, stamens, etc) that subtend, support, or are associated with sporangia. We then ask if these major parts are further differentiated into distinct subregions based on differences in shape; for example, a carpel in a flowering plant may be differentiated into an ovoid ovary, an elongate style, and a flared stigmatic region. These subregions would be considered separate METs. Other examples of subregions considered METs include various stalks, lobes, teeth, and phlanges on organs such as sporophylls, cupules, or petals. If an organ-level structure is not differentiated into subparts, as in a simple petal or leaf-like bract, it is considered a single MET. In addition to METs, we also tallied the total number of types of organ-level structures ("basic structural units", or BSUs) as an alternative way to score morphological complexity (see below). Morphological features related to sporangia themselves, such as annuli or nucellar features, were not considered in this study, although ovule parts (e.g., integuments, micropylar morphology) were because they are morphological elements located between sporangia and vegetative tissue.

We identify METs entirely by morphology and geometry without considering organ identity or homology. We used this approach because homology is often difficult to assess, or even nonexistent, across the reproductive structures of major plant groups (see discussion in 'Supplemental Text' below); defining part types based on homology would not allow for a comparison among disparate plant lineages. It is also important to emphasize that our approach treats all identifiable geometric parts of the reproductive structure equally; we do not specify which of the METs are most important in defining the overall form of the reproduction structure or in its basic functionality. Although this may introduce a degree of inflation in the overall count of part types, it is important that our data scoring remains agnostic with regards to assigning the relative importance or functional significance of any given MET, especially when including fossil data where the exact functional role of every part is not known. We also note that this follows practices from previous complexity studies regarding counts of parts or of cell types (*17*), which do not weight part numbers by their relative importance.

Scoring METs across all vascular plant reproductive structures is somewhat more straightforward than might be imagined, because plants are modular organisms that mostly consist of distinct, reiterated subunits (see *30*). Neverthless, incorporating variation and variability that does exist within reproductive structures in a non-arbitrary way is a significant challenge for consistently scoring METs across taxa. In our aproach, we incorporate two major types of variability into our definition and scoring of METs: ontogenetic variation and continuous gradation in form.

The overall morphology of plant reproductive structures, including their basic complement of parts, may change over ontogeny; for example, flowers typically shed petals and stamens as they mature into fruits. Our MET scoring reflects the sum total of parts over ontogeny, and we include morphologically distinct structures as separate METs regardless of when they occur in development. For example, the ovules of Cupressaceae conifers at pollination typically consist of a single organ (the integument) which is differentiated into two parts, or METs: a main enclosing body and a distinct micropylar funnel. As the ovule matures into a seed, the funnel may be obliterated by the continued growth of the integument body, which in many taxa also develops a lateral outgrowth wing region for aerial dispersal of the seeds. This growth sequence results in a total of three discrete morphological regions (i.e., METs) that exist at various developmental stages: the main integumentary body/seed coat enclosing the megasporangium, the micropylar funnel, and the seed wing.

Morphological variation within METs is a second major source of difficulty for consistent scoring. For example, flowers may show a smooth gradiation from sepaloid to petaloid tepals; should these be scored as one or two METs? In this study, we were primarily interested in recording morphological differentiation into discrete parts; we therefore scored individual structures or organs that showed continuous gradation in form as one MET because they do not show complete differentiation. For example, many angiosperm inflorescences and some gymnosperm pollen-producing structures (e.g., *Nageia* in Podocarpaceae or *Ephedra* in Gnetales) consist of fertile branching systems that produces bracts of slightly different sizes at different positions in the system. Although the bract at each branching node could potentially be scored as a different MET, we scored them as variation within one part type because they lacked clear morphological differentiation (both in terms of size and shape; see also discussion of the first and second integument in angiosperms in the 'Angiosperms' section of the Supplemental Data). Our approach towards variability is consistent with a generally conservative approach in scoring of METs; for example, we did not score small, irregular morphological features within a single structure or organ, such as small undulations, as separate METs.

It should be noted that the issue of continuous gradation was particularly problematic for Devonian taxa, whose reproductive structures (at least among euphyllophytes) often consist of ramifiying branch systems bearing terminal sporangia (Fig. S1). These structures are simple in their basic construction but are difficult to score in a manner consistent with later reproductive structures because they bear no lateral organs that help to discretize and organize them (for a human observer at least). For these Devonian taxa, each branching order could theoretically be considered as a separate MET. But following our general approach to variability, we treated all axial elements in these dichotomous systems (as well as rachides in phenotypically analogous fertile pinnate systems in ferns) as a single, repeated MET because they show a gradual decrease in diameter from proximal to distal elements (Fig. S1A). Scoring the degree of clustering in these systems was also challenging because defining discrete clusters of dichotomizing branches can be difficult. In general, simple dichotomizing branch systems were scored as exhibiting one level of repetition involving the sporangium and its subtending axial or rachis element (Fig. S1A). This effectively removes proximal branching elements from being scored, but this is irrelevant given that these are here considered the same MET as the distal branch tips. For Devonian taxa with a dichotomizing fertile branch system but with strongly anisotomous branching and a clear main axis (Fig. S1B), we scored lateral branches as forming clusters of sporangia and axial elements, although we did not score the main axis as a separate MET unless it was much larger in diameter (≥3 times diameter) than the lateral branches (Fig. S1C). As a general rule, we recognized different branching orders as distinct METs if they were significantly different in size or in the types of organs that they produced. For example, the leafy fertile dwarf shoot axes of Cordaitales and early walchian conifers were considered distinct METs from the main strobilius axis because they bear different structures and are quite different in diameter.

Lastly, although the fusion of parts is an important aspect of the evolution of complexity, we did not specify fusion in our charater scoring because it usually requires an interpretation and polarization of how organs have evolved. Again, we simply treated all structures as geometric parts; if two organs were completely fused into a single structure, we scored that structure as a single MET. For example, if multiple carpels were fused into a single ovary, the ovary would score as a single MET (although locule walls formed by individual carpel walls still score as a separate METs). Fused sporangia (synangia) are also common in reproductive structures; we generally treated synangia simply as sporangia and did not score them as containing separate METs unless synangia also possessed distinctive sterile tissues, such as a stalk or differentiated groundmass tissue that was separate from sporangial walls (see discussion of the Marattiales in Supplemental Data).

Regardless of our attempts at consistency, the diversity of plant reproductive structures precludes an entirely uniform and objective character scoring scheme. We encourage interested readers to explore our MET scoring (which is available in descriptive form as Supplementary Data and in table form online at Dryad: https://doi.org/10.5061/dryad.w0vt4b8qx) and rescore taxa in line with their expertise if they wish to explore the effects of different morphological interpretations on basic complexity patterns. But as a test of whether our basic results were driven by idiosyncractic or biased MET scoring, we also scored taxa using an alternative approach to characterizing morphological complexity. For this approach, we returned to our initial assessment of the basic organ-level parts in reproductive structures. We termed these 'basic structural units' (BSUs), and we tallied how many were present in a given reproductive structure. or example, we score flower petals as a single BSU regardless of whether the petals were further differentiated into morphologically discrete regions (e.g., petal claws versus blades/limbs, which would be scored as two separate METs). Likewise, we score carpels/gynoecia as a single BSU regardless of how differentiated they are; for example, such a BSU may contain many individual METs, including the style, stigma, and various placentation components. For detailed notes regarding BSU scoring in specific groups, see taxon descriptions in the Supplemental Data.

As a general illustration of our approach to scoring METs, BSUs, and their arrangement, consider representative reproductive structures from lycopsids and angiosperms (Fig. S2), two groups of vascular plants separated by at least 420 million years. A typical lycopsid strobilus (e.g., *Lycopodium*) consists of sporangia with four associated METs: a stalk (1) borne on a sporophyll (treated as a BSU) composed of a pedicel (2) and a leaf-like lamina (3), and an axis (4) bearing this entire structure. The axis was also scored as a BSU (Fig. S2A). In contrast, a representative flower has many more BSUs and METs (Fig. S2B), and those parts also exhibit higher orders of clustering. In this example, each ovule consists of the megasporangium (called the nucellus in seed plants) borne on and surrounded by repeated integuments (1) and a stalk-like funiculus (2). These may be produced in an ovary (4) separated by septa (3) and/or placentation elements. In this example, multiple ovules are produced in each locule, resulting in two degrees of clustering (indicated by the superscript ^{RR}). The ovary here is part of a larger gynoecium BSU that includes an extended style (5) and stigma for pollen reception

(6). The entire gynoecium is borne on a flower stalk or pedicel (11) that also bears the other flower parts, including multiple stamens, consisting of an anther borne on a filament (7). The anthers in a typical flower are tetrasporangiate and composed of two distinct pairs of microsporangia (pollen sacs); each individual pollen sac therefore shows two degrees of clustering (^{RR}) in the anther alone. The perianth organs of this example flower include a petal BSU consisting of a differentiated corolla tube (8) and free petal tips (9) and a whorl of sepals (10). Finally, bud bracts (12) subtend the flower stalk. If this flower were to be repeated in a simple inflorescence, all parts would show an additional degree of clustering (^{R}).

Character Data Analysis

We scored all taxa in our dataset for the number of METs, BSUs, and their hierarchical part arrangement (see below), although not all fossil taxa could not be scored for arrangement due to preservation (e.g., an individual fossil flower may be well preserved but its inflorescence structure was not). In some cases of incomplete preservation, we recorded METs that were likely present; for example, a funiculus in the ovules of a fossil eudicot for which the gynoecium was not well-preserved. We incorprate this uncertainty by scoring minimum and maximum potential MET counts for every taxon (although only 8% of all taxa include such possible variation). Because we define METs strictly as geometric parts without reference to their evolutionary or developmental origins, different intepretations of the homology of these parts rarely effects our scoring, except for the extinct Mesozoic gymnosperm group Bennettitales. One interpretion (*39*) regards a particular morphological feature as part of the sporangium (i.e., the nucellus) while another (*40*) regards this part as derived from sporophyte tissue (i.e., as an integument; see detailed discussion in the description of specific Bennettitales in the Supplementary Data). The latter interpretation would result in extra METs, as we do not score regions of the sporangium as METs by definition.

We analyzed basic patterns in MET (and BSU) number using simple statistics, including basic summary statistics (mean, variance), nonparametric Kolmogorov-Smirnov (KS) tests, and Fligner-Killeen tests in order to detect differences in MET distributions and variance among specific time intervals and major groups. We generally binned taxa to geologic periods for analyses of changes through time, although for the two intervals with considerable change in MET values (Devonian and Cretaceous), we binned taxa by epoch, including the Early and Middle-Late Devonian (referred to as D_1 and D_2, respectively) and the Early and Late Cretaceous (K_1 and K_2, respecitively) to accommodate this variation. To analyze variance in METs among time intervals, we used a bootstrapping procedure where we first sampled all reproductive structures in a time bin with MET counts as a random draw from either their minimum or maximum values. We next resampled this dataset with replacement and calculated the variance; we then repeated this process 1000 times, each time starting with a new sampling of reproductive structure minimum or maximum MET values. To compare variance among time bins, we used the mean value and 95% confidence intervals (CIs) of these resampled distributions. We also tested for significant differences in variance among time bins using a Fligner-Killeen test; here we incorporated variance in MET values by using average MET values for each reproductive structure. We also used average taxon MET values when assessing significant differences among time bins in overall MET distributions using KS tests. All statistical procedures in this study were performed using R version 4.1.0 (*41*).

We emphasize that we did not analyze METs in an explicit phylogenetic framework because interpreting the results of such an analysis would be extremely difficult, even if a well-resolved phyogeny for all living and extinct vascular plants existed. The goal of this study was to compare the degree of morphological differentiation across disparate plant groups, for many of which homology is either unknown, highly debated, or nonexistent. For example, reproductive structures in the last common ancestor of extant free-sporing plants like ferns and horsetails consisted of ramifying fertile axes (*32, 33*); any additional METs must have evolved independently and scoring complexity based on homologous parts would preclude any direct comparison of these groups. Morphological element types were therefore intentionally scored without reference to homology, and it is difficult to meaningfully interpret reconstructed ancestral MET values on a phylogeny. For example, if sister taxa both exhibited five METs, an ancestral state reconstruction would also suggest a value of five. But if the specific METs in these two taxa represented different parts or organs which happened to sum to five, which specific parts does the number in the ancestral reconstruction refer to? A more explicit phylogenetic analysis of METs is possible in subgroups whose homologies are better understood and could therefore be assigned to individual METs, as perhaps in living and fossil conifers. The general lack of an explicit phylogenetic analytical framework in this study does not preclude using phylogenetic information, however; we use known relationships among major clades such as lycophytes, euphyllophytes, moniliforms, acrogymnosperms, and angiosperms (*11, 12, 32-34*) when interpreting broad patterns in our data and assessing the potential role of inherited characters in shaping MET patterns through time.

In addition to analyzing changes in the number of METs (and BSUs), we also examined how the basic parts of reproductive structures were arranged. We were specifically interested in quantifying the extent to which vascular plant groups explored the total possible space of part (sporangia types plus METs) arrangements. In order to analyze this aspect of complexity, we scored reproductive structures for the following eight characters, two of which record the number of parts ("S" or structural characters) and six of which record the arrangement of these parts ("A" or arrangement characters):

S1. How many types of sporangia are present?

This character must be ≥ 1 because each reproductive structure will have at least one type of sporangium. If multiple types of spores (i.e., micro- and megaspores) are produced by sporangia that are otherwise morphologically identical, as in some early heterosporous taxa, they are considered here as just one type of fertile organ.

S2. How many morphological element types (METs) are present?

This character can equal zero and has no theoretical upper bound.

A1. How many total unique types (sporangia and METs) are repeated? (1° repetition)

This character can equal 0 and must be ≤ S1+S2

A2. How many types are clustered? (2° repetition)

This character refers to the subset of repeated types that are then arranged in a higher order cluster. For example, the pollen sacs on a cycad microsporophyll are arranged in multiple distinct clusters, each consisting of several pollen sacs. This character can equal 0 and must be ≤ A1.

A3. How many types display two orders of clustering (3° repetition)

This character refers to the subset of clustered types that repeat again, forming groups of clusters. To return to the cycad example, discrete clusters of pollen sacs occur on a microsporophyll, which is in turn repeated on the cone axis to generate a third order repetition. This character can equal 0 and must be ≤ A2.

A4. How many types display three orders of clustering (4° repetition)
A5. How many types display four orders of clustering (5° repetition)
A6. How many types display five orders of clustering (6° repetition)

Characters A4-A6 refer to the subset of types that show increasing orders of clustering. For example, pollen sacs in angiosperms with compound umbels would often show fifth order clustering: each anther consists of two fused pollen sacs (1° repetition), borne in pairs (2° repetition) on stamens are repeated in a flower (3° repetition). Each flower is then repeated as part of a cluster (4° repetition of pollen sacs), and the inflorescence consists of multiple flower clusters (5° repetition of pollen sacs). Each of these characters can equal 0 and must be ≤ than preceeding one.

For each reproductive structure, we can define a part arrangement as the character string that includes the number of sporangia types, the number of METs, and the number of these elements that are repeated at each hierarchical clustering order. For structures with a potential range in MET number, we used a single representative value for MET number (the "S2" column of the datatable available at Dryad). Each reproductive structure in the data set could have a unique combination of these characters or share it with another. In practice, we used nearly the full suite of our characters (S1, S2, A1-A5) and calculated all possible theoretical part arrangements given observed ranges in S1 (1,2) and S2 (0-18). Although one taxon in our data set exhibits 6th order clustering (A6), we excluded this character in determining theoretical state combinations because it would dramatically increase the potential number of arrangements but is extremely rare in observed taxa. Theoretically impossible part arrangements, such as a reproductive structure that has more parts repeated than it has total parts (A1 > S1+S2) were also excluded following rules described above. This resulted in a total of 407,322 possible unique arrangements. For each of the major groups or clades that we analyzed, we also calculated a reduced set of potential unique part arrangements bounded by observed ranges in each character state. For example, if a group in aggregate had only one sporangium, a maximum of four METs, and showed only three orders of clustering, we would calculate only possible states for S1=1, S2≤4, A1≤4, A2≤4, and A3≤4.

The number of observed part combinations of course depends on sampling; the more taxa sampled, the greater chance of finding unique arrangements. Considering the full sweep of vascular plant history, no group in our dataset is well sampled, but some groups are worse than others. In particular, achieving decent angiosperm sampling is problematic due to their taxonomic and morphological diversity. We accounted for these issues by resampling; We compared the number of observed unique part arrangements among groups via rarefaction curves that account for sampling intensity (*42*). For this approach, we randomly sampled reproductive structures from subsampled data for each focal group or clade and tallied the unique part arrangements; subsamples ranged in size from one to the total number of reproductive structures known from the group. We repeated this process 1000 times to a generate a curve with 95% confidence intervals of the expected number of unique arrangements at any given sampling intensity. Note that for morphologically identical genera that span multiple time intervals, we used a single representative species to limit overcounting and thus artificially flattening the curve.

In addition to the rarefaction approach, we also compared the observed number of unique part arrangements in a given group against that expected from a random draw of a corresponding number of taxa from the theoretically possible set. Here we analyzed all free-sporing plants together, gymnosperms in aggregate, and angiosperm seed-producing structures. For each group, we recorded how many taxa occurred in our dataset at each integer MET value. We then randomly sampled that many "taxa" with replacement from a list of all possible part arrangements at that MET number, calculated the number of unique state combinations, and repeated this process 1000 times, and calculated 95% confidence intervals (CI) from this distribution. We also repeated this process using all possible part arrangements calculated with only one sporangium (S1=1), because bisexual reproductive structures are relatively rare and including two sporangia doubles the number of possible character combinations; comparing observed versus expected numbers is fairer in almost all plant groups if the expected are calculated using only one sporangium.

Qualitatively, we noticed that differences between observed and expected sampling of part arrangement space result because observed reproductive structures rarely exhibit high levels of hierarchical clustering and therefore show fewer parts in characters A3-A5 than would be expected from a random sampling of theoretical space. This can be illustrated by calculating what we refer to as the Clustering Score (CS) for each reproductive structure, which is the sum of all the part types scored in characters A1-A5 divided by the sum of all the part types (S1 + S2). Higher numbers indicate a greater fraction of the total observed parts are clustered multiple times, where the maximum value of five indicates that every part exhibits five degrees of clustering. Expected values for CS for each clade below were calculated by sampling a random draw equal to the number of observed taxa from all possible state combinations and calculating their CS. We then fit a density function to the resulting distribution using R. We also calculated expected distributions drawn from a set of possible part arrangements constrained by the actual ranges in A1-A5 exhibited by each group or clade. For example, if a group did not exhibit any reproductive structures with characters scoring in A4 or A5, part arrangements with these character states were excluded from the possible pool.

Supplemental Text

MET results

MET patterns through time

As is apparent visually (Fig. 1A), the median, maximum, and variance in the number of METs among vascular plant reproductive structures increased in two major pulses, corresponding to the Middle-Late Devonian and the Late Cretaceous (Fig. S3, Tables S1-S4). Following these pulses, the distribution of METs and their variance remains stable, including a notable similarity from the Carboniferous through the Early Cretaceous (Fig. S3, Tables S1-S4). This overall pattern of pulsed rises in complexity is driven by differences within and among the major types of plant reproductive structures, and these differences are consistent with expectations based on their functional roles and diversity: free-sporing and pollen-producing structures show fewer METs and less change through time, particularly if they are wind-dispersed or pollinated, while seed-producing structures show more METs. The following paragraphs discuss these patterns in more detail.

Free-sporing and seed plant pollen-producing structures both increase in median and maximum complexity through the Late Carboniferous (~300 Ma; Fig. 1B, C; Table S2, S3) as they evolve parts which support and protect developing sporangia or pollen sacs prior to propagule release, including various kinds of indusia, bracts, sporophopylls, and sporophores. Many of these groups show notable similarity in overall form that presumably reflects similar functionality: they all simply release pollen or spores into the wind when mature. For example, the strobili of many lycopsids, sphenopsids, noeggerathialeans (a clade within progymnosperms, the paraphyletic free-sporing relatives of seed plants [*43*]), the pollen cones of *Ginkgo* and conifers, and the staminate inflorescences of some wind-pollinated angiosperms (e.g., *Hedyosmum*) all consist of a packed strobilus with fertile organs borne on leaf-like structures consisting of a few parts (typically a reduced stalk or pedicel attached to a peltate shield or blade-like laminar region). After the Carboniferous, both free-sporing and pollen-producing structures change little in overall MET distribution (Fig. 1B, C; Table S2, S3), although there is some variability among time bins reflecting differences in sampling of various clades. It is also important to note here that free-sporing plants with specialized megasporangiate structures do not generally exhibit higher complexity (Fig. 2), except for Salviniales within filicalean ferns ($p<0.001$ using KS test) which have more specialized bisexual reproductive biology related to their aquatic life strategy. Other free-sporing groups with megasporangiate structures (heterosporous zosterophylls, lycopsids, sphenophytes, and noeggerathialeans) do not show significant differences in MET distributions between microsporangiate and megasporangiate structures (KS test $p = 0.55$, 0.79, 0.51, and 0.95, respectively). These patterns are consistent with their functional roles; although megasporangiate structures produce large megaspores, their dispersal is essentially the same as that of spores in microsporangiate structures or homosporous free-sporing plants. Notable exceptions include megasporangiate structures in a few derived heterosporous lycopsids from the Late Carboniferous (*Lepidocarpon*, *Miadesmia* [*44,45*]) thought to have evolved a version of microspore capture akin to pollination; *Miadesmia* in particular has the most METs of any free-sporing reproductive structure.

Free-sporing and pollen-producing structures do show some differences, however; pollen-producing structures typically have more METs (Fig. 2; aggregate median value 1 and 3, respectively, although the extremely low median value for free-sporing plants is driven in part by the large number of filicalean ferns in the data set) and show a more directional trend through time; extremely simple types disappear by the Permian (Fig. 1C) and post-Permian time intervals show significantly different distributions by KS test (Table S3). Some insect-pollinated pollen-producing structures are also notably more complex than free-sporing plant structures, including those from both Gnetales and angiosperms (Fig. 2). Although pollination is not known with certainty in fossils, insect-pollination is assumed in many angiosperm staminate flowers, especially those with clear nectary structures, and likely contributes to the occasionally high complexity scores of staminate structures in the Cretaceous, Cenozoic, and modern (Fig. 1C).

Seed-producing structures generally have more METs than either free-sporing and pollen-producing structures. They also show a more pronounced increase in complexity over time, which occurs later in their history (Fig. 1D). Seed-producing structures show general stasis in average complexity and variance in complexity from their origins in the Late Devonian through much of the Mesozoic, with an abrupt rise in maximum and median number of METs over the Late Cretaceous (Fig. 1D; Table S4), reflecting the diversification of derived angiosperm clades (Fig. 2). Cenozoic seed-producing structures show a slight decline in median complexity (Fig. 1D) that likely reflects poor preservation of flowers during this time interval relative to the Cretaceous (see Supplemental Materials and Methods), although the overall distribution is not significantly different from the Late Cretaceous (Table S4) and variance remains similar (Table S1).

Reproductive complexity in extant taxa largely mirrors that of comparable fossil taxa (see Fig. 1A), suggesting that the fossil record does not introduce an overall bias in the preservation of complexity; median MET counts are similar among aggregate fossil and extant free-sporing plants (median value 1 and 2, respectively), aggregate gymnosperms (median value 4 and 4, respectively), and aggregate angiosperms (median value 9.5 and 10, respectively). The overall range in variation between fossil and extant taxa is also similar among these major categories with the exception of angiosperms, where extant taxa display higher maximum levels. This difference is likely to reflect preservation, given that the delicate and often large flowers at the highest MET levels (e.g., *Passiflora*, certain Fabaceae and Zingerberales) are unlikely to be preserved with their full complement of parts intact, if they are preserved at all. It is therefore difficult to determine exactly when these extremely high levels of complexity would have appeared in angiosperms, although the presence of Passifloraceae seeds by the Late Eocene (*46*) suggests it may have been present throughout much of the Cenozoic.

Homology and MET patterns across groups

Different levels of complexity observed among free-sporing, pollen-producing, and seed-producing structures are largely consistent across groups (Fig. 2), but this similarity is unlikely to reflect common ancestry as many of the METs in any given group are unique. The last common ancestor (LCA) of free-sporing lycophytes and euphyllophytes, as well as the LCA of free-sporing euphyllophytes themselves (including that of the crown monilophyte clade (*33, 34*)) produced sporangia on an axis or axis system (see *32);* METs beyond the supporting axis in lycopsids, horsetails, and extant "fern" groups (Figs. 2) must have evolved independently. Assessing deep homologies across fossil and living seed plants is difficult due to uncertain phylogenetic relationships, and many different topologies have been recovered (e.g., *11, 12, 47*). But the similarity in MET number between many pollen-producing and free-sporing structures, at least in groups with compact strobili like lycopsids and horsetails, is not due to common ancestry. The free-sporing ancestors of seed plants (broadly referred to as "progymnosperms") produced ramifying systems of fertile axes as did other Devonian euphyllophytes (*32*). The various kinds of sporophylls that they exhibit (e.g., those of extant cycads or conifers) must therefore be independently derived lateral organs. In fact, it appears almost certain that the microsporophylls of extant cycads and conifers are also independently derived, given the morphology of early fossil representatives (e.g., *48*).

Understanding homologies among seed-producing structures is especially challenging, and the lack of a resolved phylogeny does complicate understanding patterns in their MET number. All seed plants inherited at least one MET (the integument) in their seed-producing structures, but similar ranges in MET counts across gymnosperms (Fig. 2) and through time (Fig. 1D) cannot simply be due to common ancestry. Gymnosperm seed-producing structures are morphologically disparate and specific MET counts include parts that are unique to various groups; for example, the seed plant LCA could not (and did not) simultaneously possess all of the specific METs expressed in corystosperm cupules, conifer ovuliferous scales, peltasperm megasporophylls, and bennettitalean "flowers", to name just a few groups. Additionally, gymnosperm groups exhibit considerable variability in MET number, from relatively simple *Ginkgo* to complex Bennettitales. Even within extant groups like conifers that have reasonably well-resolved phylogenies and assesments of homology, there is variability in total MET number. Among Cupressaceae *sensu stricto* seed cones, for example, which likely had five METs ancestrally (ovule integument, micropylar funnel, seed wing, cone scale bract, and cone axis), MET counts range from three to eight (e.g., some *Juniperus* species versus *Calocedrus*). Among angiosperms, taxa inherited at least two METs (integument(s), carpel) in their seed-producing structures, and ancestral reconstructions of early flowers suggest between 5-6 (a flower stalk, tepals, stamen filament, carpels ± a stigma, and a repeated ovule integument; *49*). But angiosperms have also evolved extreme variation in complexity, from highly reduced flowers to extremely elaborates ones, and the uniquely high MET counts in some monocots and eudicots have clearly evolved independently: their specific METs are unique to their respective perianth, androecium, and gynoecium organs (see full taxa descriptions in the Supplemental Data). In general, although it is likely that suites of inherited organs will predispose groups to exhibit particular MET ranges and may set limited lower bounds, there is no reason to expect that their exact realized number is determined by their phylogenetic relationships.

BSU results

Morphological complexity patterns based on basic structural units (BSUs) are broadly similar to those of METs: maximum complexity increased in an early pulse with a sharp subsequent rise in the Late Cretaceous, free-sporing structures have the fewest BSUs and seed-producing structures the most, and extant flowering plants show substantially higher numbers on average than other groups within seed plants (Fig. S4). Basic temporal patterns among the types of reproductive structures are also similar: free-sporing and pollen-producing structures rise in BSU number over the Devonian and Carboniferous and then remain similar (Fig. S4B, C), while seed-producing structures increase most strongly in the Late Cretaceous (Fig. S3D). Basic structural unit patterns across individual groups or clades (Fig. S5) are also broadly similar to those of METs (Fig. 2).

Patterns in BSUs do show some differences from METs, especially in the Paleozoic. The initial rise in BSUs occurs over the Devonian as in METs, but then peaks in the Late Carboniferous (Fig. S4A). The reason for this difference relates to the structure of the earliest seed plants, which exhibit a relatively high number of discrete parts (i.e., METs), but these parts appear to be derived from just a few organs. Namely, their reproductive structures consist of various lobes and cupule elements produced by a dichotomizing rachis system. In contrast, early coniferophytes and presumed relatives (e.g., Cordaitales) of the Late Carboniferous produced a fertile shoot system bearing clearly differentiated organs including bracts, sterile scales, and sporophylls, resulting in higher BSU numbers even if the total number of morphological parts (METs) is similar to some of the earliest plants. In these taxa, the number of reproductive organ types (i.e., BSUs) essentially equals the number of METs (Fig. S4A). Interestingly, few subsequent seed-producing structures achieve the high BSU values of these early coniferophytes until angiosperms. That the MET values of Mesozoic seed-producing structures do not show the same decrease as BSUs suggests that the basic organs which they do possess are more differentiated into subregions than those of the high-BSU Paleozoic taxa.

Analysis of BSU data also shows a stronger Cretaceous uptick in median values for pollen-producing structures (Fig. S4C); this pattern is due to angiosperm staminate flowers, which although relatively simple compared to pistillate or bisexual flowers, often have more organs than gymnosperm pollen cones (Fig. S5). Seed-producing structures also show slightly more of a temporal trend in median values from the Devonian through the Early Cretaceous (Fig. S4D) in BSU data than in MET counts. Finally, angiosperm pollen-producing and seed-producing structures show less difference between abiotic and biotic pollination syndromes when analyzed in terms of BSUs rather than METs (Fig. S5); highlighting that the extreme complexity of some animal-pollinated angiosperms reflects increased differentiation within organs rather than the appearance of new ones.

Complexity Space Results

Almost no major plant group samples a large fraction of its theoretically possible number of part arrangements (Fig. S6). Even free-sporing plants, which have relatively few METs and therefore a more limited total number of possible combinations, exhibit fewer unique part arrangements than expected from randomly sampling (Fig. S6A). This result makes sense, however; reproductive structures within clades are not particularly variable in their basic arrangement and morphology. If they were, botanists would probably not have recognized them as belonging to the same group in the first place. The reproductive structures of gymnosperms likewise show far fewer unique part arrangements than would be expected from random sampling of character space (Fig. S6B). Of the studied groups, only angiosperm seed-producing structures sample character space well, showing the expected number of unique combinations given their sampling intensity (Fig. S6B). Again, this is not unexpected; our sampling focused on representatives from major families, which are therefore likely to show basic differences in reproductive organization that would translate into unique arrangements of METs. A more intensive sampling of angiosperms would no doubt result in a greater deviation between observed and theoretical sampling, but it is nonetheless notable that angiosperms in our dataset show more combinations than gymnosperm seed-producing structures (Fig. S6B), which have much more thorough sampling among both living and extinct clades.

The reproductive structures of taxa in our data set are also highly skewed towards lower clustering scores (CS), indicating that most of their parts are repeated only a few times or not at all (Fig. S7). Draws from the more constrained part arragements (those conditioned on observed character ranges) resulted in distributions that were sometimes closer in CS to the observed taxa, although there were some notable exceptions: observed monilophytes, gymnosperm seed-producing structures, and angiosperm ovulate structures were all skewed towards lower values that would be expected even from the reduced set of possibilities (Fig. S7). These results suggest that a few taxa in these groups do exhibit higher orders of clustering, which expands their allowed value ranges for higher order clustering characters, but most reproductive structures do not expore this part of character space. Note, however, that angiosperm seed-producing structures do show higher mean and median CSs than all other groups, which is consistent with the increased hierarchical arrangement of their reproductive structures in general.

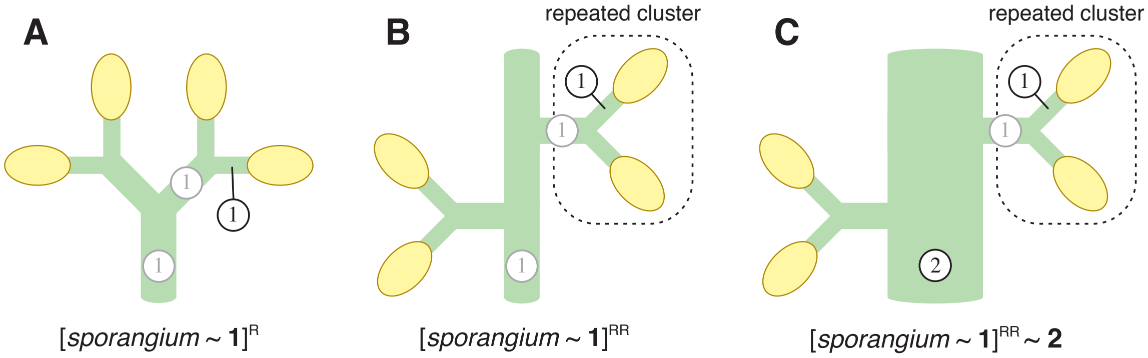

Figure S1. Scoring framework for dichotomous fertile axis systems. (A) A simple dichotomous branching system; all branching orders are considered representatives of one MET. Taxa are scored as repeated units consisting of a sporangium plus its subtending branching element. **(B)** An anisotomous fertile branching system (or a fertile rachis system) with main axial element and lateral clusters of sporangia. Here all axial elements are considered representatives of the same MET, but lateral branches are scored as distinct clusters of repeated sporangia and subtending axis elements. **(C)** An anisotomous fertile branching system where the main axis is much larger than the lateral branches; here main axis is considered a second MET because it does not show a gradation in diameter with lateral branch elements.

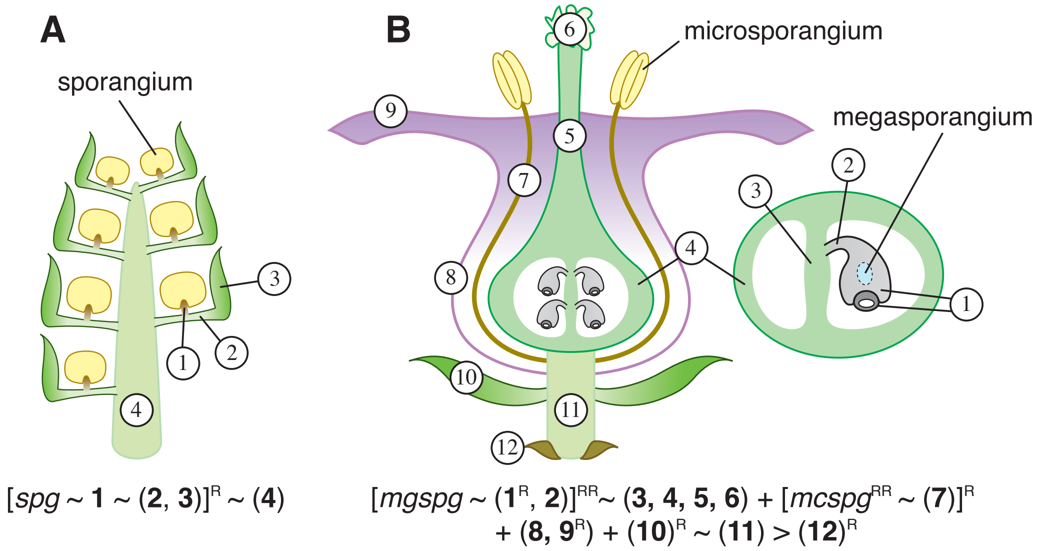

Figure S2. Worked examples of morphological element type (MET), basic structural unit (BSU), and clustering scores in a representative lycopsid strobilus (A) and flower (B). Numbers in bold identify specific METs, which are discussed in the Materials and Methods section above. The character string below each reproductive structure summarizes the part types (sporangia, METs, BSUs) and their clustering (^{R}) in the same format as the complete list of scored taxa given in the Supplemental Data. The character string also provides a basic idea of how the parts are organized: ~ = borne on the following MET, > = subtended by the following MET, and + indicates multiple METs borne or subtended by the following MET. Parentheses indicate METs or groups of METs that constitute a BSU.

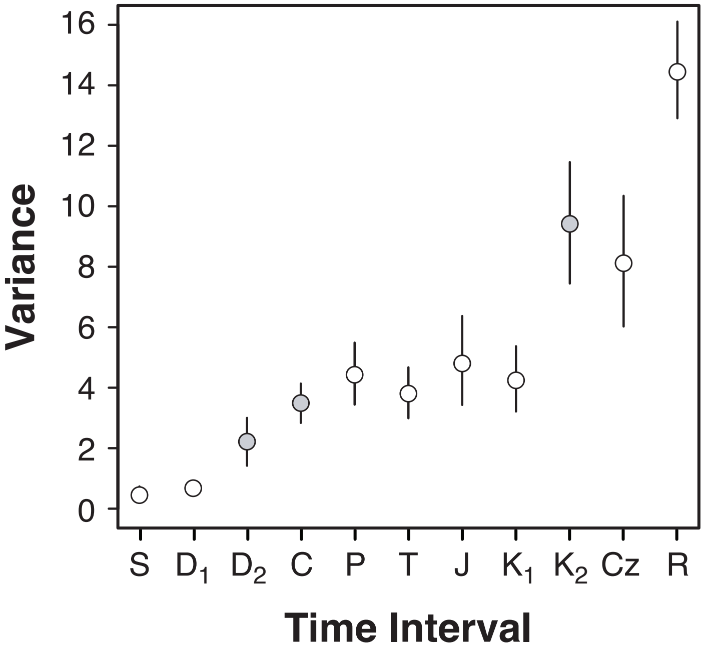

Figure S3. Variance in METs among reproductive structures across geologic time bins. Points represent the mean variance of 1000 bootstrap replicates of taxon MET values from a given time interval, which itself itself is based on a random sampling of maximum and minimum possible MET values for each taxon (see Supplemental Materials and Methods). Error bars indicate 95% CI of the boostrap distribution of calculated variances. Points in gray indicate time intervals with significantly higher variance than the preceeding interval by a Fligner-Killeen test (see Table S1). S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

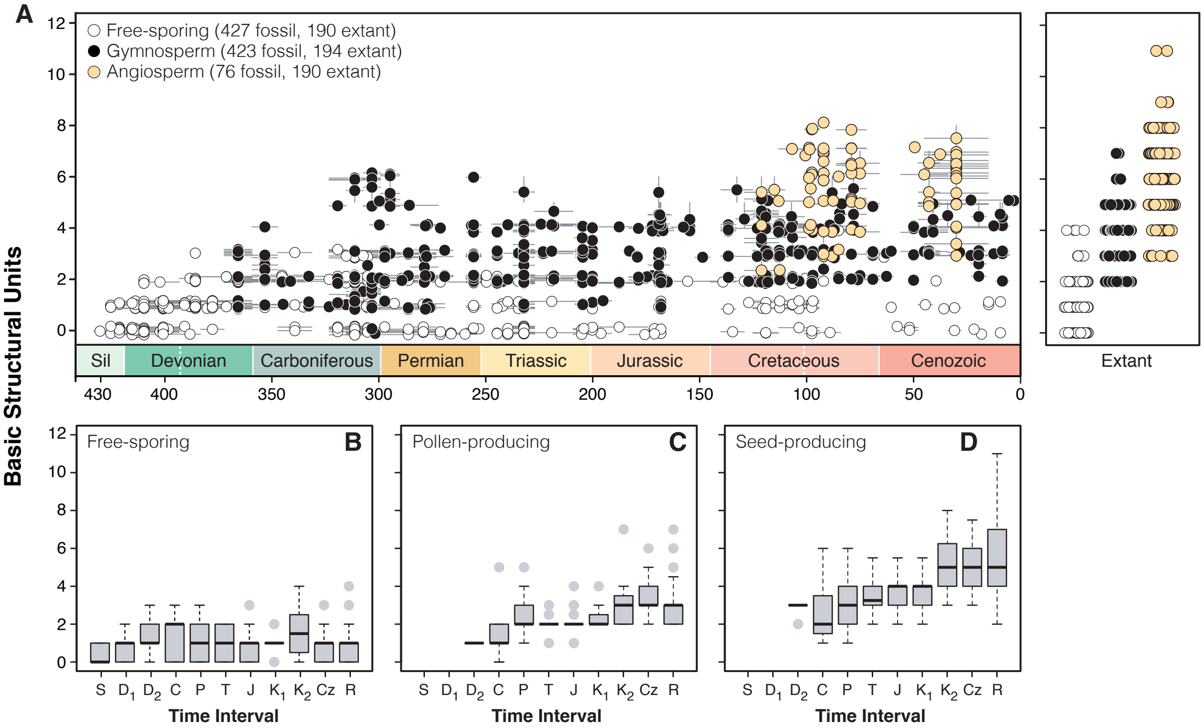

Figure S4. Complexity patterns in vascular plant reproductive structures through time. (A) Number of basic structure units (BSUs) through time. Free-sporing plants reproduce through spores, while both gymnosperms and angiosperms produce seeds; 'gymnosperm' refers to any non-flowering seed plant. A small amount of random noise was added to integer BSU values to better visualize patterns. Error bars represent uncertainty in age and BSU count; for taxa with potential BSU variation, data points represent the average between minimum and maximum. Reproductive structures from extant taxa are shown as stripcharts in the panel on the right. **(B-D)** Boxplots of free-sporing **(B),** pollen-producing **(C),** and seed-producing **(D)** structures over binned geologic time intervals. The Devonian and Cretaceous periods were divided into subintervals corresponding to Early and Middle-Late Devonian, and Early and Late Cretaceous; these subintervals are shown on the geologic time scale in (A) by dotted lines. S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

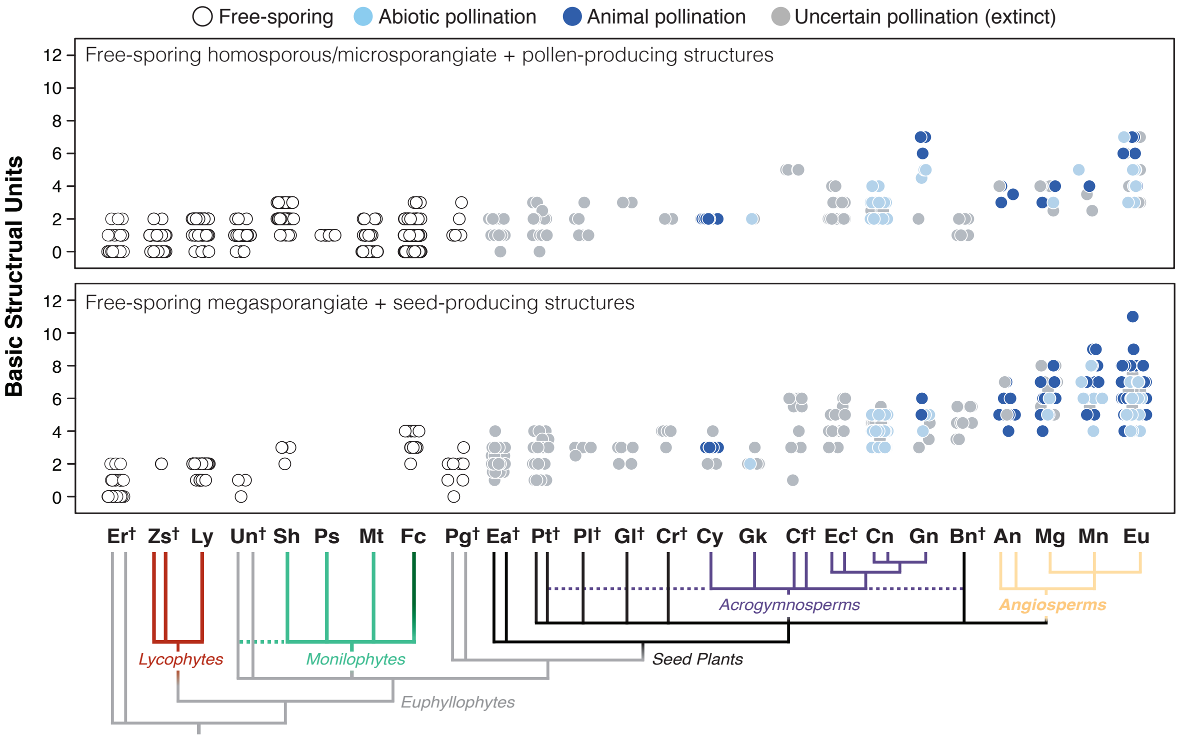

Figure S5. Complexity patterns in vascular plant reproductive structures across groups. Stripcharts of BSU number for free-sporing homosporous and microsporangiate structures, and seed plant pollen-producing structures (upper panel), and for free-sporing megasporangiate and seed-producing structures (lower panel); seed-producing structures may also produce pollen if bisexual. For taxa with uncertain MET number, average value is shown. Abiotic pollination includes wind and water vectors. Provisional phylogeny based on previous studies (*11,12,32-34*) with major crown clades labeled. Acrogymnosperms and monilophytes are based on extant taxa and may include unresolved fossil groups (shown by dotted lines). Multiple branches leading to a group indicate potential paraphyly or polyphyly; extinct groups are indicated by a dagger. Er = early plants, Zs = zosterophylls, Ly = lycopsids, Un = unplaced early euphyllophytes, Sh = sphenophylls, Ps = Psilotales + Ophioglossales, Mt = Marattiales, Fc = Filicales, Pg = progymnosperms, Ea = early “pteridosperms”, Pt = later “pteridosperms”, Pl = Peltaspermales, Gl = Glossopteridales, Cr = Corystospermales, Cy = Cycadales, Gk = Ginkgoales, Cf = early coniferophytes, Ec = early conifers (walchians, voltziales, unplaced stem), Cn = crown conifers, Gn = Gnetales, Bn = Bennettitales, An = ANA grade angiosperms, Mg = magnoliids, Mn = monocots, Eu = eudicots.

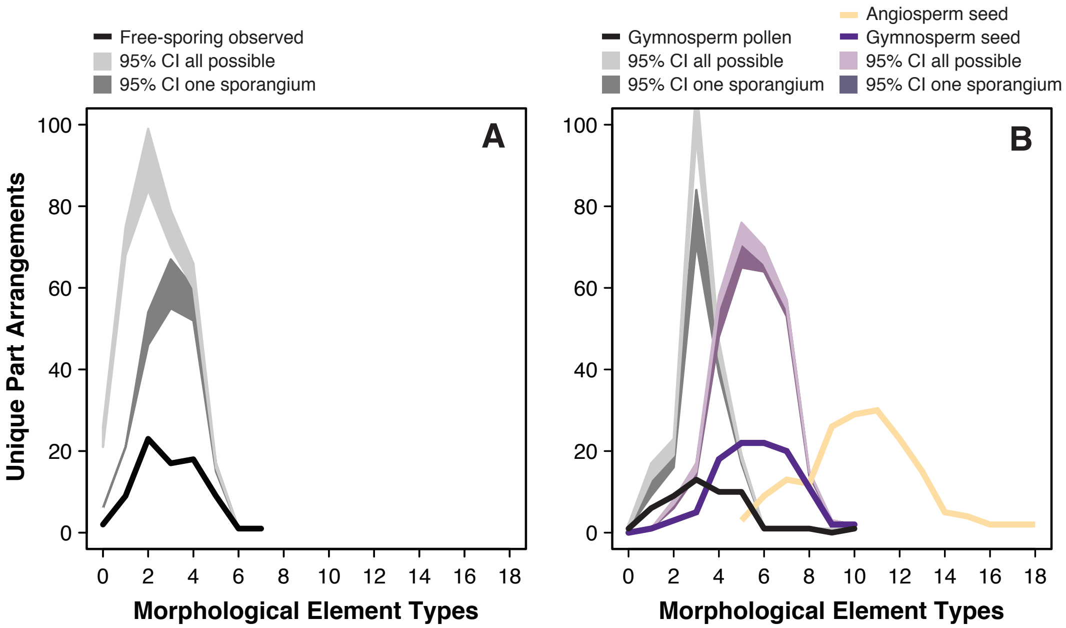

Figure S6. Deviation between observed and expected number of unique part arrangements in free-sporing plants (A) and seed plants (B). For each group or subgroup, the lighter polygon indicates the 95% confidence intervals (CIs) based on resamping the number of observed taxa at each number of METs from all possible state combinations. The darker polygon represents 95% CIs based on resampling from all possible state combinations calculated with only one sporangium type (see text above for details). Note that CIs for angiosperms are smaller than the illustrated line, indicating that their number of observed unique state combinations follows expectations from random sampling.

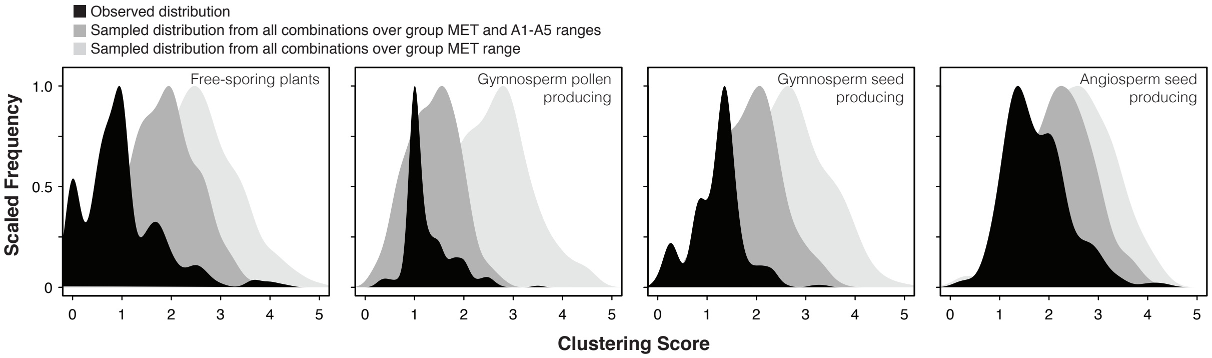

Figure S7. Deviation between observed and expected clustering scores (CSs) for different types of reproductive structures. The observed distribution of CSs for each type of structure is shown in black, and is calculated by dividing the sum of characters A1-A5 by the total number of parts (S1 [sporangia types] + S2 [METs]); a higher score indicates a greater fraction of the parts are clustered or reiterated multiple times. For each panel, the light gray distribution is that expected based on a random sampling of theoretically possible character combinations over the range of METs shown by each type of reproductive structure; the dark gray distribution is based on a subset of all possible character combinations conditioned on the range of METs and A1-A5 values observed in the type of reproductive structure (see Supplemental Materials and Methods for details).

	S	**D_1**	**D_2**	**C**	**P**	**T**	**J**	**K_1**	**K_2**	**Cz**
D_1	0.793									
D_2	*0.037*	**<0.001**								
C	**<0.001**	**<0.001**	**0.002**							
P	**<0.001**	**<0.001**	**0.001**	0.196						
T	**0.003**	**<0.001**	*0.014*	0.951	0.320					
J	**0.001**	**<0.001**	**0.001**	0.191	0.888	0.292				
K_1	**<0.001**	**<0.001**	**<0.001**	0.080	0.220	0.142	0.945			
K_2	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**		
Cz	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.002**	**<0.001**	**0.005**	**0.002**	0.667	
R	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.345	0.105

Table S1. Pairwise comparisons of variance in METs in different geologic time bins. Taxon MET counts are based on the average between the minimum and maximum possible values. The numbers are p-values from a Fligner-Killeen test; gray indicates no significant differences in the distribution, italics indicates differences at $p < 0.05$ and bold indicates significant differences at $p < 0.01$. The Devonian and Cretaceous periods were divided into subintervals corresponding to Early (D_1) and Middle-Late Devonian (D_2), and Early (K_1) and Late Cretaceous (K_2) because major changes in complexity occur during them. S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

	S	**D_1**	**D_2**	**C**	**P**	**T**	**J**	**K_1**	**K_2**	**Cz**
D_1	0.820									
D_2	*0.010*	**.002**								
C	**<0.001**	**<0.001**	**0.006**							
P	0.219	0.448	**0.001**	*0.025*						
T	*0.014*	**<0.001**	0.103	**0.009**	0.295					
J	0.173	0.347	0.237	**0.006**	0.701	0.095				
K_1	**0.007**	**0.007**	0.995	*0.046*	*0.030*	0.404	0.546			
K_2	*0.017*	**0.006**	0.171	0.995	0.211	0.813	0.092	0.322		
Cz	0.122	0.397	1.000	0.114	0.060	0.398	0.655	0.962	0.233	
R	**0.003**	**<0.001**	0.879	**<0.001**	**<0.001**	*0.046*	0.168	0.995	0.411	0.960

Table S2. Pairwise comparisons among MET distributions for all free-sporing plants in different geologic time bins. Taxon MET counts are based on the average between the minimum and maximum possible values. The numbers are p-values from a Kolmogorov-Smirnov (KS) test; gray indicates no significant differences in the distribution, italics indicates differences at $p < 0.05$ and bold indicates significant differences at $p < 0.01$. The Devonian and Cretaceous periods were divided into subintervals corresponding to Early (D_1) and Middle-Late Devonian (D_2), and Early (K_1) and Late Cretaceous (K_2) because major changes in complexity occur during them. S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

	S	**D_1**	**D_2**	**C**	**P**	**T**	**J**	**K_1**	**K_2**	**Cz**
D_1										
D_2										
C			0.695							
P			**0.006**	**0.001**						
T			*0.014*	**0.002**	0.973					
J			**0.004**	**<0.001**	1.000	0.960				
K_1			**<0.001**	**<0.001**	0.987	0.253	0.955			
K_2			**<0.001**	**<0.001**	0.681	0.159	0.401	0.193		
Cz			**<0.001**	**<0.001**	0.107	**0.006**	*0.028*	*0.011*	0.923	
R			**<0.001**	**<0.001**	0.980	*0.042*	0.560	0.210	0.967	0.116

Table S3. Pairwise comparisons among MET distributions for all seed plant pollen-producing structures in different geologic time bins. Taxon MET counts are based on the average between the minimum and maximum possible values. The numbers are p-values from a Kolmogorov-Smirnov (KS) test; gray indicates no significant differences in the distribution, italics indicates differences at $p < 0.05$ and bold indicates significant differences at $p < 0.01$. The Devonian and Cretaceous periods were divided into subintervals corresponding to Early (D_1) and Middle-Late Devonian (D_2), and Early (K_1) and Late Cretaceous (K_2) because major changes in complexity occur during them. S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

	S	**D_1**	**D_2**	**C**	**P**	**T**	**J**	**K_1**	**K_2**	**Cz**
D_1										
D_2										
C			*0.043*							
P			0.060	0.361						
T			0.808	0.058	0.133					
J			0.493	0.180	0.480	0.750				
K_1			0.843	*0.029*	*0.045*	0.477	0.925			
K_2			*0.010*	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**		
Cz			*0.013*	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.002**	0.654	
R			*0.011*	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.309	*0.027*

Table S4. Pairwise comparisons among MET distributions for all seed plant seed-producing structures in different geologic time bins. Taxon MET counts are based on the average between the minimum and maximum possible values. The numbers are p-values from a Kolmogorov-Smirnov (KS) test; gray indicates no significant differences in the distribution, italics indicates differences at $p < 0.05$ and bold indicates significant differences at $p < 0.01$. The Devonian and Cretaceous periods were divided into subintervals corresponding to Early (D_1) and Middle-Late Devonian (D_2), and Early (K_1) and Late Cretaceous (K_2) because major changes in complexity occur during them. S = Silurian, D_1 = Early Devonian, D_2 = Middle-Late Devonian, C = Carboniferous, P = Permian, T = Triassic, J = Jurassic, K_1 = Early Cretaceous, K_2 = Late Cretaceous, Cz = Cenozoic, R = Recent.

Data S1: Character scorings for all taxa

The following list, arranged by taxonomic groupings, contains all scorings used in this study. We generally refer to METs using names that correspond to those used by the references, or that would be broadly recognized by botanists. Specific notes or justifications are provided for some taxa following an asterisk. Scorings are also written in a way that provides a sense of the basic organization of the structure and its component parts using the following notation:

red type = denotes a sporangium
black type = denotes an MET
gray type = denotes a previously listed MET
italics = denotes an MET that is assumed to be present but missing due to preservation; we capture this uncertainty by including these METs as a possible range for each taxon.
^{R} = indicates that a part type is repeated, where number of "R"s refers to degree of compounding (characters A1-A6)
[ ] = brackets enclose repeated units
( ) = parentheses enclose a structure scored as a BSU; component METs are separated by a "|" and those that form substructures within the BSU are enclosed by { }
~ = indicates that a part type is born on the next listed MET or major structural unit
> = indicates that a structure is subtended by the next listed part or multi-part structure, but not directly borne on it
+ = indicates two distinct METs or major structural units that are separately borne on a supporting structure like an axis.
† = indicates a fossil taxon; for completely extinct groups only the broader taxonomic group is labelled.

We typically scored morphological information from one species, although in some cases we scored composite taxa and labelled them as such; for example, we might combine ovule structure and gynoecium information available from one species with floral or inflorescence data from another (e.g., *Siparuna* composite). In cases where the exact species could not be identified, the genus name is followed "sp." A genus name followed by "spp." indicates that the scoring applies to multiple species in our dataset; the full list can be found in the data available on Dryad (https://doi.org/10.5061/dryad.w0vt4b8qx).

1. Early Plants/Rhyniophytes/Cooksonioids†

This represents an informal paraphyletic or polypheletic grouping of early vascular plant taxa whose relationships are unclear. These taxa produced simple reproductive structures, often consisting of sporangia that terminate axes representing the plant vegetative body. In some cases, these taxa may show more specialized reproductive structures consisting of ramified units of dedicated fertile branches.

Aberlemnia bohemica: sporangium

Aberlemnia caledonica: sporangium

Aglaophyton major: sporangium

Amplectosporangium jiangyouense: [sporangium ~ (dichotomous branch element)]^{RR}

Amplectosporangium unilaterale: [sporangium ~ (dichotomous branch element)]^{R}

Bracteophyton variatum: sporangium^{R} + (sporophyll)^{R} ~ (strobilus axis)

Caia langii: sporangium + spine^{R}

Catenalis beckii: [sporangium ~ (dichotomous branch element)]^{RR}

Celatheca digitata: [sporangium ~ (sporophyll)]^{R} ~ (dichotomous branch element)]^{R}

Concavatheca banksii: sporangium

Cooksonia spp: sporangium

Dibracophyton acrovatum: [sporangium ~ stalk + (bract)^{R}]^{R} ~ (strobilus axis)
*In this taxon, the stalked sporangium is borne between two bracts borne on a strobilus axis; this appears to form a functional unit and is scored as such.

Eocooksonia sphaerica: sporangium + spine^{R}

Filiformorama simplex: sporangium

?Fusiformitheca sp: sporangium

Grisellatheca salopensis: sporangium

Horneophyton lignieri: sporangium

Hsua deflexa: sporangium

Hsua robusta: [sporangium^{R} ~ (dichotomous branch element)]^{R}

Huvenia spp: [sporangium ~ (dichotomous branch element)]^{R}
*This taxon also apparently produces isolated lateral sporangia on main axes; I score the more complex ones borne on ramified fertile axes.

Isidrophyton iniguezii: sporangium^{R}
*The sporangia appear as a cluster terminating a branch, with no obvious distinction between fertile and sterile branches.

Jiangyounia gengi: sporangium

Pertonella species A: sporangium

Polycladophyton gracilis: sporangium

Renalia spp: [sporangium ~ (dichotomous branch element)]^{R}

Rhynia gwynne-vaughanii: sporangium

Salopella spp: sporangium

Sartilmania jabachensis: sporangium

Stachyophyton yunnanense: [sporangium ~ (sporophyll | sporophyll tip^{R})]^{R} ~ (strobilus axis)

Stockmansella langii: sporangium ~ pad

Tarrantia sp: sporangium

Tichavekia grandis: [sporangium ~ (dichotomous branch element)]^{R}
*This taxon is intermediate between a condensed cluster of sporangia and a forking fertile axial system; it has a pair of sporangia subtended by extremely short axes.

Uskiella spp: sporangium

Wutubulaka multidichotoma: [sporangium^R ~ (dichotomous branch element)]^{RR}

Lycophytes

Lycophytes are free-sporing plants whose surviving lineages (the lycopsids) form a sister group to all other extant vascular plants (the euphyllophytes). Reproductively, lycophytes are characterized by producing lateral rather than terminal sporangia.

2. Zosterophylls†

Zosterophylls are a likely paraphyletic group (*32*) of early lycophytes that were abundant in the Early Devonian. Zosterophyll reproductive structures typically consist of lateral sporangia borne on short stalks, which may be arranged in compact strobili or may be scatted across the vegetative body. Fertile stalks in some taxa may be modified into more specialized fertile appendages, as in the Barinophytales, considered as zosterophylls here. Although the stalks may ultimately be derived from fertile axes, they are considered separate METs from the main strobilus axis (if it exists) due to differences in size. For zosterophylls and other taxa more broadly, we scored stalks as a separate MET if they were small diameter, unbranched structures less than or equal to the length than the longest sporangium dimension.

Adoketophyton parvulum: [sporangium ~ stalk ~ (sporophyll)]^R ~ (strobilus axis)

Baoyinia sichuanensis: [sporangium ~ stalk]^R ~ (strobilus axis)

Barinophyton citrulliforme: [sporangium ~ (fertile appendage)]^R ~ (strobilus axis)]^R
*Sporangia contain both microspores and megaspores

Bathurstia denticulata: sporangium^R ~ (strobilus axis)

cf. Bathurstia: sporangium^R ~ (strobilus axis)

Crenaticaulis verruculosus: sporangium ~ stalk

Deheubarthia splendens: sporangium ~ stalk

Demersatheca contigua: sporangium^R ~ (strobilus axis)

Discalis longistipa: sporangium + spine^R ~ stalk

Distichophytum sp: sporangium^R ~ (strobilus axis)

Gosslingia breconensis: sporangium ~ stalk

Guangnania minor: [sporangium ~ stalk]^R ~ (strobilus axis)

Gutzeitia timanica: [microsporangium/megasporangium ~ stalk]^R ~ (strobilus axis)]^{RR}
*Micro and megasporangia are not obviously different in morphology

Huia gracilis: [sporangium ~ stalk]^R ~ (strobilus axis)

Huia recurvata: sporangium ~ stalk

Kaulangiophyton akantha: sporangium ~ stalk

Konioria andrychoviensis: sporangium + spike^{R} ~ stalk

Krithodeophyton croftii: [sporangium^{R} + (sporophyll)^{R} ~ (strobilus axis)]^{R}

Macivera gracilis: [sporangium^{R} ~ (strobilus axis)]^{R}

Nothia aphylla: [sporangium ~ stalk]^{R}
*This taxon exhibits considerable variability, including some arrangements that appear to be terminal clusters of sporangia. We generally scored taxa according to maximum complexity exhibited; we therefore score as having terminal clusters.

Odonax borealis: [[sporangium + spine^{R} ~ stalk]^{R} ~ (strobilus axis)]^{R}

Oricillia bilinears: sporangium ~ stalk

Ornicephalum sichuanense: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Protobarinophyton spp*:* [sporangium ~ (fertile appendage)]^{R} ~ (strobilus axis)]^{R}

Ramoferis amalia: sporangium ~ stalk

Rebuchia ovata: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Sawdonia spp*:* sporangium + spine^{R} ~ stalk

Serrulacaulis spineus: sporangium ~ stalk

Sichuania uskielloides: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Tarella trowenii: sporangium ~ stalk

Thrinkophyton formosum: sporangium ~ stalk
*This taxon has distal forking fertile branches, but we do not consider them to be strobili.

Wenshania zichangensis: sporangium ~ stalk

Zosterophyllum sp Kotyk et al 2002: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Zosterophyllum sp A Kotyk et al 2002: sporangium ~ stalk

Zosterophyllum australianum: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Zosterophyllum deciduum: sporangium ~ stalk

Zosterophyllum fertile: sporangium ~ stalk

Zosterophyllum myretonianum: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Zosterophyllum qujingense: [sporangium ~ stalk]^{R} ~ (strobilus axis)

Zosterophyllum xishanense: [sporangium ~ stalk]^{R} ~ (strobilus axis)

3. Lycopsids

Lycopsids produce stalked lateral sporangia that are typically borne on leaf-like sporophylls. The sporophylls of many taxa are arranged in compact strobili, although they may also be borne in a loose fertile zone or even scattered across the vegetative body. Lycopsid sporophylls are often further differentiated into several METs, typically a thinner pedicel region and an expanded leaf-like distal lamina region, although many taxa show no or intermediate levels of differentiation. Pedicel morphology also often includes projections laterally ("alations") and abaxially ("keels"); we consider these features to be part of the basic shape of the pedicel and did not score them as separate METs unless they were either exceptionally long or exhibited distinctive geometry that clearly distinguished them from the rest of the pedicel. For example, some derived isoetalean lycopsids produce cup-like, sporangium-enclosing alations. Pedicel keels may also be continuous with downward projections of the distal lamina typically called a "heel". We did not score heels as separate METs unless they were substantially different in morphology than the distal lamina, as in *Mazocarpon*. Lycopsids include homosporous and heterosporous taxa and may produce microsporangiate, megasporangiate, or mixed strobili.

†*Asteroxylon mackei*: sporangium ~ stalk

Austrolycopodium magellanicum: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]ᴿ ~ (strobilus axis)

†*Baragwanathia longifolius*: sporangium ~ (sporophyll)

†*Barsostrobus famenensis:* [megasporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]ᴿ ~ (strobilus axis)

†*Bisporangiostrobus harrisii:* [microsporangium or megasporangium ~ (sporophyll pedicel | sporophyll lamina)]ᴿ ~ (strobilus axis)

†*Bothrodendrostrobus mundus:* [microsporangium or megasporangium ~ stalk ~ (sporophyll | ligule)]ᴿ ~ (strobilus axis)

†*Carinostrobus foresmani:* [sporangium ~ stalk ~ (sporophyll | alation cup | distal alation flap)]ᴿ ~ (strobilus axis)

†*Caudatocorpus arnoldii:* [megasporangium ~ (sporophyll pedicel | sporophyll lamina | ligule)]ᴿ ~ (strobilus axis)

†*Changxingia longifolia:* [megasporangium ~ (sporophyll pedicel | sporophyll keel | sporophyll lamina)]ᴿ ~ (strobilus axis)

†*Colpodexylon gracilentum*: sporangium ~ (sporophyll pedicel | sporophyll lobeᴿ)

†*Cylostrobus* sp*:* [microsporangium or megasporangium ~ (sporophyll lamina | *ligule*)]ᴿ ~ (strobilus axis)
*Ligule not present but assumed to exist

†*Cymastrobus irvingii:* [microsporangium or megasporangium ~ (sporophyll pedicel | sporophyll lamina)]ᴿ ~ (strobilus axis)

Dendrolycopodium dendroideum: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]ᴿ ~ (strobilus axis)

†*Diaphorodendron* concept (micro, *Achlamydocarpon varius*): [microsporangium ~ (sporophyll pedicel | sporophyll lamina | ligule)]ᴿ ~ (strobilus axis)

†*Diaphorodendron* concept (mega; *Achlamydocarpon varius*): [megasporangium ~ (sporophyll pedicel | sporophyll lamina | ligule)]ᴿ ~ (strobilus axis)
* Small alations are present, but we consider them to be continuous with the pedicel.

Diphasiastrum alpina: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^R ~ (strobilus axis)

Diphasiastrum digitatum: [[sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^R ~ (strobilus axis)]^R

Diphasium sp*:* [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^R ~ (strobilus axis)

†*Drepanophycus spinaeformis*: sporangium ~ stalk

†*Flemingites arcuatus*: [microsporangium or megasporangium ~ (sporophyll)]^R ~ (strobilus axis)

†*Flemingites (Lepidostrobus) diversus*: [microsporangium or megasporangium ~ (sporophyll pedicel | heel | distal lamina)]^R ~ (strobilus axis)

†*Halleophyton zhichangense:* sporangium ~ stalk

†*Haskinsia hastata:* sporangium ~ stalk ~ (sporophyll blade | sporophyll lobe^R)

†*Hoxtolgaya robusta*: sporangium ~ (sporophyll)

†*Hueberia zhichangensis:* sporangium

†*Huperzia appalachiana:* sporangium ~ stalk ~ (sporophyll)

Isoetes echinospora (micro): microsporangium ~ (swollen sporophyll base | distal lamina | vellum | ligule)

Isoetes echinospora (mega): megasporangium ~ (swollen sporophyll base | sporophyll distal lamina | vellum | ligule)

†*Isoetites madygensis* (micro): microsporangium ~ (swollen sporophyll base | sporophyll distal lamina | *vellum* | ligule)

†*Isoetites madygensis* (mega): megasporangium ~ (swollen sporophyll base | sporophyll distal lamina | *vellum* | ligule)
*We score *I. madygensis* as modern *Isoetes*, although vellum is not preserved in fossils generally.

†*Kladnostrobus clealii:* [microsporangium ~ (sporophyll)]^R ~ (strobilus axis)

†*Kowieria alveoformis*: [microsporangium or megasporangium ~ (sporophyll)]^R ~ (strobilus axis)

†*Leclercqia complexa*: sporangium ~ (sporophyll pedicel | sporophyll lobe^R | ligule)

†*Lepacyclotes zeilleri* (micro): microsporangium ~ (sporophyll base | distal lamina | ligule)

†*Lepacyclotes zeilleri* (mega): megasporangium ~ (sporophyll base | distal lamina | ligule)
*It is uncertain if this taxon formed a strobilus or a fertile zone; we score as fertile zone.

†*Lepidodendron hickii* (micro, *Lepidostrobus* sp.): [microsporangium ~ (sporophyll pedicel | distal lamina | ligule)]^R ~ (strobilus axis)

†*Lepidodendron hickii* (mega, *Achlamydocarpon tahktajanii*): [megasporangium ~ (sporophyll pedicel | keel | distal lamina | ligule)]^R ~ (strobilus axis).

†*Lepidophloios* concept (micro, *Lepidostrobus* sp.): [microsporangium ~ (sporophyll pedicel | distal lamina | ligule)]^R ~ (strobilus axis)

†*Lepidophloios* concept (mega; *Lepidocarpon*: [megasporangium ~ (sporophyll pedicel | alation cup | sporophyll lamina | ligule)]^{R} ~ (strobilus axis)

†*Lepidostrobus xinjiangensis*: [microsporangium ~ (sporophyll pedicel | distal lamina | *ligule*)]^{R} ~ (strobilus axis)
*The presence of a ligule is unclear.

†*Longostachys latisporophyllus:* megasporangium ~ (sporophyll | sporophyll teeth^{R})

Lycopodiastrum casuarinoides: [[sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)]^{R}

Lycopodiella alopecuroides: [sporangium ~ stalk ~ (sporophyll)]^{R} ~ (strobilus axis)

†*Lycopodites falcatus*: [SE: mcspg ~ *stalk* ~ (*sporophyll pedicel* | sporophyll lamina)]^{R} ~ (strobilus axis)
*We score as identical to modern Lycopodiales strobili based on their general similarity.

Lycopodium clavatum: [[sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)]^{R}

†*Miadesmia membranacea:* [megasporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina | ligule | vellum | vellum projection^{R}})^{R} ~ (strobilus axis)
**Miadesmia* is difficult to score because the sporangium-enclosing vellum is formed from different regions of the sporophyll and surrounds multiple component parts; it does nevertheless form a continuous enveloping structure, however, and is scored as a single MET.

†*Minarodendron cathaysiense*: sporangium ~ (sporophyll pedicel | sporophyll lobe^{R})

†*Minostrobus chaohuensis* (micro): [microsporangium ~ (sporophyll pedicel | distal heel/keel | distal lamina)]^{R} ~ (strobilus axis)

†*Minostrobus chaohuensis* (mega): [megasporangium ~ (sporophyll pedicel | distal heel/keel | distal lamina)]^{R} ~ (strobilus axis)
*This taxon is described as having long alations, but these appear continuous with the margins of the distal lamina and are regarded as the same MET.

†*Mixostrobilus givetensis:* [microsporangium or megasporangium ~ stalk ~ (sporophyll)]^{R} ~ (strobilus axis)

†*Monilistrobus yixingensis:* microsporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina | sporophyll teeth^{R})

†*Omphalophloios feistmantelii* (micro): microsporangium ~ (sporophyll pedicel | sporophyll lamina)

†*Omphalophloios feistmantelii* (mega): megasporangium ~ (sporophyll pedicel | sporophyll lamina)

†*Oxroadia gracilis:* [microsporangium or megasporangium ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

Palhinhaea cernua: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

†*Paralycopodites* concept *(Flemingites schopfii):* [microsporangium or megasporangium ~ (sporophyll pedicel | lamina | ligule)]^{R} ~ (strobilus axis)

†*Paurodendron fraipontii:* [microsporangium or megasporangium ~ stalk ~ (sporophyll lamina | ligule)]^{R} ~ (strobilus axis)

Phlegmariurus cumingii: sporangium ~ stalk ~ (sporophyll)

Phlegmariurus dichaeoides: [sporangium ~ stalk ~ (sporophyll)]^{R} ~ (strobilus axis)

Phylloglossum drummondii: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

†*Pleuromeia rossica:* [microsporangium or megasporangium ~ (sporophyll lamina | ligule)]^{R} ~ (strobilus axis)

†*Porostrobus nathorstii:* [[microsporangium or megasporangium ~ (sporophyll)]^{R} ~ (strobilus axis)]^{R}

Pseudodiphasium volubile: [[sporangium ~ stalk ~ (sporophyll)]^{R} ~ (strobilus axis)]^{R}

Pseudolycopodiella caroliniana: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

Pseudolycopodium deuterodensum: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

Selaginella diffusa: [microsporangium or megasporangium ~ stalk ~ (sporophyll | ligule)]^{R} ~ (strobilus axis)

Selaginella labutae: [microsporangium or megasporangium ~ stalk ~ (sporophyll | ligule)]^{R} ~ (strobilus axis)

†*Selaginellites leonardii:* [microsporangium or megasporangium ~ stalk ~ (sporophyll | ligule)]^{R} ~ (strobilus axis)
*This taxon is described simply as a mixed strobilus similar to modern *Selaginella*; we score the same as extant.

†*Sigillaria* concept (micro; *Mazocarpon*): [microsporangium ~ (sporophyll pedicel | distal heel | distal lamina | ligule)]^{R} ~ (strobilus axis)

†*Sigillaria* concept (mega; *Mazocarpon*): [megasporangium ~ (sporophyll pedicel | distal heel | distal lamina | ligule)]^{R} ~ (strobilus axis)

†*Skilliostrobus* sp*:* [microsporangium or megasporangium ~ (inflated sporophyll base | distal lamina | ligule)]^{R} ~ (strobilus axis)

†*Spencerites insignis:* sporangium ~ stalk ~ (sporophyll pedicel | peltate shield | distal lamina)

†*Spencerites moorei:* sporangium ~ (sporophyll pedicel | peltate shield | distal lamina)

Spinulum annotinum: [sporangium ~ stalk ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

†*Synchysidendron* concept (micro, *Achlamydocarpon varius*): [microsporangium ~ (sporophyll pedicel | sporophyll lamina | ligule)]^{R} ~ (strobilus axis)

†*Synchysidendron* concept (micro, *Achlamydocarpon varius*): [megasporangium ~ (sporophyll pedicel | sporophyll lamina | ligule)]^{R} ~ (strobilus axis)

†*Yuguangia ordinata*: [microsporangium or megasporangium ~ (sporophyll pedicel | sporophyll lamina | sporophyll teeth^{R} | ligule)]^{R} ~ (strobilus axis)
*Reconstruction suggests a stalk, but camera lucida drawing does not show a stalk and the sporangium is described as directly attached.

†*Zhenglia radiata*: sporangium ~ *stalk* ~ (sporophyll)
*This taxon is described as as possibly having a stalk.

Free-Sporing Euphyllophytes

This broad category encompasses all euphyllophytes excluding seed plants. Euphyllophytes are ancestrally characterized by producing terminal sporangia, although this is likely the pleisiomorphic condition for vascular plants in general. Phylogenetic relationships among major groups, especially fossil groups, are largely unresolved.

4. Early and Unplaced Lineages†

This grouping represents a paraphyletic or polyphyletic grouping of early lineages whose exact placement is unknown. Most of these taxa produce clusters of terminal sporangia on fertile branching systems.

Aarabia brevicaulis: [sporangium ~ (fertile branching element)]^{R}

Anapaulia moodyi: [sporangium^{R} + enation ~ (fertile branching element)]^{RR}

Arctophyton gracile: [sporangium^{R} ~ (fertile branching element)]^{R}

Calamophyton primaevum: [[sporangium^{R} ~ (fertile branching element)]^{R} ~ fertile branching element]^{R}
*A difficult taxon to score due to its variability. Dichotomizing fertile appendages are borne on larger diameter axes, and produce sterile branch tips distal to the sporangia that are considered part of one dichotomous branch system and are not scored as separate METs. As with many early euphyllophytes, there is no clear morphological distinction between the proximal and distal fertile axes other than gradation in size; we therefore score as the same MET. Multiple fertile branches appear to be borne on a larger branching unit.

Cephalopteris mirabilis: [sporangium ~ (fertile branching element)]^{R}

Chaleuria cirrosa: [microsporangium^{R} or megasporangium^{R} ~ (fertile branching element)]^{R}

Childanophyton dublinensis: [sporangium ~ (fertile branching element)]^{R}

Compsocradus laevigatus: [sporangium^{R} ~ (fertile branching element)]^{R}

Denglongia hubeiensis: [sporangium^{R} ~ (fertile branching element)]^{R}
*Sterile branch tips distal to the sporangia are considered part of the same dichotomous branch element.

Douaphyton levigata: [sporangium ~ (fertile branching element)]^{R}

Eocladoxylon minutum: [sporangium^{R} ~ (fertile branching element)]^{RR} ~ fertile branching element

Eophyllophyton bellum: sporangium

Estinnophyton wahnbachense: [sporangium^{R} ~ stalk]^{R} ~ (bifurcating sporophyll element)^{R}
*The fertile structure is considered a sporophyll rather than a branching element by the authors, and we follow their interpretation. Because the sporophyll is bifurcating throughout, I do not consider each tip to be a separate part, but rather equivalent to the ramified axial parts of a dichotomous element. The main axis appears to be vegetative rather than a dedicated fertile axis, and is not scored as an MET.

Estinnophyton yunnanensis: sporangium ~ stalk ~ (bifurcating sporophyll element)^{R}

Eviostachya hoegii: [[sporangium^{R} + spine^{R} ~ (fertile branching element)]^{R}]^{RR} ~ fertile branching element
*This taxon produces fertile appendages arranged in repeated whorls (= ^{RR}) around a fertile axis. There is no clear distinction in morphology between the fertile axis and the fertile branching units, and they are scored as a single MET.

Foozia minuta: [sporangium^{R} ~ (fertile branching element)]^{R}

*This taxon consists of occasionally dichotomous fertile appendages borne on a larger axis that terminates in vegetative appendages.

Hedeia sinica: [sporangium ~ (fertile branching element)]RR

Ibyka amphikoma: [sporangium ~ (fertile branching element)]R

Kunia venusta: [sporangium ~ (fertile branching element)]RR

Lorophyton goense: sporangiumR ~ (fertile branching element)R
*The larger axis that bears the dichotomizing fertile appendages also bears vegetative appendages distally; it is therefore not scored as a separate MET.

Melvillipteris quadriseriata: [sporangium ~ (fertile branching element)]RR ~ fertile branching element

Metacladophyton ziguinum: [sporangium ~ (fertile branching element)]RRR ~ fertile branching element

Oocampsa catheta: [sporangium ~ (fertile branching element)]RR ~ fertile branching element

Panxia gabata: [[sporangium ~ stalk]R ~ (fertile branching element)]R ~ fertile branching element

Pauthecophyton gracile: [sporangium ~ (fertile branching element)]R

Pertica quadrifaria: [sporangium ~ (fertile branching element)]RR ~ fertile branching element
*Clusters of sporangia sometimes occur on adjacent major dichotomies, although this is not consistent. Nevertheless, we score as repeated clusters reflecting the highest complexity attained by regions of this reproductive structure.

Pertica varia: [sporangium ~ (fertile branching element)]R

Planatophyton hujiersitense: [sporangium + enation ~ (fertile branching element)]R

Polypetalophyton wufengensis: [sporangium ~ (fertile branching element)]RR ~ fertile branching element

Polythecophyton demissum: [sporangium ~ (fertile branching element)]RR

Protocephalopteris praecox: [sporangiumR ~ (fertile branching element)]R

Pseudosporochnus nodosus: [sporangiumR ~ (fertile branching element)]R
*Although dichotomous fertile elements are borne on a higher order branch in this taxon, the branch also bears sterile units and is therefore not scored as a fertile MET.

Psilophyton crenulatum: [sporangiumR ~ (fertile branching element)]RR ~ fertile branching element + enationR

Psilophyton dapsile: [sporangiumR ~ (fertile branching element)]RR

Psilophyton forbesii: [sporangiumR ~ (fertile branching element)]R

Psilophyton primitivum: [sporangiumR ~ (fertile branching element)]R

Ramophyton givetianum: [sporangiumR ~ (fertile branching element)]R
*Although dichotomous fertile elements are borne on a higher order branch in this taxon, the branch also bears sterile units and is therefore not scored as a fertile MET.

Rhacophyton ceratangium: [[sporangium ~ (rachis element)]^{RR} + [(sterile dichotomous appendage element)^{R} ~ (rachis element)]^{R}]^{R} ~ (rachis element)
*This taxon is difficult to score. Each node on what is interpreted as the fertile frond rachis bears multiple sterile and fertile pinnae. The fertile pinnae consist of dichotomizing branch elements. The sterile pinnae rachides are here considered the same part type as the main frond rachis, analogous with how some filicalean ferns are scored.

Rhipidophyton acanthum: [sporangium^{R} + enation^{R} ~ (fertile branching element)]^{R} ~ fertile branching element

Shougangia bellum: [sporangium ~ (fertile branching element)]^{R}

Tauritheca cornuta: [sporangium^{R} ~ (fertile branching element)]^{RR}

Tenuisa frasniana: [sporangium^{R} ~ (fertile branching element)]^{R} fertile branching element

Trimerophyton robustius: [sporangium^{R} ~ (fertile branching element)]^{R}

Tsaia denticulata: [sporangium^{R} ~ (fertile branching element)]^{R}

Unnamed trimerophyte: [sporangium^{R} ~ (fertile branching element)]^{R}

Wattieza casasii: [sporangium^{R} ~ (fertile branching element)]^{RR} fertile branching element

Paleozoic "Fern" Groups

Phylogenetic relationships among early groups of fern-like euphyllophytes are unclear, and we have pulled out several fossil groups to list separately, although they may not be closely related to each other. These groups are likely to fall within extant monilophytes, but this is not known for certain; we analyze them here simply as unplaced euphyllophyte lineages.

Biscalitheca kansana: [[sporangium ~ (soral stalk element)]^{RR} ~ (fertile rachis)]^{R}
*In this taxon, the frond rachis and the soral stalk elements are dramatically different in size and branching habit; we therefore score them as separate METs and BSUs.

Biscalitheca musata: [sporangium ~ (soral stalk element)]^{R}

Corynepteris cabriensis: [sporangium ~ stalk]^{R} ~ (fertile pinnule)
*Fertile pinnules in this taxon are sometimes arranged in fertile pinnae, but these pinnae generally also contain sterile leaves; we did not see strong evidence for consistent higher order clustering.

Corynepteris involucrata: sporangium^{R} ~ (involucre)^{R}
*Soral clusters in this taxon are borne on a fertile pinnule, but it is not known if that pinnule is specialized or if it is similar to vegetative pinnules; we therefore score as a simple sorus borne on a vegetative structure.

Corynepteris sternbergii: [[sporangium ~ stalk]^{R} ~ (fertile pinnule)]^{R} ~ (pinna rachis)
*This taxon has fertile pinnae with sterile basal pinnules (considered vegetative organs) and a distal, purely fertile section bearing fertile pinnules with clusters of stalked sporangia.

Gillespiea randolphensis: [megasporangium^{R} ~ (fertile axis element)]^{R}
*This taxon is described as produing slightly stalked sporangia, sometimes in pairs, borne on branching fertile shoot systems. The stalks do not appear to be fundamentally different than branching fertile axes and they are not scored here as separate METs.

Musatea duplex: [sporangium^{R} ~ (fertile rachis element)]^{RR}

Musatea globata: sporangium^{R}
*Sporangial clusters in this taxon are borne on pinnules that appear to be identical to sterile foliage; we do not score them as repeated.

Nemejcopteris feminaeformis: [[sporangium ~ (soral stalk element)]^{RR} ~ (fertile rachis)]^{R}

Stauropteris burntislandica: megasporangium

Stauropteris oldhamia: sporangium

5. Sphenophytes

This group encompasses free-sporing euphyllophytes with whorled appendages and includes Equisetales (horsetails and fossil relatives) and Sphenophyllales, an extinct group that may be sister to the Equisetales (*32*). For the group analysis in this study, Equisetales and Sphenophyllales were analyzed together as a single clade, although their respective strobili (and their level of complexity) likely evolved independently. This group is included in the broader monilophyte clade based on the position of its sole surviving genus, *Equisetum*, in molecular phylogenies. Most reproductive structures in this group consist of multiple sporangia borne on some kind of "sporophore" (likely derived from a bifurcating branch system) which are produced in whorls and subtended by a whorl of bracts. Repeated whorls form the strobili, which typically results in double clustering (=^{RR}) of fertile organs and METs.

Early taxa or incertae sedis

†*Cheirostrobus pettycurensis:* [[sporangium^{R} ~ (sporophore stalk | sporophore foliar apex) > (bract pedicel | bract heel | bract lamina)]^{RR} ~ (strobilus axis)

†*Hamatophyton verticillatum:* [sporangium ~ stalk]^{RR} ~ (fertile axis)
*This taxon has a branching fertile axis that sometimes produces whorls of stalked sporangia, while at other times it produces lateral branches subtended by vegetative leaves. We consider the main axes to be vegetative in nature but with occasional sporangia; scoring is based on the lateral dedicated fertile axes.

†*Pseudobornia ursina:* sporangium^{R} ~ (sporangium cup) > (bract lobe)^{R}

†*Rotafolia songziensis:* [sporangium^{R} ~ (bract)]^{RR} ~ (fertile axis)

Sphenophyllales

†*Bowmanites bifurcatus:* [sporangium ~ (sporophore element)]^{RR} ~ (bract cup | bract free tip^{R})]^{R} ~ (strobilus axis)

†*Bowmanites fertilis:* [[[sporangium ~ stalk]^{R} ~ (inflated head | sporophore stalk element)]^{R} > (bract lobe)^{R}]^{RR} ~ (strobilus axis)
*This taxon is difficult to score. It consists of somewhat differentiated, bifurcating sporophores around a higher order axis. I score this axis and the sporophore stalks as the same MET because they are not clearly different in size.

†*Bowmanites pseudoaquensis:* [sporangium ~ sporophore/stalk ~ (bract)]^{RR} ~ (strobilus axis)
*The sporophore in this taxon is reduced to a single axial element, and could thus be considered a stalk. It is therefore not considered a separate BSU, following our scoring of stalks generally.

†*Lilpopia raciborskii:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{R} ~ (strobilus axis)

†*Peltastrobus reedae:* [[sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{R} > (bract base | bract free tip^{R})]^{RR} ~ (strobilus axis)

†*Sentistrobus goodii:* [sporangium ~ (axial sporophore element)]^{RRRR} ~ (strobilus axis)

†*Sphenostrobus iowensis:* [[sporangium ~ stalk]^{R} ~ (bract cup | bract free tips^{R})]^{R} ~ (strobilus axis)

Equisetales

†*Calamocarpon insignis:* [microsporangium^{R} or megasporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} + (bract)^{RR} ~ (strobilus axis)

†*Calamostachys americana:* [microsporangium^{R} or megasporangium^{R} ~ (sporophore)]^{RR} + [(bract cup | bract tips^{R})]^{R} ~ (strobilus axis)
*The *Calamostachys* sporophore is differentiated into a clear peltate shield in some species, but is virtually nonexistent in others.

†*Calamostachys binneyana:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} + [(bract cup | bract tips^{R})]^{R} ~ (strobilus axis)

†*Calamostachys longibracteata:* [sporangium^{R} ~ (sporophore)]^{RR} + (bract)^{RR} ~ (strobilus axis)

†*Cetistachys cetensis:* [sporangium^{R} ~ (sporophore stalk | sporophore shield)]^{RR} ~ (strobilus axis)

†*Cingularia typica:* [[sporangium^{R} ~ (sporophore lamina | sporophore tips^{R})]^{R} > (bract cup | bract tips^{R})]^{R} ~ (strobilus axis)

†*Cruciatheca patagonica:* sporangium^{R} ~ (sporophore)

†*Echinostachys paradoxa* (micro): [microsporangium^{R} ~ (sporophore stalk | sporophore shield)]^{RR} ~ (strobilus axis)

†*Echinostachys paradoxa* (mega): [megasporangium^{R} ~ (sporophore stalk | sporophore shield)]^{RR} ~ (stroblus axis)

†*Equicalastrobus chinleana:* [sporangium^{R} ~ (sporophore shield | sporophore stalk | sporophore lamina)]^{RR} ~ (strobilus axis)

†*Equisetinostachys grandis :* sporangium^{R} ~ (sporophore shield | sporophore stalk)

†*Equisetites* spp*:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Equisetites arenaceus:* [[sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)]^{R}
*We score this taxon differently from other *Equisetites*, as producing a cluster of cones on a dedicated fertile branch.

Equisetum telmateia: [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Gondwanostachys australis:* [[sporangium^{R} ~ (sporophore shield) ~ (sporophore element)]^{R}
*This taxon produced a branched sporophore bearing multiple peltate heads; it scored as if it was a dichotomizing fertile axis system.

†*Huttonia spicata:* [[microsporangium^{R} or megasporangium^{R} ~ stalk]^{R} > (bract cup | bract lamina^{R})]^{R} ~ (strobilus axis)

†*Kallostachys scottii:* [microsporangium^{RR} ~ (bract cup | bract tips^{RR})]^{R} ~ (strobilus axis)

†*Kraaiostachys plaatkopensis:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Mazostachys pendulata:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} + (bract)^{RR} ~ (strobilus axis)

†*Neocalamites:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Neocalamostachys* spp*:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Palaeostachya andrewsii* (micro): [[microsporangium^{R} ~ (sporophore shield | sporophore stalk)]^{R} > (bract cup | bract tips^{R})]^{R} ~ (strobilus axis)

†*Palaeostachya andrewsii* (mega): [[megasporangium^{R} ~ (sporophore shield | sporophore stalk)]^{R} > (bract cup | bract tips^{R})]^{R} ~ (strobilus axis)

†*Palaeostachya decacnema:* [[microsporangium^{R} ~ (sporophore shield | sporophore stalk) > (bract)]^{RR} ~ (strobilus axis)

†*Palaeostachya elongata:* [[microsporangium^{R} ~ (sporophore) > (bract)]^{RR} ~ (strobilus axis)

†*Palaeostachya guanglongii:* [microsporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} > (bract | bract keel)^{RR} ~ (strobilus axis)
*The sporophores in this taxon are inserted slightly above the bracts, but they are essentially axillary and recorded as such.

†*Paracalamitina striata:* sporangium^{R} ~ (sporophore shield | sporophore stalk)

†*Paracalamostachys cartervillei:* [sporangium^{R} ~ (sporophore)]^{RR} + (bract)^{RR} ~ (strobilus axis)

†*Peltotheca furcata:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)
*The "cone" in this taxon is a terminal fertile branch that still retains clear node separation; we nevertheless score it similarly to *Equisetum*.

†*Pendulostachys cingulariformis:* [[sporangium^{R} ~ (sporophore)^{R} ~ (bract disk | lamina tip^{R})]^{R} ~ (strobilus axis)

†*Pothocites grantonii:* [sporangium^{R} ~ (axial sporophore element)]^{RRR} ~ (strobilus axis)

†*Protocalamites arranensis:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Protocalamites farringtonii:* [microsporangium or megasporangium ~ (axial sporophore element)]^{RRR} ~ (strobilus axis)

†*Sendersonia matura:* sporangium^{R} ~ (sporophore shield | sporophore stalk)

†*Spaciinodum collinsonii:* [sporangium^{R} ~ (sporophore shield | sporophore stalk)]^{RR} ~ (strobilus axis)

†*Viridistachys moltenensis:* [sporangium^{R} ~ (sporophore shield | sporophore stalk | sporophore lamina)]^{RR} ~ (strobilus axis)

†*Weissistachys kentuckiense:* [sporangium^{RR} ~ (sporophore shield ring | sporophore stalk^{R})]^{R} + (bract)^{RR} ~ (strobilus axis)
*The bracts in this taxon are fused at their base, but we score them as separate structures because they do not produce a clear cup.

6. Ophioglossales and Psilotales

These groups have a poor fossil record, but molecular analyses place them in a broader monilophyte clade. They typically produce pinnate fertile leaves with several orders of sporangial clustering following the arrangement of pinnae.

Botrychium lunaria: [sporangium^{R} ~ (fertile rachis element)]^{R}

Botrychium virginiana: [sporangium^{R} ~ (fertile rachis element)]^{RR}

†*Botrychium wightonii*: [sporangium^{R} ~ (fertile rachis element)]^{RR}

Botrypus languinosum: [sporangium^{R} ~ (fertile rachis element)]^{RR}

Cheiroglossum palmata: sporangium^{R} ~ (fertile rachis)

Ophioglossum vulgatum: sporangium^{R} ~ (fertile rachis)

Psilotum nudum: sporangium^{R} ~ (sporophyll)

Sceptridium dissectum: [sporangium^{R} ~ (fertile rachis element)]^{RR}

Tmesipteris elongata: sporangium^{R} ~ (sporophyll)

7. Marattiales

Marattiales typically produce clusters of sporangia on vegetative leaves, and these clusters may be partially or completely fused into synangia. For Marattiales, as for morphologically similar early seed plant staminate structures, we do not score synangia as separate METs or BSUs unless they are highly differentiated. Specifially, we score synangia as separate parts if their sporangia are sunken within a groundmass of tissue that is clearly distinct from sporangial wall tissue. A separate synangium MET or BSU was not scored in taxa whose sporangia were partially or fully fused but which were still clearly identifiable. In many Marattiales, fused clusters of sporangia have small stalks or pads of tissue at their base, which we score as additional METs. Marattiales are resolved by molecular studies as part of the monilophyte clade.

†*Acaulangium bulbaceus:* sporangium^{R}

†*Acrogenotheca ramificata:* sporangium^{R} ~ basal bulge
*Synangia in this taxon are borne on compound leaf without lamina, but it does not appear that the leaf is specialized only for reproduction because not all of the terminal appendages end in synangia. We therefore do not score the leaf as a separate MET.

Angiopteris sp: sporangium^{R}

Archangiopteris sp: sporangium^{R}

†*Asterotheca* spp*:* sporangium^{R}

†*Buritiranopteris costata:* [sporangium^{R} ~ (fertile pinnule)]^{R} ~ (fertile rachis element)

Christensenia sp: sporangium^{R} ~ (synangium groundmass)

†*Convexocarpus distichus:* sporangium^{R}

†*Corsinopteris dicranophora:* sporangium^{R}

†*Corsinopteris semilibera:* [sporangium^{R} ~ (sporangiophore element)]^{R}

Danaea alata: sporangium^{R} ~ (synangium groundmass)

†*Danaeites rigida*: sporangium^{R} ~ (*synangium groundmass*)
*Whether this synangium truly contains distinct groundmass tissue is unclear, but the outline and dehiscence of the synangium suggests similarities with Marattiales that do produce this tissue, and we score as possessing a synangium.

†*Danaeopsis lunzensis:* sporangium

†*Drepanozamites dutioitii:* sporangium

†*Escapaia christensenioides*: sporangium^{R} ~ (synangium groundmass)
*This taxon is interpreted to show a synangial groundmass, although it does not completely cover the sporangia in this case.

Eupodium laeve: sporangium^{R} ~ (synangium groundmass | synangium stalk)

†*Gemellitheca saudica:* sporangium^{R}

Marattia fraxinea: sporangium^{R} ~ (synangium groundmass)

†*Marattia anglica*: sporangium^{R} ~ (synangium groundmass)

†Marattiaceae synangium: sporangium^{R} ~ (synangium groundmass | synangium apex^{R})

†*Marattiopsis hoerensis*: sporangium^{R} ~ (synangium groundmass)

†*Mertensides bullatus:* sporangium^{R}

†*Mesozoisynangium trilobus:* sporangium^{R}

†*Millaya tularosana:* sporangium^{R}

†*Pectinangium lanceolatum:* sporangium^{R}

†*Radstockia kidstonii:* sporangium^{R} ~ (synangium groundmass)

†*Rhinipteris nitida:* sporangium^{R}

†*Scolecopteris (Cyathotrachus) altissimus:* sporangium^{R}

†*Scolecopteris guizhouensis:* sporangium^{R}

†*Scolecopteris incisifolia:* [[sporangium^{R} ~ stalk]^{R} ~ (fertile pinnule)]^{R} ~ (fertile rachis element)
* The synangium in *Scolecopteris* is not as well developed as some extant Marattiales and it does not appear to have separate and distinctive ground tissue; we therefore do not score it as a separate MET or BSU. The true extent of fertile rachis compounding is not obvious in this taxon, but at least entire pinnae are modified and fertile, which is reflected in the scoring.

†*Scolecopteris iowensis:* sporangium^{R} ~ stalk

†*Scolecopteris latifolia:* [sporangium^{RR} ~ (fertile pinnule)]^{R} ~ (fertile rachis element)

†*Scolecopteris libera:* sporangium^{R} ~ stalk

†*Sydneia manleyi:* [[sporangium^{RR} ~ (fertile pinnule)]^{R} ~ (fertile rachis element)]^{R}

†*Symopteris lunzensis:* sporangium

†*Zhutheca densata:* sporangium^R

8. Filicales

Filicalean ferns are a well-supported clade with characteristic sporangium development (leptosporangiate-type) and anatomical features (the presence of an annulus). This group typically produces clusters of stalked sporangia (called a sorus) on a vegetative leaf. The presence or absence of sporangial stalks is often difficult to assess due to poor preservation; we generally score filicalean sporangia as stalked unless they are specifically described as sessile. We also score sporangia as stalked if they belong to an extant stalked family. The sorus may be further protected by a flap(s) of tissue called an indusium, although many clades produce naked clusters of sporangia or even lack soral clusters altogether. Some clades produce more complex structures or part arrangements, however, including dedicated fertile fronds with fertile pinnae and pinnules. Extant Filicales is extremely diverse taxonomically, but shows relatively limited reproductive variation; for simplicity, many extant genera that we scored are not listed here but are given in the full data posted on Dryad. Typical soral arrangements in Filicales are scored in the following way:

Taxon without sori or indusia: sporangium ~ stalk
Taxon with sori but no indiusum: [sporangium ~ stalk]^R
Taxon with sori and simple indusium: [sporangium ~ stalk]^R > (indusium)

Only extant taxa with different morphologies or arrangement are specifically detailed below.

†*Anachoropteris clavata:* [sporangium ~ stalk]^R > (indusium)

†*Anachoropteris* Galtier and Phillips 2014: [sporangium ~ (soral stalk element)]^R

†*Anachoropteris* Phillips and Andrews 1965: [sporangium ~ (fertile rachis element)]^{RRRR}
*The exact branching pattern in this taxon is not well described. It is described as possessing tertiary branches, which would make it similar to *Botryopteris globosa*, and is scored as such.

Anemia adiantifolia: [[[sporangium ~ stalk]^R ~ (fertile pinnule lobe)^R]^R ~ (fertile frond rachis)]^R
*Fertile pinnule is formed by lobes, with not distinct central part, but the sporangia occur throughout the entire structure with not clear clustering.

†*Anemia fremonti*: [[[sporangium ~ stalk]^R ~ (fertile pinnule lobe)^R]^R ~ (frond rachis)]^R
*The sporangia of this taxon are not directly preserved, but we score as extant *Anemia* due to its general similarity.

†*Aninopteris formosa:* sporangium^R
*A stalk is not visible in this taxon; we score as absent as in Matoniaceae generally.

†*Ankyropteris brongiartii:* [sporangium ~ stalk]^R

†*Ankyropteris sp:* [[sporangium ~ stalk]^{RR} ~ (fertile pinnule)]^R ~ (fertile rachis)

†*Aspidites thomasi:* [sporangium ~ stalk]^R > (indusium)

†*Asplenium changcaium*: [sporangium ~ stalk]^R > (indusium)

†*Azolla coloniensis*: [[microsporangium ~stalk]^R > (microsporangiate indusium) ~ (sporophore element)]^R > (sporocarp envelope)

*We score this taxon as extant *A. nilotica* due to its overall similarlity to Azolla, although some of the METs are not preserved. As described, there are only micro or megasporangia, and we score as having only one type of sporangium.

Azolla filiculoides: [microsporangium ~ stalk]^{R} > (microsporangiate indusium) + megasporangium > (megasporangiate indusium) ~ (sporophore element)^{R} > sporocarp envelope
* Recorded here as a maximum complexity form with two kinds of sporangia. It is also possible for the sorus to be either entirely microsporangiate or megasporangiate. In *Azolla*, the micro and megasporangiate indusia are distinct in size, but they are otherwise identical and are scored as the same MET.

†*Azolla keuja*: [microsporangium ~stalk]^{R} > (microsporangiate indusium) + [megasporangium ~ (megasporangiate indusium)]^{R} ~ (sporophore element)^{R} > (sporocarp envelope)
*Scored based on figure showing one microsporangial sorus and two megasporangial sori; indusia and envelope are not obvious in the fossil, but are scored based on extant representatives.

Azolla nilotica: [[microsporangium ~stalk]^{R} > (microsporangiate indusium)]^{R} + [megasporangium ~ (megasporangiate indusium)]^{R} ~ (sporophore element)^{R} > (sporocarp envelope)

†*Birtodites holmesii:* [sporangium ~ stalk]^{R}

†*Boodlepteris turoniana:* [sporangium ~ stalk]^{R}

†*Botryopteris globosa*: [sporangium + (sterile sporangium) ~ (fertile rachis element)]^{RRRR}
*The current scoring as 4th order compounding is an interpretation based on the description of tertiary branching. Heavily modified sterile sporangia appear to function as a protective wall, and are scored as a separate MET.

†*Botryopteris sp*: sporangium ~ stalk

†*Botryopteris tridentata*: [sporangium ~ stalk]^{R}

†*Boweria nowarudensis*: sporangium ~ stalk

†*Chansitheca wudaensis*: sporangium^{R}

†*Clathropteris reticulata:* [sporangium ~ stalk]^{R}

Claytosmunda claytoniana: [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RR}

†*Coniopteris bella:* [sporangium ~ stalk]^{R} > (indusium cup)

†*Coniopteris hymenophylloides:* [[sporangium ~ stalk]^{R} ~ (indusium cup) ~ (reduced fertile pinnule)]^{R} ~ (frond rachis)
*This taxon is morphologically variable and difficult to consistently score; we treat as specialized fertile pinnules around a fertile rachis.

†*Coniopteris simplex:* [[[sporangium ~ stalk]^{R} ~ (indusium cup) ~ (reduced fertile pinnule)]^{R} ~ (frond rachis)]^{R}

†*Cretacifilix fungiformis:* [sporangium ~ stalk]^{R} > (indusium stalk | indusium shield)

†*Culcita remberi:* [sporangium ~ stalk]^{R} ~ (indusium)

†*Cyathea cranhamii:* [sporangium ~ stalk]^{R} > (indusium cup)

†Cyatheales indet: [sporangium ~ stalk]^{R} ~ (receptacle) > (indusium valve)^{R}

†*Cyclosorus scutum*: [sporangium ~ stalk]^{R} ~ (indusium stalk | indusium shield)

†*Cynepteris bolichii:* sporangium ~ stalk

†*Cystodium sorbifolioides:* [sporangium ~ stalk]R > (indusium flap)

†*Delosorus macrocarpus:* sporangiumR ~ (indusium stalk | indusium shield)

†*Dendraena pinnatilobata*: sporangium
*This taxon may show some degree of sporangial clustering, but they appear loose and irregular and are not described as sori; sporangia are described as sessile and thus stalkless.

†*Dicksonia dissecta:* [sporangium ~ stalk]R ~ (indusium)

†*Dicksonia mariopteris:* [sporangium ~ stalk]R > (indusium cup)

†*Dictyophyllum* spp*:* [sporangium ~ stalk]R

†*Digitopteris repanda:* [sporangium ~ stalk]R

†*Discopteris* sp: [sporangium ~ stalk]R

†*Doneggia complura*: [sporangium ~ stalk]R

†*Drynaria propinqua*: [sporangium ~ stalk]R

†*Dvinopteridium edemskii*: sporangium ~ stalk

†*Eboracia lobifolia:* [sporangium ~ stalk]R > (indusium cup)

†*Elantodites turneri:* sporangium ~ stalk

†*Elaphoglossum miocenicum:* sporangium ~ stalk

†*Eocyathea remesaliae:* [sporangium ~ stalk]R > (indusium cup)

†*Geperapteris rotunda*: sporangiumR

†*Gleichenia chaloneri:* [sporangium ~ stalk]R

†*Gleichenipteris antarcticus:* [sporangium ~ stalk]R
*A stalk is not described in the fossil; we scored based on extant Gleicheniaceae.

†*Gleichenites nitida:* [sporangium ~ stalk]R

†*Hausmannia sinensis:* [sporangium ~ *stalk*]R
*A stalk is inferred by the authors.

†*Heinrichsia cheilanthoides:* [sporangium ~ stalk]R

†*Holttumopteris burmensis:* [sporangium ~ stalk]R > (indusium)

†*Hopetedia praetermissa:* [sporangium ~ stalk]R > (indusium)

†*Humata henryana:* [sporangium ~ stalk]R ~ (indusium)

Hymenophyllum asplenioides: [sporangium ~ stalk]R ~ (receptacle) > (indusium flap)R

†*Hymenophyllum iwatsukii:* [sporangium ~ stalk]R ~ (indusium flap)R

Hymenophyllum sp: [sporangium ~ stalk]^{R} > (indusium flap)^{R}
*A representative taxon for *Hymenophyllum* with a reduced receptacle; this is essentially similar to a standard filicalean sorus.

†*Kaplanopteris clavata:* [sporangium ~ stalk]^{R} > (indusium)

†*Kidstonia* sp: sporangium

†*Kidstoniopteris minor*: [sporangium ~ stalk]^{R}

†*Klukia exilis:* sporangium

†*Klukiopsis jurassica*: sporangium

†*Konijnenburgia alata*: sporangium^{R} ~ (indusium stalk | indusium shield)

†*Krameropteris resinatus*: [sporangium ~ stalk]^{R}

†*Kylikipteris arguta*: [[sporangium ~ stalk]^{R} ~ (indusium cup)]^{R} ~ (fertile rachis)
*Sori in this taxon occur on specialized fertile pinnae

†*Lophosoria* spp*:* [sporangium ~ stalk]^{R}

†*Lygodium bierhorstiana*: [sporangium ~ stalk > (indusium)]^{R} ~ (fertile pinnule lobe)

Lygodium flexuosum: [sporangium ~ stalk > (indusium)]^{R} ~ (fertile pinnule lobe)

Lygodium palmatum: [[sporangium ~ stalk]^{R} ~(indusium)^{R} ~ (fertile pinnule lobe)]^{R} ~ (fertile frond rachis element)]^{RR}

†*Makotopteris princetonensis*: [sporangium ~ stalk]^{R}

Marsilea quadrifolia: [[[microsporangium + megasporangium ~ stalk]^{R} > (indusium) ~ (fertile rachis element)]^{R} ~ (fertile rachis element) > (sporocarp envelope) ~ (sporocarp stalk)]^{R}
*This taxon has the same structure as other *Marsilea*, but the sporocarps occur in clusters.

Matonia pectinata: sporangium^{R} ~ (indusium stalk | indusium shield)

†*Matonia* spp: sporangium^{R} ~ (indusium stalk | indusium shield)

†*Matonidium goepperti*: sporangium^{R} ~ (indusium stalk | indusium shield)

Matteuccia struthiopteris: [[sporangium ~ stalk]^{R} ~ (indusium)]^{R} ~ (fertile pinnule)]^{R} ~ (frond rachis)

†*Norwoodia angustum*: [sporangium ~ stalk]^{R}
*Sporangia in this taxon can be either isolated or in loose clusters, although it is described as soral. We treat as having sori.

†*Oligocarpia kepingensis:* [sporangium ~ *stalk*]^{R}
*There is no mention of a stalk in this taxon, but it is unlikely to be preserved in this case. We score as potentially stalked, following other *Oligocarpia*.

†*Oligocarpia lindsaeoides:* [sporangium ~ stalk]^{R}

Onoclea sensibilis: [[sporangium ~ stalk]^{R} ~ (indusium) ~ (fertile pinnule lobe)]^{RR} ~ (frond rachis)

†*Onychiopsis psilotoides:* [[sporangium ~ stalk]^{R} ~ (indusium | indusium stalk)]^{R} ~(fertile rachis)

*We score the fertile sections of the frond as dedicated fertile pinna.

†*Osmunda (Claytosmunda) claytoniites:* [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RR}

Osmunda regalis/Osmundastrum cinnamomea: [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RRR}

†*Osmundopsis plectophora/zunigai:* [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RRR}

†*Osmundopsis rafaelii:* [sporangium ~ stalk]^{R}

†*Osmundopsis sturi:* [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RR}

†*Paleoazolla patagonica*: [microsporangium ~ stalk]^{R} > (microsporangiate indusium)]^{R} + megasporangium > (megasporangiate indusium) ~ (sporophore element)^{R} > *sporocarp envelope*
*Although not directly preserved, we assume the sori were borne on a branched axial element. The scoring of the stalks follows modern *Azolla*; it is not known if an envelope would have been present.

†*Paralygodium vancouverensis:* [[sporangium ~ stalk]^{R} ~ (fertile pinnule lobe)^{R}]^{R} ~ (fertile frond rachis)
*Lobed pinnules in clusters of three; we score the fertile pinnule has formed entirely by repeated lobes. Higher order compounding is likely but unknown; not scored for arrangement analysis.

†*Pekinopteris articulata:* sporangium ~ stalk

Phanerosorus sarmentosus: sporangium^{R} ~ (indusium stalk | indusium shield)

†*Phlebopteris* spp: sporangium^{R}

†*Phlebopteris woodwardi*: sporangium^{R} ~ (indusium stalk | peltate shield)

Pilularia globulifera: [[microsporangium + megasporangium ~ stalk]^{R} > (indusium) ~ (fertile rachis element)]^{R} ~ (fertile rachis element) > (sporocarp envelope) ~ (sporocarp stalk)

Polybotrya cervina: [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RR}

Polybotrya fractiserialis: [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{R}

Polybotrya osmundacea: [[sporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RRR}

†*Polyphacelus stormensis:* [sporangium ~ stalk]^{R}

†*Polypodium radionii:* [sporangium ~ stalk]^{R}

†*Proodontosoria myanmariensis:* [sporangium ~ stalk]^{R} > (indusium)

†*Prynadaeopteris karpovii*: sporangium^{R}

†*Psalixochlaena cylindrica*: [sporangium ~ stalk]^{R}
*Sporangia in this taxon are mostly solitary, but can occur in pairs.

†*Pterisorus radiata:* [sporangium ~ stalk]^{R}

Regnellidium diphyllum: [[microsporangium + megasporangium ~ stalk]^{R} > (indusium) ~ (fertile rachis element)]^{R} ~ (fertile rachis element) > (sporocarp envelope) ~ (sporocarp stalk)

†*Regnellidium upatoiensis*: [[microsporangium + megasporangium ~ stalk]^{R} > (indusium) ~ (fertile rachis element)]^{R} ~ (fertile rachis element) > (sporocarp envelope) ~ (sporocarp stalk)
*Not all features are preserved, but I score as extant *Regnellidium*.

†*Rooitoides pulchra:* sporangium ~ stalk

†*Ruffordia goeppertii*: [[[sporangium ~ stalk]^{R} ~ (fertile pinnule)]^{R} ~ (fertile pinna rachis)]^{R}

Salvinia minima: [[[microsporangium + megasporangium ~ stalk]^{R} > (indusium) ~ (sporophore element)]^{R}
*In this taxon, each sorus is subtended by a small stalk that we score as part of a larger sporophore branching system due to similarity in size.

Schizaea dichotoma: [sporangium^{R} ~ (fertile pinnule)]^{R}

Schizaea fistulosa: [sporangium^{R} ~ (fertile pinnule)]^{R} ~ (fertile rachis)

†*Schizaeopsis ekrtii:* sporangium^{R} ~ (fertile pinnule)
*The fertile pinnule listed here is the specialized portion of the leaf that bears sporangia. We consider it distinct from the vegetative tissue.

†*Scolopendrites scolopendroides:* sporangium

†*Selenocarpus muensterianus*: sporangium^{R}

†*Senftenbergia oregonensis:* sporangium ~ stalk

†*Senftenbergia plumosa:* [sporangium ~ stalk]^{R}

†*Sergioa austrina:* [sporangium ~ stalk]^{R}

†*Sermaya biseriata*: sporangium^{R}

†*Sonapteris pilsensis*: [sporangium ~ (fertile axial element)]^{RRRR} ~ (amphlebia)

†*Speirseopteris orbiculata*: [sporangium ~ stalk]$^{R\,|}$

†*Stachypteris spicans*: sporangium^{R} ~ (fertile pinnule)

†*Sturia* sp: sporangium

†*Szea sinensis:* sporangium^{R}

†*Tedelea glabra:* [sporangium ~ stalk]^{R}

†*Tenchovia bulgariensis*: sporangium^{R}

†*Thaumatopteris schenki:* [sporangium ~ stalk]^{R}

†*Thelypteris* sp: [sporangium ~ stalk]^{R} ~ (indusium)

†*Thyrsopteris cretacea:* [[[sporangium ~ stalk]^{R} ~ (indusium cup | indusium stalk)]^{R} ~ (fertile rachis element)]^{R}
*We score as modern *Thyrsopteris*, although higher order fertile rachides are not known in the fossil.

Thyrsopteris elegans: [[[sporangium ~ stalk]^{R} ~ (indusium cup | indusium stalk)]^{R} ~ (fertile rachis element)]^{R}

†*Todea amissa:* sporangium ~ stalk

†*Todites* spp: sporangium ~ stalk

†*Tomaniopteris katonii*: [sporangium ~ stalk]^{R} ~ (indusium stalk | indusium shield)

†*Tumidopteris clavata*: sporangium^{R}

†*Weichselia reticulata:* [[sporangium^{R} ~ (indusium stalk | indusium shield)]^{RR} ~ (fertile rachis element)]^{R}
*We score this as a fertile frond with multiple pinnae, but that is an interpretation based on the orientation of pinnae.

†*Wingatea plumosa*: [sporangium ~ stalk]^{R} > (indusium)

†*Woodwardia virginica*: [sporangium ~ stalk]^{R} ~ (indusium)

9. Progymnosperms†

Vegetative and wood anatomy (e.g., the presence of a bifacial cambium) suggests that these free-sporing euphyllophytes are more closely related to seed plants than to extant monilophytes. Relationships within and between members of the group are uncertain, and they are likely paraphyletic. Here we score taxa from three general subgroups: aneurophytes, archaeopterids, and Noeggerathiales. These groups generally have different types of reproductive structures: aneurophytes produce pinnate fertile complexes, archaeopterids generally produce a fertile shoot bearing loosely arranged sporophylls, and Noeggerathiales produce compact strobili with sporangia borne on sporophylls. The relationships of several taxa (*Cecropsis*, *Protopitys*) are uncertain, but they are here provisionally grouped with archaeopterids. Both archaeopterids and Noeggerathiales are heterosporous, while aneurophytes are homosporous.

Aneurophytes

Aneurophyton doui: [sporangium ~ stalk ~ (fertile rachis element)]^{RRR} ~ fertile rachis element
*As in *Tetraxylopteris*, the sporangia are borne in a pinnate complex of rachides/axes. For the purposes of this analysis, we treat this complex as a single cluster rather than dividing it into several pinnate orders as the authors do (Jiang et al. (2013). Although this division is entirely justified from a structural perspective, in practice these complexes form single aggregations of sporangia. These clusters are then borne on a larger rachis, which is in turn borne on a fertile axis. I do not treat the rachis and fertile axis elements as separate METs, because they appear as a gradiation of axes with the distal pinnate elements.

Rellimia thomsonii: [microsporangium^{R} ~ stalk ~ (fertile rachis element)]^{RRRR} ~ fertile rachis element
*We scored as similar in architecture to *Tetraxylopteris* following Hammond and Berry (2005), although in this taxon the sporangia are clustered.

Tetraxylopteris schmidtii: [[microsporangium ~ stalk ~ (fertile rachis element)]^{RRRR} ~ fertile axis
*We score following the interpretation in Hammond and Berry (2005), although we treat the pinnate clusters as only one order of branching as in *Aneurophyton*. This cluster is repeated on a branch of the fertile appendage, which is in turn repeated to create the entire fertile appendage. Lastly, the appendage is then repeated around a fertile axis.

Triloboxylon ashlandicum: [microsporangium ~ stalk ~ (fertile rachis element]^{RR}

Archaeopterids

Archaeopteris halliana: [microsporangium or megasporangium ~ stalk]^{R} ~ (bifurcating sporophyll element^{R})
*Fertile shoots in this species include sterile foliage as well; thus it is not scored as having a separate fertile axis.

Archaeopteris roemeriana: [[microsporangium or megasporangium ~ stalk]^{R} ~ (bifurcating sporophyll element^{R})]^{R} ~ (fertile axis)
*This species has dedicated fertile shoots that produce only sporophylls.

Cecropsis lucilentum: [microsporangium or megasporangium]^{R}

Protopitys scotica: [[microsporangium or megasporangium ~ stalk ~ (fertile rachis element)]^{RRRR} ~ fertile rachis element
*The morphology of this taxon is not fully described; we score as *Tetraxylopteris* based on general description in Decombiex et al. (2015). In both taxa, we consider the main fertile branch to be the same MET as the fertile pinnate branching structures that it bears.

Svalbardia furcihasta: [[microsporangium or megasporangium ~ stalk]^{R} ~ (bifurcating sporophyll element^{R})]^{R} ~ (fertile axis)

Noeggerathiales

Discinites sinensis: [[microsporangium or megasporangium ~ stalk]^{R} ~ (bract cup | bract free tip^{R})]^{R} ~ (strobilus axis)

Dorsalistachya quadrisegmentorum: [microsporangium or megasporangium ~ (proximal lamina | distal lamina^{R})]^{RR} ~ (strobilius axis)

Lacoea seriata: [microsporangium^{R} ~ (bract cup | bract free tips^{R})]^{R} ~ (strobilus axis)

Noeggerathiaestrobus bohemicus: [microsporangium^{R} or megasporangium^{R} ~ (bract cup | bract free tip^{R})]^{R} + (sterile bract)^{R} ~ (strobilus axis)

Paratingia wudensis: [microsporangium^{R} or megasporangium^{R} ~ (bract cup | bract free tip^{R})]^{R} ~ (strobilus axis)

Tingia unita: [microsporangium^{R} or megasporangium^{R} ~ (bract)]^{R} ~ (strobilus axis)
* sporophylls arranged in verticels, which I am not scoring as multiple clusters in general.

Tingiostachya tetralocularis: [[microsporangium^{R} ~ (sporophyll pedicel "alation cup" | sporophyll lamina)]^{R} ~ (strobilus axis)]^{R} + (sterile bract)^{R}

10. Free-sporing incertae sedis†

These taxa include a range of forms from seed-like megasporangiate structures whose affinities are unresolved to microsporangiate structures that may either be early ferns or pollen-organs from seed plants. Of particular note, *Runcaria* may be a stem seed plant and *Sphinxiocarpon* and *Suavitas* have been linked with lycophytes. Incertae sedis taxa are included in compilations of MET number through time but are not shown on group plots.

Lugardonia paradoxa: [sporangium^{R} ~ stalk]^{R} ~ (fertile axis)

Rhacopteris paniculifera: [sporangium^{R} ~ (fertile axis element)]^{RRR}

Runcaria heinzelinii: [megasporangium ~ (integument lobe^{R}) ~ (cupule | cupule lobe^{R}) ~ (dichotomous branch element)]^{R}
*The interpretation of the "integument" is somewhat uncertain and the lobes may represent some kind of degradation artifact. But here we follow the authors.

Sphinxiocarpon wuhanium: megasporangium ~ (sporophyll envelope | papilla^{R})
*The interpretation of this taxon is somewhat uncertain; it appears that a sporophyll-derived envelope partially covers the megasporangium.

Suavitas imbricata: [megasporangium ~ (sporophyll basal flare | sporophyll distal flare | apical flap element^{R})]^{R} ~ (strobilus axis)

Zeilleria avoldensis: sporangium^{R} ~ stalk

Zimmermannitheca cupulaeformis (micro): [sporangium^{R} ~ (dichotomous branch element)]^{R}

Seed Plant Euphyllophytes

11. Early seed plants†

This grouping includes the earliest seed plants ("hydraspermans") from the Late Devonian, as well as early "pteridosperm" groups including the Lyginopteridales and Medullosales from the Carboniferous. These groups generally have a well-developed pollen chamber and produce "prepollen", meaning pollen has a spore-like haptotypic mark and proximal germination. This grouping is almost certainly paraphyletic and possibly polyphyletic, although extact relationships among the groups are unstable. Most analyses resolve these groups as branching prior to all crown gymnosperms and likely fossil relatives (*11,12*). These early groups generally produce ovules or cupules on what is interpreted as a fertile frond, so the axial elements are here referred to as fertile rachides. For Carboniferous taxa in particular, the attachment of ovules to the parent plant is often unknown due to preservation. We score several taxa for the possibility that they produced a fertile rachis system, because this feature is widespread among taxa with better preservation. However, we generally did not score these taxa for arrangement characters A1-A6 because their exact organization is not preserved.

Albertlongia incostata (mega): megasporangium ~ (integument | ovule stalk) ~ (*fertile rachis element*)
*As in many Carboniferous ovules, it is unclear if the ovule is solitary on a leaf or borne on a fertile rachis system. As noted above, we score this taxon to include the possibility of a fertile rachis for use in MET analyses, but do not score for arrangement characters.

Angaranthus victorii (micro): [microsporangium ~ stalk]^{R} ~ (fertile rachis element)]^{RR}

Archaeosperma arnoldii (mega): [[megasporangium ~ (integument | papilla^{R} | integument lobes^{R} | ovule stalk) ~ (cupule blade | cupule lobe^{RR})]^{R} ~ (fertile rachis element)]^{R}
*The cupules of the earliest seed plants are difficult to consistently score. We here score *Archaeosperma*,

Elkinsia, *Moresnetia*, and *Xenotheca* as having a similar structure consisting of a swollen fertile cupule blade bearing multiple orders of unevenly sized lobes that is repeated four times to form a cupule. Although the base of each cupule blade is narrow and virtually indistinguishable from the subtending dichotomous fertile rachis element, we do not consider the rachis proper to begin until below the dichotomies that give rise to the cupule.

Aulacotheca iowensis (micro): [microsporangium^{R} ~ (fertile rachis element)]^{RR}
*We score this taxon as pinnate system with lateral rachides.

Bernaultia formosa (micro): microsporangium^{RR} ~ (synangium ground mass | synangium ridges^{R} | synangium stalk)
*The groundmass tissue in this synangium is here scored as forming a single BSU, but there appears to be some internal organization of repeating fertile areas; we scored as two orders of clustering, analogous to multiple locules within a single ovary. *Dolerotheca* is not scored in this study, as it is likely a compression of *Bernaultia*.

Calathospermum fimbriatum (mega): [megasporangium ~ (integument | integument lobe^{R} | ovule stalk)]^{R} ~ (basal cupule lobe | distal cupule lobe^{R})^{R} + (sterile pinnule elements)^{RR} ~ (fertile rachis)
*As with other taxa whose cupules are formed from dichotomizing elements, defining parts is somewhat difficult. Here we consider the cupule to have two basal lobes, which then dichotomize into additional lobes. Some ovules appear to be born on slightly more distal parts of this dissected structure, but for simplicity, I score them all as simply repeated at the base of the structure.

Codonospermum anomalum (mega): megasporangium ~ (integument | micropylar funnel | chalazzal rim | ovule stalk$^{!}$) ~ (*fertile rachis element*)

*Exact arrangement on parent plant is unknown; not scored for A1-A6. The distal portion of this ovule includes an apparent air chamber; we score this feature as similar to a locule in angiosperms by considering projections into that space as the MET that defines it. In this case, the space is defined by a projection of the integument at the chalazzal end of the nucellus ("chalazzal rim") that forms a partition.

Codonotheca caduca (micro): [microsporangium^{R} ~ (synangium lobe^{R} | synangium base) ~ (fertile rachis element)]^{RR}
*Taxon described as producing a pinnate fertile rachis.

Conostoma villosum (mega): megasporangium ~ (integument | integument projection^{R}) ~ (*fertile rachis element*)
*Exact arrangement on parent plant is unknown; not scored for A1-A6.

Cornutheca glandulosa (micro): [microsporangium^{R} ~ (synangium | capitate gland^{R}) ~ (fertile rachis element)]^{R}

Cosmosperma polyloba (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Crossotheca sagittata (micro): [[microsporangium^{R} ~ (fertile pinnule)]^{R} ~ (fertile rachis)]^{R}

Dichotangium quadrothecum (micro): [[SE: microsporangium^{R} ~ synagium pad]^{R} ~ (fertile rachis element)]^{R}

Dorinnotheca streeli (mega): megasporangium ~ integument lobe^{R} ~ (cupule | cupule lobe^{R} | lobe tip^{RR})]^{R} ~ (fertile (rachis element)]^{RR}

Elkinsia polymorpha (mega): [[megasporangium ~ (integument | integument lobe^{R} | ovule stalk) ~ (cupule blade | cupule lobes^{RR})]^{R} ~ (fertile rachis element)]^{R}

Elkinsia polymorpha (micro): [microsporangium^{R} ~ (fertile rachis element)]^{RR}

Eonotosperma arrondoi (mega): megasporangium ~ (integument lobe^{R} | ovule stalk)

Feraxotheca culcitas (micro): [microsporangium^{R} ~ synangium pad ~ (fertile rachis element)]^{RR}

Geminitheca scotica (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Geminitheca scotica (mega): [megasporangium ~ (integument | integument lobes^{R} | ovule stalk)]^{R} ~ (cupule | cupule lobe^{R}) + emergence^{R} ~ (fertile rachis element)]^{R}

Genomosperma kidstonii (mega): megasporangium ~ (integument lobe^{R} | ovule stalk)]^{R} ~ cupule ~ (*fertile rachis element*)
*Unknown if this taxon was born on a dichotomizing axis system, although it seems likely given other early pteridosperms with similar morphology. This taxon was not scored for A1-A6.

Gnetopsis elliptica (mega): [[megasporangium ~ (integument | {arm spine^{R} ~ integument arm}^{R})]^{R} ~ (cupule lobe^{R} ~ cupule blade)]^{R} ~ (*fertile rachis element*)
*The ovules of this taxon are described are essentially sessile, but are depicted as having a short stalk. I follow the description and do not record a stalk. The taxon likely produced clusters of cupules, but it is not known for certain; we do not score for arrangement analysis.

Gnetopsis hispida (mega): [[megasporangium ~ (integument | {arm spine^{R} ~ integument arm}^{R})]^{R} ~ (cupule lobe^{R} ~ cupule blade)]^{R} ~ (*fertile rachis element*)
*Only the ovules of this taxon are well known, but we score the entire structure score as *G. elliptica* (which is consistent with isolated cupules).

Halletheca reticulata (micro): microsporangium^{R} ~ (synangium groundmass | synangium stalk)

Hexaloba finisensis (mega): megasporangium ~ (integument | integument rib^{R}) ~ (*fertile rachis element*)

*Exact arrangement unknown; we do not score for arrangement characters A1-A6.

Hexapterospermum delevoryii (mega): megasporangium ~ (integument | integument rib^{R}) ~ (*fertile rachis element*)
*Exact arrangement unknown; we do not score for arrangement characters A1-A6.

Lagenostoma ovoides (mega; ovule with *Calymmatotheca haueri* cupule architecture): [megasporangium ~ (integument | integument lobes^{R}) ~ (cupule | cupule lobes^{R} | {glandular head ~ glandular stalk}^{R}) ~ (fertile rachis element)]^{RRR}
*This taxon produces two cupules per forking "pinna", which is in turn repeated along a rachis. This rachis is then repeated to form a forking structure.

Latisemenia longshania (mega): [megasporangium ~ (integument | integument lobe^{R} | ovule stalk) ~ (cupule lobe^{R})]^{R} ~ (fertile rachis)

Melissiotheca sp (micro): [microsporangium^{R} ~ (synangium cushion lobe^{R} | synangium stalk)

Moresnetia zalesskyi (mega): [[megasporangium ~ (integument lobe^{R} | ovule stalk) ~ (cupule blade | cupule lobes^{RR})]^{R} ~ (fertile rachis element)]^{R}

Murielatheca delicata (micro): microsporangium^{R} ~ (synangium groundmass | synangium stalk)

Ocllou cesarina (micro): [microsporangium^{R} ~ (fertile rachis element)]^{RRR}

Ocllou cesarina (mega): [megasporangium ~ (integument | integument lobe^{R} | gland^{RR}) ~ (fertile rachis element)]^{R}

Ovulipteris (Ilfeldia) gregoriensis: sporangium^{R}

Pachytesta gigantea (mega): megasporangium ~ (integument) ~ (*fertile rachis element*)

Pachytesta vera (mega): megasporangium ~ (integument | integument rib^{R}) ~ (*fertile rachis element*)
* *Pachytesta* ovules are often thought to have been borne on vegetative fronds in place of pinnules, but the only medullosan ovule whose attachment is known in detail (*Stephanospermum*) produced them on a fertile rachis. We therefore score METs to allow the possibility that *Pachytesta* was likewise produced on a fertile rachis, although we score *Pachytesta* as borne directly on the leaf for arrangement analyses, reflecting the general consensus of their arrangement.

Parasporotheca leismanii (micro): [microsporangium^{R} ~ (synangium groundmass) ~ (fertile rachis element)]^{RR}
*The stalk of the syangium in this taxon does not appear in reconstructions as fundamentally different than the fertile rachis elements.

Parkvillia northcuttii (micro): microsporangium^{R} ~ (synangium rim) ~ (fertile rachis element)]^{RR}

Phacelotheca pilosa (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Placotheca minuta (micro): microsporangium^{R} ~ synangium pad ~ (fertile rachis element)
*The synangial pad is well developed in this taxon, although we do not treat it as a separate BSU. We score as borne on a fertile rachis element based on other contemporaneous taxa, although this is not known for certain.

Polylophospermum stephanense (mega): megasporangium ~ (integument | internal micropylar funnel | ovule stalk) ~ (*fertile rachis element*)

Polypterospermum renaultii (mega): megasporangium ~ (integument | integument rib^{R}) ~ (*fertile rachis element*)

Potoniea bechii (micro): [microsporangium^{RR} ~ (synangium groundmass) ~ (fertile rachis element)]^{RR}

Pseudosporogonites bertrandii (mega): megasporangium ~ (integument | integument lobe^{R} | ovule stalk) ~ (cupule | cupule lobe^{R}) ~ (fertile rachis element)

Pseudosporogonites hallii (mega): megasporangium ~ (integument | integument lobe^{R} | ovule stalk) ~ (cupule | cupule lobe^{R}) ~ (fertile rachis element)]^{R}

Pullaritheca longii (mega): [megasporangium ~ (integument | integument lobe^{R})]^{R} ~ ({distal cupule lobe^{R} ~ basal cupule lobe}^{R} | cupule stalk)

Rhetinotheca tetrasolenata (micro): microsporangium^{R} ~ (synangium groundmass) ~ (fertile rachis element)]^{R}
*There is limited evidence for exactly how *Rhetinotheca* was borne, but various authors describe it as borne in a cluster on some sort of primary axis.

Ruxtonia minuta (mega; biovulate): [megasporangium ~ (integument | integument lobe^{R} | ovule stalk)]^{R} ~ ({distal cupule lobe^{R} ~ basal cupule lobe}^{R} | cupule stalk)
*The bi-ovulate form is scored here like *Pullaritheca*; it has initial split into two main cupule base lobes, each of which bears an ovule, and each of which has further lobes.

Saharatheca lobata (micro): microsporangium^{R} ~ (synangium lobe^{R} | synangium stalk)
*We scored this taxon as three synangium lobes without any extra central tissue.

Stamnostoma huttonense (mega): [megasporangium ~ (integument) ~ (fertile rachis element)]^{RR}

Stamnostoma oliverii (mega): megasporangium ~ (integument | papilla^{R} | micropylar funnel) ~ (fertile rachis element)]^{RR}
*The cupule lobes of this taxon are not clearly distinguishable from the dichotomizing fertile rachis system subtending it; the ovules are therefore scored as occurring on a dichotomous system with two orders of compounding.

Stephanospermum konopeonus (mega): [megasporangium ~ (integument | integument wing^{R} | integument funnel) ~ (fertile rachis element)]^{R}

Stewartiotheca warrenae (micro): microsporangium^{R} ~ (synagium groundmass | dehiscence tissue lobe^{R} | synangium stalk)

Sullitheca dactylifera (micro): microsporangium^{R} ~ (synangium groundmass | synangium stalk)

Telangiopsis schweitzerii (micro): [microsporangium^{R} ~ synangium pad ~ (fertile rachis element)]^{R}
*Some early pteridosperm pollen organs have a slightly inflated basal region; we score them as an MET but not a BSU.

Telangiopsis sp (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Telangium sp (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Thorezia vezerensis (mega): [[megasporangium ~ (integument | integument lobe^{R} | ovule stalk) ~ (cupule lobe^{R})]^{R} ~ (fertile rachis element)]^{R}
*This taxon has the same basic structure as *Moresnetia*, but the cupule lobes are so deeply dissected that there is no real blade.

Tyliosperma orbiculatum (mega): megasporangium ~ (integument | integumentary lobe^{R}) ~ (cupule | cupule lobe^{R})

Vallitheca valentia (micro): microsporangium^{R} ~ (synangium groundmass | synangium stalk)

Whittleseya elegans (micro): microsporangium^{R} ~ (synangium stalk/fertile element rachis)

Xenotheca devonica (mega): [megasporangium ~ (integument lobe^{R} | ovule stalk) ~ (cupule blade | cupule lobe^{RR})]^{R} ~ (fertile rachis element)]^{R}

12. Derived "pteridosperms" †

Here we use the term "pteridosperms" broadly to include unplaced Paleozoic and Mesozoic seed plant groups. This polyphletic grouping includes many different lineages, such as Caytoniales, Corystospermales, Erdmannithecales, Glossopteridales, Peltaspermales, and several others. As befitting this unnatural grouping, these taxa display a wide diversity of specific staminate and ovulate morphologies. Relatioships among these groups are poorly resolved and understood, but we have pulled some of the larger, and likely monophyletic, subgroups out for separate group analysis, including Peltaspermales, Glossopteridales, and Corystospermales.

12.1 Unresolved "pteridosperms" †

Alexia urceolus (mega): [megasporangium ~ (integument | micropylar funnel)]^{R} ~ (strobilus axis)

Amydostrobus groenlandicus (micro): microsporangium^{R} ~ (sporophyll pedicel | sporophyll lamina)^{R} ~ (strobilus axis)

Avatia bifurcata (mega): [megasporangium ~ (integument | integument wing^{R})]^{R} ~ (sporophyll head) ~ (fertile axis element)]^{R}
*Here we consider the described "megasporophyll pedicel" as equivalent to a fertile axis element.

Bayeritheca hughesii (micro): [[microsporangium^{R} ~ synangium stalk]^{R} ~ (sporophyll head | sporophyll stalk | tubercle^{R})]^{R} ~ (strobilus axis)

Bernettia phialophora (micro): [microsporangium^{R} ~ (sporophyll stalk | distal shield | nub)]^{R} ~ (strobilus axis)

Callospermarion pusillum (mega): megasporangium ~ (integument | integument wing^{R})

Callospermarion undulatum (mega): megasporangium ~ (integument | integument bump^{R})

Carnoconites compactus (mega): [[megasporangium ~ (integument | raised micropyle)]^{R} ~ (sporophyll/peduncle)]^{R} ~ (strobilus axis)
*For *Carnoconites*, we follow the interpetation of Rothwell and Serbet (1994) as consisting of linear sporophylls arranged around an axis. Raised micropyle based on description of *C. cranwellii*.

Carnoconites cranwellii (mega): [[megasporangium ~ (integument | raised micropyle)]^{R} ~ (sporophyll/peduncle)]^{R} ~ (strobilus axis)
*This taxon is described as producing a raised micropyle, which we consider a separate MET.

Caytonanthus arberi (micro): [microsporangium^{R} ~ (fertile rachis element)]^{RR}

Caytonia nathorstii (mega): [[megasporangium ~ (integument | ovule stalk)]^{R} ~ (cupule | cupule lip | cupule stalk)]^{R} ~ (fertile rachis)

Creberanthus bealeii (micro): [microsporangium^{R} ~ (synangium groundmass | synangium stalk)]^{R} ~ (strobilus axis)
*Individual sporangia are not clearly visible in the synangium; we therefore assume some kind of specialized groundmass tissue was present.

Dechellyia gormani (mega): [[megasporangium ~ (integument) ~ (sporophyll/wing)]^{R} + (sterile scale)^{R} ~ (strobilus axis]^{R}

Dordrechtites arcanus (mega): [[megasporangium ~ (integument | micropylar projection)]^{R} ~ (cupule | arm)]^{R} ~ (strobius axis)

Dordrechtites elongatus (mega): [[megasporangium ~ (integument | *micropylar projection*)]^{R} ~ (cupule | wing^{R} | arm)]^{R} ~ (strobilus axis)
*Ovular structure not known; scored as in *D. arcanus.*

Dordrechtites macrocirrus (mega): [[megasporangium ~ (integument | *micropylar projection*)]^{R} ~ (cupule | | arm)]^{R} ~ (strobilus axis)
*Ovular structure not known; scored as in *D. arcanus.*

Drepanolepis cf. angustior (mega): [megasporangium ~ (integument) ~ (fertile scale) > (bract)]^{R} ~ (strobilus axis)

Emplecopteris triangularis (mega): megasporangium ~ (integument | integument horn^{R} | ovule stalk)

Eosteria eosterianthus (micro): [microsporangium ~ stalk]^{R} ~ (strobilus axis)

Erdtmanitheca spp (micro): [microsporangium^{R} ~ (sporophyll pedicel | peltate shield)]^{R} ~ (strobilus axis)

Eremopteris artimesiaefolia (mega): megasporangium ~ (integument | integument wing^{R} | micropylar horn^{R} | pedicel)

Eucommiitheca hirsuta (micro): [microsporangium^{R} ~ (sporophyll pedicel | peltate shield)]^{R} ~ (strobilus axis)

Fredianthus maysiformis (micro): [SE: microsporangium^{RR} ~ (sporophyll pedicel | distal lamina | distal lamina lobe^{R})]^{R} ~ (strobilus axis)

Geminispermum virginianum (mega): [megasporangium ~ (integument | micropylar lobe^{R}) ~ (cupule) > (bract)]^{R} ~ (fertile unit stalk)
*It is somewhat difficult to say whether the fertile unit stalk should be considered as separate BSU. I score as an organ-level structure (e.g., it is presumably the remains of an axis).

Helvetianthus tintinnabulum (micro): microsporangium^{RR} ~ (strobilus axis)

Hercynostrobus digitalis (micro): [[microsporangium ~ (pedicel element)]^{R} ~ (bract)]^{R} ~ (strobilus axis)

Hydropterangium roesleri (micro): [microsporangium^{RR} ~ (capsule lobe^{R} | capsule stalk)]^{R} ~ (strobilus axis)

Idanothekion callistophytoides (micro): microsporangium^{RR}

Ixostrobilus groenlandicus (micro): [microsporangium^{R} ~ (sporophyll)]^{R} ~ (strobilus axis)

Ixostrobilus longicalcaratus (micro): [microsporangium^{R} ~ (sporophyll stalk | distal spine)]^{R} ~ (strobilus axis)

Kannaskoppia vincularis (mega) [[[megasporangium ~ (integument | integument tube)]^{R} ~ (cupule | cupule stalk)]^{R} ~ (fertile axial element)]^{R}
*Ovule morphology scored as *Petriellaea*

Kannaskoppianthus lutinumerus (micro): [[microsporangium^{R} ~ (microsporophyll head | microsporophyll pedicel)]^{R} ~ (fertile axial element)]^{R}

Ktalenia circularis (mega): [[megasporangium ~ (integument)]^{R} ~ (cupule | raised cupule pore | cupule stalk)]^{R} + (fertile leaf lobe)^{RR} ~ (fertile axis)

Lepidopteris ottonis (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R} ~ fertile rachis element

Lepidopteris ottonis (mega): [[megasporangium ~ (integument$^{!}$ | integument tube)]^{R} ~ (ovulate disc | downwards flap^{R} | stalk)]^{R} ~ (*fertile axis*)

Leptostrobus cancer (mega): [[megasporangium ~ (integument)]^{RR} ~ ([valve lip ~ sporophyll valve]^{R} | capsule stalk)]^{R} + (bract)^{R} ~ (strobilus axis) > bud bract^{R}
*The bud bracts at the base of the strobilus appear similar to sterile bracts on the basal portion of the cone axis, and are treated as the same MET.

Leptostrobus sphaericus (mega): [[megasporangium ~ (integument)]^{RR} ~ ([valve lip ~ sporophyll valve]^{R} | capsule stalk)]^{R} + (*bract*)^{R} ~ (strobilus axis)
*Bracts are not preserved, but are inferred.

Lutanthus hemidiscus (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Lutanthus ornatus (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina | lamina lobe^{R})]^{R} ~ (strobilus axis)

Lutanthus robustus (micro): [microsporangium^{RR} ~ (sporophyll pedicel | distal lamina | lamina lobe^{R})]^{R} ~ (strobilus axis)

Masculostrobus clathratus (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Mooia lidgettonioides (mega): megasporangium ~ (integument) ~ (megasporophyll | megasporophyll lobes^{R} | megasporophyll pedicel)]^{R} ~ (fertile leaf)

Nidpuria falcatum (micro): [microsporangium^{R} ~ (microsporophyll)]^{R} ~ (strobilus axis)

Nystroemia pectinata (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R}

Nystroemia pectinata (mega): [[megasporangium ~ (integument$^{!}$ | integument horn^{R})]^{R} ~ (fertile rachis element)]^{R}

Odyssianthus crenulatus (micro): [microsporangium^{RR} ~ (sporophyll pedicel | *pedicel keel* | distal lamina)]^{R} ~ (strobilus axis)
*A keel is described as a separate part of the microsporophyll, although we see little evidence of it as figured; we score as possible.

Ottokaria sanctae-catharinae (mega): [megasporangium ~ (integument)]^{R} ~ (receptacle | receptacle lobe^{R} | receptacle stalk)

Paravojnovskya imbricata (mega): [megasporangium ~ (integument | integument wing | ovule stalk)]^{R} + (scale)^{R} ~ (strobilus axis)

Petriellaea triangulata (mega) [[[megasporangium ~ (integument | integument tube)]^{R} ~ (cupule | cupule stalk)]^{R} ~ (fertile axis element)]^{R}

Polyspermophyllum sergii (mega): megasporangium ~ (integument | micropylar arm^{R}) ~ (ovule cover) ~ (fertile axis element)]^{R}

Reymanownaea kvacekii (mega): [[megasporangium ~ (integument | ovule stalk)]^{R} ~ (cupule | cupule stalk)]^{R} ~ (fertile axis)
*Neither the ovule stalk nor the fertile axis/rachis is preserved, but I score as *Caytonia* due to close similarity in overall structure.

Sahnia laxiphora (micro): [[microsporangium ~ stalk]^{R} ~ (sporophore element)]^{RR} ~ (receptacle) + (bract)^{R}

Schmeissneria microstachys (micro): [microsporangium^{R} ~ (fertile axis element)]^{R} ~ fertile axis element

Schmeissneria microstachys (mega): [[megasporangium ~ (integument | wing) ~ (cupule ridge^{R})]^{R} ~ (fertile axis element)]^{R} ~ fertile axis element
*The cupule is a strongly ribbed structure; rather than scoring that as two separate METs (the cupule body plus ridges), we score as a repeated (and fused) ridge element. This is similar to how we score angiosperm ovaries formed from partially fused carpels.

Semionandra laxa (micro): [microsporangium^{R} ~ stalk]^{R} ~ (fertile axis) > (bud scale)^{R}

Semionogyna bracteata (mega): [megasporangium ~ (integument | micropylar beak) ~ (bract)]^{R} ~ (fertile axis)

Sorosaccus gracilis (micro): [microsporangium^{R} ~ (sporophyll stalk | lamina)]^{R} ~ (fertile axis)

Stachyopitys matatilongus (micro): [microsporangium^{R} ~ (branching fertile element]^{RR} ~ (fertile axis) > (*bud scale)*^{R}
*This structure is known to be produced on a fertile short shoots; there would likely have been fertile bud scales.

Stachyopitys maziramus (micro): [microsporangium^{R} ~ (branching fertile element)]^{R} > (bud scale)^{R}

Stenomischus athrous (micro): [microsporangium^{R} ~ (microsporophyll stalk | microsporophyll lamina)]^{R} ~ (fertile axis)

Trichopitys heteromorpha (mega): [megasporangium ~ (integument) ~ (branching fertile element)]^{R}

Umaltolepis mongolica (mega): [megasporangium ~ (integument | wing)]^{R} ~ (shield lobe^{R} | central column | expanded base | stalk)

Vladimaria octopartita (mega): [megasporangium ~ (integument | wing)]^{R} ~ (sheild lobe^{R} | central column | expanded base | stalk)

12.2 Peltaspermales†

Antevsia mazenodensis (micro): microsporangium^{RR} ~ (fertile rachis element)]^{R}

Antevsia zeilleri (micro): microsporangium^{R} ~ (fertile rachis element)]^{RR}

Autunia confera (mega): [megasporangium ~ (integument) ~ (sporophyll | sporophyll ridge^{R} | sporophyll pedicel)]^{R} ~ (strobilus axis)

Callipterianthus arnhardtii (micro): [[microsporangium^{R} ~ (fertile pinnule)]^{R} ~ (fertile rachis element)]^{R}

Lepidopteris ottonis (micro): [microsporangium^{R} ~ (fertile rachis element)]^{R} ~ fertile rachis element

Lepidopteris ottonis (mega): [[megasporangium ~ (integument$^{!}$ | integument tube)]^{R} ~ (ovulate disc | downwards flap^{R} | stalk)]^{R} ~ (*fertile axis*)

Matatiella dejerseyi [[(mega): [[megasporangium ~ (integument | seed ridge^{R})]^{R} ~ (megasporophyll lobe^{R} | megasporophyll pedicel)]^{R} ~ (strobilus axis)
*This structure is described as a deeply lobed megasporophyll and we follow that description, although it appears similar to a branching axis in appearance.

Peltaspermum quindiscum (mega): [[megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (peltate head lobe^{R} | central disk bulge | megasporophyll stalk)]^{R} ~ (fertile axis element)]^{R} ~ fertile axis element

Peltaspermum retensorum (micro): [microsporangium^{R} ~ (fertile axis element)]^{R}

Peltaspermum retensorum (mega): [[megasporangium ~ (integument)]^{R} ~ (peltate sporophyll head | marginal lobe^{R} | stalk)]^{R} ~ (fertile axis)

Peltaspermum rotula (mega): [[megasporangium ~ (integument | micropylar beak)]^{R} ~ (peltate sporophyll head | marginal lobe^{R} | stalk)]^{R} ~ (fertile axis)

Peltaspermum turbanatum (mega): [[megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (peltate head lobe^{R} | central disk bulge | megasporophyll stalk)]^{R} ~ (fertile axis)

Permoxylocarpus trojanus (mega): [[megasporangium ~ (integument)]^{R} ~ (sporophyll head | sporophyll lobe^{R} | sporophyll stalk)]^{R} ~ (*fertile axis*)
*We assume, following other peltasperms, that sporophyll units were borne around an axis.

Sylvocarpus armatus (mega): [[megasporangium ~ (integument)]^{R} ~ (peltate shield | stalk)]^{R} ~ (fertile axis)

Townrovia polaris (micro): [microsporangium^{R} ~ (sporophyll)]^{R} ~ (fertile axis) ~ (bud bract)^{R}

12.3 Glossopteridales†

Austroglossa walkomii (mega): [megasporangium ~ (integument | integument wing^{R})]^{R} ~ (cupule | cupule stalk)

Ediea homevalensis (micro): [[microsporangium^{R} ~ (sporophore element)]^{R}]^{R} ~ (sporophyll)]^{R} ~ (strobilus axis)

Eretmonia macloughlinii (micro): [microsporangium ~ (sporophore element)]^{RR} ~ (sporophyll lamina | sporophyll pedicel)]^{R} ~ (strobilus axis)

Glossopterid cupule (mega): [megasporangium ~ (integument | integument wing^{R})^{R} ~ (cupule lobe^{R} | cupule stalk)

Homevaleia gouldii (mega): [megasporangium ~ (integument | integument filament^{R} | ovule stalk)]^{R} ~ (megasporophyll lamina | megasporophyll stalk)

Lidgettonia africana (mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (megasporophyll | megasporophyll lobe^{R} | megasporophyll pedicel)]^{R} ~ (fertile leaf)
*The subtending leaf is scored here as part of the reproductive structure because it is described as a modified scale leaf rather than as a vegetative leaf.

Lidgettonia muronata (mega): [[megasporangium ~ (integument)]^{R} ~ (megasporophyll | megasporophyll lobes^{R} | megasporophyll pedicel)]^{R} ~ (fertile leaf)

Lonchiphyllum aplospermum (mega): [megasporangium ~ (integument)]^{R} ~ (megasporophyll)

Mooia lidgettonioides (mega): megasporangium ~ (integument) ~ (megasporophyll | megasporophyll lobes^{R} | megasporophyll pedicel)]^{R} ~ (fertile leaf)

Ottokaria sanctae-catharinae (mega): [megasporangium ~ (integument)]^{R} ~ (receptacle | receptacle lobe^{R} | receptacle stalk)

12.4 Corystospermales†

Doylea (Umkomasia) corniculata (mega): [megasporangium ~ (integument | integumentary wing^{R} | micropylar arm^{R})^{R} ~ ([cupule flap^{R} + cupule horn ~ sporophyll axial element^{R}]^{R}) ~ (bract)]^{R} ~ (strobilus axis)
*There is no clear distinction between the "stalks" of the "cupules" and the pedicel region bearing them. Similarly, in *Doylea tetrahedrasperma* the entire structure is referred to as a sporophyll. We treat them all as parts of a single organ, which is likely a reduced axial system adnate to, and fused with, a bract.

Doylea (Umkomasia) mongolica (mega): [megasporangium ~ (integument | integumentary wing^{R} | micropylar arm^{R})^{R} ~ ([cupule flap^{R} ~ sporophyll axial element^{R}]^{R}) ~ (bract)]^{R} ~ (strobilus axis)

Doylea tetrahedrasperma (mega): [megasporangium ~ (integument | integumentary wing^{R} | micropylar arm^{R})^{R} ~ ([cupule flap^{R} + cupule horn ~ sporophyll axial element^{R}]^{R}) ~ (bract)]^{R} ~ (strobilus axis)

Fanerotheca cruciformis (mega): [megasporangium ~ (integument | integument wing | micropylar arm^{R}) ~ (cupule lobe^{R} | cupule stalk)]^{R} + (bracteole)^{R} ~ (fertile axis element]^{R} ~ fertile axis element

Pilophorosperma geminatum (mega): [[megasporangium ~ (integument | integument arm^{R}) ~ (cupule lobe^{R} | cupule stalk)]^{R} ~ (fertile axis element) > (bract)]^{R}

Pteroma thomasi (micro): [microsporangium^{R} ~ (sporophyll)]^{R} ~ (fertile axis)

Pteruchus fremouensis/frenguellii (micro): [microsporangium^{R} ~ (microsporophyll blade | petiole)]^{R} ~ (fertile axis)

Pteruchus lepidus (micro): [microsporangium^{R} ~ (microsporophyll blade | lobe^{R} | petiole)]^{R} ~ (fertile axis)

Umkomasia asiatica (mega): [[megasporangium ~ (integument | micropylar arm^{R}) ~ (cupule lobe^{R} | cupule stalk)]^{R} ~ (fertile axis element) + (bract)^{R}]^{R}

Umkomasia quadripartita (mega): [[megasporangium ~ (integument | micropylar arm^{R}) ~ (cupule lobe^{R} | cupule stalk)]^{R} + (bracteole)^{RR} ~ (fertile axis element)]^{R} ~ fertile axis element

Umkomasia resinosa (mega): [[megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (cupule lobe^{R} | cupule stalk)]^{R} ~ (fertile axis)

13. Cycads and cycadophytes

These taxa produce either fertile, leaf-like megasporophylls or compact strobili consisting of modified megasporophylls. Cycad strobili are often surrounded by cataphylls that appear to function as bud scales during early cone development; for consistency, we did not score these cataphylls as part of the reproductive structure because they are interspersed throughout the vegetative axis and are not unique to the reproductive structure itself.

†*Androstrobus patagonica* (micro): [[microsporangium^{R} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

†*Androstrobus prisma* (micro): [[microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)
*With a form genus like *Androstrobus*, it is not necessarily the case that each species belongs to the same biological genus. We score this taxa as a separate genus for the analysis.

†*Androstrobus wonnacotti* (micro): [[microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Bowenia spectabilis (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Bowenia spectabilis (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Ceratozamia sp (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis | spine^{R})]^{R} ~ (strobilus axis)

Ceratozamia sp (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll stalk | apophysis | spine^{R})]^{R} ~ (strobilus axis)

†*Crossozamia chinensis* (mega): [megasporangium ~ (integument)]^{R} ~ (megasporophyll | swollen seed attachment area^{R} | megasporophyll lobe^{R})

†*Crossozamia minor* (mega): [[megasporangium ~ (integument)]^{R} ~ (megasporophyll | megasporophyll lobe^{R})]^{R} ~ (strobilus axis)

Cycas sp (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Cycas circinalis (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll | swollen seed attachment area^{R})

Cycas revoluta (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll | swollen seed attachmen area^{R} | megasporophyll lobe^{R})

†*Delemaya spinulosa* (micro): [microsporangium^{R} ~ receptacle]^{R} ~ (microsporophyll stalk | apophysis | distal spines^{R})]^{R} ~ (strobilus axis)

Dioon sp: (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Dioon sp: (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll pedicel | lamina)]^{R} ~ (strobilus axis)

†*Eocycas wuhaia* (mega): [megasporangium ~ (integument)]^{R} ~ (megasporophyll | megasporophyll lobes^{R})

Macrozamia sp (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis | spine)]^{R} ~ (strobilus axis)

Macrozamia sp (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll stalk | apophysis | spine)]^{R} ~ (strobilus axis)

Microcycas sp (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Microcycas sp (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

†*Microzamia gibba* (mega): [[megasporangium ~ (integument)]^{R} ~ (megasporophyll stalk | apophysis | tubercle^{R})]^{R} + (bract)^{R} ~ (strobilus axis)

†*Nilssonia* concept (micro; *Androstrobus* sp): [[microsporangium^{RR} ~ (sporophyll | distal lamina)]^{R} ~ (strobilus axis)

†*Nilssonia* concept (mega; *Beania*): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (sporophyll stalk | distal lamina)]^{R} ~ (strobilus axis)

†*Phasmatocycas* spp (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (megasporophyll)

†*Sobernheimia jonkeri* (mega): [megasporangium ~ (integument | apical phlange^{R})]^{R} ~ (megasporophyll | sporophyll lobe^{R})

Stangeria eriopus (micro): [[microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

Stangeria eriopus (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll base | lamina)]^{R} ~ (strobilus axis)

†Unnamed staminate cone (micro): [microsporangium^{R} ~ (sporophyll | sporophyll lobe^{R})]^{R} ~ (strobilus axis)

Zamia paucifoliolata (micro): [microsporangium^{RR} ~ (sporophyll stalk | apophysis)]^{R} ~ (strobiluis axis)

Zamia paucifoliolata (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll stalk | apophysis)]^{R} ~ (strobilus axis)

14. Ginkgoales

†*Ginkgo apodes* (mega): [megasporangium ~ (integument)]^{R} ~ (collar^{R} | fertile stalk)

Ginkgo biloba (micro): [microsporangium^{R} ~ (sporophyll pedicel | sterile tip)]^{R} ~ (fertile axis)

Ginkgo biloba (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (collar^{R} | fertile stalk)

†*Ginkgo ginkgoidea* (mega): [megasporangium ~ (integument) ~ (fertile stalk element)]^{R}

†*Ginkgo hamiensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | sterile tip)]^{R} ~ (fertile axis)

†*Ginkgo liaoningensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | sterile tip)]^{R} ~ (fertile axis)

†*Ginkgo neimengensis* (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (collar^{R} | fertile stalk)

†*Ginkgo pediculata* (mega): [megasporangium ~ (integument) ~ (collar | fertile stalk element)]^{R}
*Here we score the "pedicels" of each ovule as the same MET as the "peduncle"; that is, we score it as a ramifying fertile axis system.

†*Ginkgo yimaiensis* (mega): [megasporangium ~ (integument | micropylar tube) ~ (fertile stalk element)]^{R}

†*Karkenia cylindrica* (mega): [megasporangium ~ (integument | integument rib^{R} | ovule stalk)]^{R} ~ (fertile axis)

†*Karkenia hauptmannii/incurva* (mega): [megasporangium ~ (integument | ovule stalk)]^{R} ~ (fertile axis)

†*Nehvizdyella bipartita* (mega): [megasporangium ~ (integument) ~ (cupule)]^{R} ~ (fertile stalk)

†*Yimaia qinghaiensis* (mega): [megasporangium ~ (integument | micropylar tube)^{R} ~ (fertile axis)

Coniferophytes

Coniferophytes here includes early taxa considered to be related to living conifers, such as Cordaitales, putative early coniferophytes like *Feruglioclad us*, and Vojnovskiales, and other early groups thought to be more directly related to extant conifers like walchian and volzialean taxa and fossil crown conifers. Coniferophytes here also includes the Gnetales, which is consistently resolved by recent genomic studies within crown conifers, typically as sister to Pinaceae. The monophyly of coniferophytes is uncertain depending on the resolution of early coniferophyte groups, although extant coniferophytes (when including Gnetales) generally form a clade. For the purposes of this analysis, we consider walchian, voltzialean, and fossil members of crown conifer clades to belong to the Acrogymnospermae. Early coniferophytes likely do as well, but they are not included in this analysis due to uncertainty in their placement.

15. Early coniferophytes and unplaced conifer-like taxa†

Buriadia heterophylla (mega): megasporangium ~ (integument | micropylar arm^{R} | ovule stalk)

Cordaicarpus cordei (mega): [[megasporangium ~ (integument) ~ (megasporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)

*The structure bearing the ovule is normally interpreted as a megasporophyll in cordaites, although it might also fit our definition of a stalk because it subtends a single ovule. There are examples of multiple ovules borne on a single structure, however, so for consistency across taxa, we score this as a separate megasporophyll BSU in all taxa.

Cordaitanthus dumusum (micro): [[microsporangium^{R} ~ (microsprophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)

Cordaitanthus dumusum = duquesnensis (mega): [[megasporangium ~ (integument | micropylar tube) ~ (megasporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)
*This taxon produces *Cordaicarpus* ovules, which are not typically described as having a well-defined wing and thus it is not scored here.

Cordaitanthus pseudofluitans (mega): [[[megasporangium ~ (integument | micropylar tube)]^{R} ~ (megasporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)

Cordaixylon tianii (micro): [[microsporangium^{R} ~ (microsporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} + (fertile axis)

Cordaixylon tianii (mega): [[megasporangium ~ (integument | integumentary ridge^{R}) ~ (megasporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)

Ferugliocladus riojanum (mega): [megasporangium ~(integument | micropylar horn^{R}) > (bract)]^{R} ~ (fertile axis)

Gothania lesliana (micro): [[microsporangium^{R} ~ (microsporophyll)]^{R} + (sertile scale)^{R} ~ (dward shoot axis) > (bract)]^{R} ~ (fertile axis)

Loroderma henania (mega): [[megasporangium ~ (integument) ~ (*megasporophyll*)]^{R} + (sterile scales)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)
*The exact mode of ovule attachment in this taxon is unclear; the authors suggest they were likely borne on a stalk, which would be scored as a megasporophyll for consistency with other cordaites.

Mesoxylon priapi (micro): [[microsporangium^{R} ~ (sporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} + (fertile axis)

Mitrospermum (mega): [[megasporangium ~ (integument | integument wing^{R}) ~ (megasporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot) > (bract)]^{R} ~ (fertile axis)

Mutoviaspermum sp (mega): [[megasporangium ~ (integument)]^{R} ~ (peltate scale head | scale lobes^{R} | scale stalk)]^{R} > (bract)^{R} ~ (fertile axis)

Sergeia neuburgii (mega): [[megasporangium ~ (integument | integument wing^{R}) ~ stalk)]^{R} + (sterile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)
*The structures interpreted as a megasporophyll are quite short and have phlanges that are continuous with the ovule wings; we therefore primarily score this stsructure as an MET belonging to the ovule, although we include it as a possible BSU as well.

Shanxioxylon sinense (micro): [[microsporangium^{R} ~ (sporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot) > (bract)]^{R} ~ (fertile axis)

Shanxioxylon sinense (mega): [[megasporangium ~ (integument | integument wing^{R}) ~ (sporophyll)]^{R} + (sertile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (fertile axis)

Ugartecladus genoensis (mega): [megasporangium ~ (integument) > (bract)]^{R} ~ (fertile axis)
*This taxon is described as having a 1 mm wide wing, but these are similar to the tiny wings of *Emporia* and some other early conifers. We considered them to be too small and poorly defined to constitute a distinct MET.

Vojnovskya paradoxa (mega): [megasporangium ~ (integument | integument wing^{R})]^{R} + (sterile scale)^{R} ~ (fertile axis)
*Seed morphology in this taxon is somewhat unclear; figured in Mamay 1976 as having a bifid apex, but described in other sources as having an elongate micropyle formed from a wing; we score as a wing alone.

16. Walchian, Voltzialean, and other unplaced stem conifers†

Aethophyllum stipulare (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Aethophyllum stipulare (mega): [[megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | constricted pedicel) > (bract)]^{R} ~ (strobilus axis)

Bancroftiastrobus digitata (mega): [[megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | constricted pedicel) > (bract)]^{R} ~ (strobilus axis)

Barthelia furcata (micro): [microsporangium^{R} ~ (pedicel "shank" | distal lamina | lamina lobe^{R})]^{R} ~ (strobilus axis)

Barthelia furcata (mega): [[megasporangium ~ (integument) ~ (scale)]^{R} + (scale)^{R} ~ (dwarf shoot axis) > (bract | bract tip^{R})]^{R} ~ (fertile axis)

Callipitys leptoderma (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (cone scale)]^{R} ~ (strobilius axis)

Chimaerostrobus minutes (micro): [microsporangium^{R} ~ (microsporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Compsostrobus neotericus (mega): [[megasporangium ~ (integument | micropylar process)]^{R} ~ (ovuliferous complex stalk | ovuliferous scale pad) > (bract)]^{R} ~ (strobilus axis)
*The bract is almost entirely fused to the complex; I nevertheless still score as a separate organ following typical interpretations of the conifer cone scale.

Conewagia longiloba (mega): [[megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | constricted pedicel) > (bract)]^{R} ~ (strobilus axis)
*I consider co-occuring dispersed seeds as conspecific with the cone; they show an extremely reduced ridge or wing which is not considered here as a distinct part. Assumed to be multiple per scale

Cycadocarpidium swabi (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous complex lobe^{R} | ovuliferous complex | constricted pedicel)]^{R} ~ (strobilus axis)

Darneya mougeoti (micro): [[microsporangium ~ (axial element)]^{RR} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Emporia lockardii (micro): [microsporangium^{R} ~ (pedicel | distal lamina)]^{R} ~ (strobilus axis)

Emporia lockardii (mega): [[megasporangium ~ (integument) ~ (sporophyll)]^{R} + (sterile scale)^{R} ~ (dwarf shoot axis) > (bract | bract tip^{R})]^{R} ~ (strobilus axis)
*Described as having a narrow wing, which refers to a small ridge that could represent a compressed sarcotesta; I did not score as a wing following my approach for other taxa. The "fertile scale" generally considered a megasporophyll akin to that of cordaites, and I score as a separate organ.

Hanskerpia hamiltonensis (mega): [[megasporangium ~ (integument | stalk)]^{R} + (sterile scale)^{R} ~ (dwarf shoot axis) > (bract | bract tip^{R})]^{R} ~ (strobilus axis)
*Described as having a narrow wing, but is similar to *Emporia*.

Kobalostrobus olmosensis (micro): [microsporangium^{R} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Krassilovia mongolica (mega): [[megasporangium ~ (integument | wing^{R})]^{R} ~ (ovuliferous scale complex pedicel | ovuliferous scale shield | distal spine^{R}) ~ (bract)]^{R} ~ (strobilus axis)
*The bract is almost entirely fused to the complex; I nevertheless still score as a separate organ following typical interpretations of the conifer cone scale.

Lebowskia grandifolia (mega): [[megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | constricted pedicel) > (bract)]^{R} ~ (strobilus axis)

Majonica alpina (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Majonica alpina (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (ovuliferous scale pedicel | ovuliferous scale blunt lobe^{R} | ovuliferous scale acicular lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Manifera talaris (mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (ovuliferous scale pedicel | ovuliferous scale blunt lobe^{R} | ovuliferous scale acicular lobe^{R}) > (bract)]^{R} ~ (strobilus axis)
*Only isolated scales have been found; I assume bract and cone axis were present.

Masculostrobus vectensis (micro): [microsporangium^{R} ~ (sporophyll pedicel | sporophyll lamina blade| lamina tooth^{R})]^{R} ~ (strobilus axis)

Masculostrobus warrenii (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Masculostrobus zeilleri (micro): [[microsporangium^{R} ~ (microsporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) ~ (bract)]^{R} ~ (fertile axis)

Millerostrobus pekinensis (micro): [microsporangium^{R} ~ (microsporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Moyliostrobus texanum (mega): [[megasporangium ~ (integument | integument lobe^{R}) ~ fertile appendage pad + (sterile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (strobilus axis)
*The pad is a slightly raised region; I do not consider it to be a fundamental organ. Essentially equivalent to a stalk.

Nothodacrium warrenii (mega): [megasporangium ~ (integument) ~ (ovuliferous scale blade | ovuliferous scale lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Ontheodendron sternbergi (mega): [megasporangium ~ (integument) ~ (scale base | scale blade)]^{R} ~ (strobilus axis)

Ortiseia leonardii (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)
*Cones are not well preserved; microsporophyll structure is clear but I am assuming multiple pollen sacs were present.

Ortiseia leonardii (mega): [[megasporangium ~ (integument | integument horn^{R}) ~ (blunt scale)^{R} + (acicular scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (strobilus axis)
*The ovules are complex; they include several chalazzal horns and a ridge of small bumps around 1 mm high. The horns are clearly separate parts, but I am unsure how to consider the smaller bumps. I score here as a potential part.

Otovicia hypnoides (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Otovicia hypnoides (mega): [[megasporangium ~ (integument | integument wing | micropylar arm^{R}) ~ (cone scale)]^{R} + (cone scale)^{R} ~ (dwarf shoot axis) > (bract | bract tip^{R})]^{R} ~ (fertile axis)

Palissya tillackiorum (mega): [[megasporangium ~ (integument | micropylar beak)]^{R} ~ (scale flap)^{RR} ~ (bract)]^{R} ~ (strobilus axis)
*Here I consider the major and minor scales surrounding the ovule as the same basic part because they are fairly similar in morphology. These would typically be considered separate organs, given that the ovule subtending structures in conifers are generally considered separate organs.

Patokaea silesiaca (micro): [microsporangium^{R} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Patokaea silesiaca (mega): [[megasporangium ~ (integument | micropylar arm^{R}) ~ (large ovuliferous scale lobe^{R} | small ovuliferous scale lobe^{R} | ovuliferous scale pedicel) > (bract)]^{R} ~ (strobilus axis)

Pseudovoltzia liebeana (mega): [megasporangium ~ (integument | micropylar lobe^{R})]^{R} ~ (ovuliferous scale pedicel | ovuliferous scale blunt lobe^{R} | ovuliferous scale acicular lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Rissikianthus media (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Rissikistrobus plenus (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe | scale complex pedicel) > (bract lobe)^{R}]^{R} ~ (strobilus axis)

Rissikistrobus reductus (mega): [megasporangium ~ (integument)]^{RR} ~ (ovuliferous scale lobe^{R} | scale complex pedicel) > (bract)^{R}]^{R} ~ (strobilus axis)
*In Rissikistrobus, the bracts are fused to the ovuliferous scale. But as in other conifers with this morphology, I continue to treat them as separate organs.

Sertostrobus laxus (micro): [[microsporangium^{R} ~ (axial element)]^{R} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Stachyotaxus elegans (micro): [microsporangium^{R} ~ (microsporophyll lamina | stalk)]^{R} ~ (strobilus axis)

Stachyotaxus septentrionalis (mega): [[megasporangium ~ (integument) ~ (cup)]^{R} ~ (bract)]^{R} ~ (strobilus axis)

Swedenborgia nissleri (micro): [microsporangium^{R} ~ (microsporophyll lamina | stalk)]^{R} ~ (strobilus axis)

Swedenborgia nissleri/crytopmerioides (mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | ovuliferous scale pedicel) > (bract)]^{R} ~ (strobilus axis)

Telemachus conifer (*Leastrobus/Switzianthus*; micro): [microsporangium^{R} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis) > (sterile bract)^{R}

Telemachus plant (*Telemachus*; mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (ovuliferous scale lobe^{R} | ovuliferous scale | ovuliferous scale pedicel) > (bract)]^{R} ~ (strobilus axis)

Thucydia mahoningensis (micro): [[microsporangium ~ stalk]^{R} + (sterile scale)^{R} ~ (dwarf shoot axis) > (bract)]^{R} ~ (strobilus axis)

Thucydia mahoningensis (mega): [megasporangium ~ (integument) ~ (sporophyll)]^{R} + (sterile scale)^{R} ~ (dwarf shoot) > (bract)
*Ovule anatomy is not known; I scored as *Emporia* because isolated seeds of similar morphology are found in association. I score the megasporophyll as a separate organ because the seeds are clearly shed from them, in contrast to a simple stalk.

Ullmannia bronnii (mega): [megasporangium ~ (integument) ~ (ovuliferous scale) > (bract)]^{R} ~ (strobilus axis)

Uralostrobus voltzioides (micro): microsporangium^{R} ~ (microsporophyll pedicel | microsporophyll lamina | lamina spine^{R})]^{R} ~ (strobilus axis)

Voltzia hexagona (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Voltzia hexagona (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale complex pedicel | large lobe^{R} | small lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Walchianthus sp (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Wantus acaulis (mega): [megasporangium ~ (integument) ~ (ovuliferous scale | ovuliferous scale lobe^{R}) > (bract)]^{R} ~ (strobilus axis)
*Only isolated dwarf shoots known; bracts and cone axis is assumed.

Willsiostrobus cordiformis (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina | basal lamina lobe)]^{R} ~ (strobilus axis)

Willsiostrobus denticulatus (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina | lamina teeth^{R})]^{R} ~ (strobilus axis) > (bract)^{R}

Willsiostrobus rhomboidalis (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis) > (bract)^{R}

17. Crown Conifers

Araucariaceae

Agathis australis (micro): [microsporangium^{R} ~ (distal nub | sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Agathis australis (mega): [megasporangium ~ (integument | integument wing) ~ (scale complex base | scale complex upturned lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}
*Slight wing extensions of the bract/scale complex are treated here as extensions of the base, not as a separate part. In contrast, the papery-thin wings of extant *Araucaria* are treated as separate parts.

†*Agathis zamunerae* (micro): [microsporangium^{R} ~ (distal nub | sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Agathis zamunerae* (mega): [megasporangium ~ (integument | integument wing lobe^{R}) ~ (scale complex base | scale complex upturned lamina | lateral phlange^{R})]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Alkastrobus peltatus* (micro): [microsporangium^{R} ~ (microsporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Araucaria araucana (micro): [microsporangium^{R} ~ (distal lamina | sporophyll pedicel)]^{R} ~ (strobilus axis)

Araucaria araucana (mega): [megasporangium ~ (integument) ~ (ovuliferous scale) ~ (seed covering flap | bract base | bract upturned lamina | bract prickle)]^{R} ~ (strobilus axis)

Araucaria bidwillii (mega): [megasporangium ~ (integument) ~ (ovuliferous scale | scale prickle) ~ (seed covering flap | bract base | swollen bract apophysis | bract prickle)]^{R} ~ (strobilus axis)

†*Araucaria bladenensis* (micro): [microsporangium^{R} ~ (distal lamina | sporophyll pedicel)]^{R} ~ (strobilus axis)

Araucaria heterophylla (micro): [microsporangium^{R} ~ (distal lamina | sporophyll pedicel)]^{R} ~ (strobilus axis) > (basal bract)^{R}

Araucaria heterophylla (mega): [megasporangium ~ (integument) ~ (ovuliferous scale | ovuliferous scale prickle) ~ (seed covering flap | bract wing^{R} | swollen bract apophysis | bract spine)]^{R} ~ (strobilus axis)

*In many extant *Araucaria* species, the thin wings of the bract/scale complex are continuous extensions of the thin medial portion of the bract underlying the seed. We therefore score the bract base as consisting only of two wings, without a central body.

†*Araucaria mirabilis* (mega): [megasporangium ~ (integument) ~ (ovuliferous scale) ~ (seed covering flap | bract wing^R | swollen bract apophysis | bract upturned lamina)]^R ~ (strobilus axis)

†*Araucaria pichileufensis* (micro): [microsporangium^R ~ (distal lamina | sporophyll pedicel)]^R ~ (strobilus axis) > (basal bract)^R

†*Araucaria pichileufensis* (mega): [megasporangium ~ (integument) ~ (ovuliferous scale | ovuliferous scale prickle) ~ (seed covering flap | bract wing^R | swollen bract apophysis | bract spine)]^R ~ (strobilus axis)

†*Araucaria sphaerocarpa* (mega): [megasporangium ~ (integument) ~ (ovuliferous scale | ovuliferous scale prickle) ~ (seed covering flap | bract wing^R | swollen bract apophysis | bract prickle)]^R ~ (strobilus axis)

†*Araucaria vulgaris* (mega): [megasporangium ~ (integument) ~ (ovuliferous scale) ~ (seed covering flap | bract wing^R | swollen bract apophysis | bract upturned lamina)]^R ~ (strobilus axis)

†Araucarian microsporophyll sp. (micro): [microsporangium^R ~ (distal lamina | sporophyll pedicel)]^R ~ (strobilus axis) > (*basal bract*)^R

†*Brachyphyllum mammilare* (micro): [microsporangium^R ~ (microsporophyll lamina | pedicel)]^R ~ (strobilus axis)

†*Callialastrobus sousai* (micro): [microsporangium^R ~ (microsporophyll lamina | lamina lobe^R | pedicel)]^R ~ (strobilus axis) > (basal bract)^R

†*Rabagostrobus hispanicus* (micro): [microsporangium^R ~ (microsporophyll lamina | pedicel)]^R ~ (strobilus axis)

†*Upatoia barnardii* (micro): [microsporangium^R ~ (microsporophyll lamina | pedicel)]^R ~ (strobilus axis)

†*Wairarapaia mildenhallii* (mega): [megasporangium ~ (integument | integumentary wing^R)] ~ (scale complex base | swollen bract apophysis | spine)]^R ~ (strobilus axis)
*Not explicitly stated to have an inflated bract apophysis, but from the figures it looks as though it does; taxon appears similar to *Wollemia*.

Wollemia nobilis (micro): [microsporangium^R ~ (distal nub | sporophyll pedicel)]^R ~ (strobilus axis) > (basal bract)^R

Wollemia nobilis (mega): [megasporangium ~ (integument | integumentary wing)] ~ (scale complex base | swollen bract apophysis | lamina)]^R ~ (fertile axis) > (bud bract)^R

Cheirolepidiaceae†

Classostrobus crossii/elliotti/comptonensis (micro): [microsporangium^R ~ (sporophyll lamina | pedicel)]^R ~ (strobilus axis)
**C. elliottii* is treated here as a separate taxon for analysis because its arrangement of pollen sacs is different from *C. crossii*, although this distinction is not recorded in the characters used in this study. *C. comptonensis* is from a different time interval.

Frenelopsis alata/sp. (micro): [microsporangium^R ~ (sporophyll lamina | pedicel)]^R ~ (strobilus axis)

Frenelopsis alata (mega; *Alvinia bohemica*): [[megasporangium ~ (integument | micropylar tube)]^R ~ (ovuliferous scale body |ovule covering flap | ovuliferous scale abaxial lobe^R | ovuliferous scale adaxial lobe) > (bract)]^R ~ (strobilus axis)

Hirmeriella muensteri (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Hirmeriella muensteri (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (ovuliferous scale body | ovule covering flap | ovuliferous scale major lobe^{R} | ovuliferous scale minor lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Kachaikestrobus acuminatus (mega): [megasporangium ~ (integument) ~ (ovuliferous scale body | ovule covering flap | ovuliferous scale major lobe^{R} | ovuliferous scale minor lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Paraucaria delfueyoi (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (ovuliferous scale body | ovule covering flap | ovuliferous scale lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Paraucaria patagonica (mega): [megasporangium ~ (integument | micropylar tube) ~ (ovuliferous scale body | ovule covering flap | ovuliferous scale lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Pseudofrenelopsis parceramosa (micro): [microsporangium^{R} ~ (sporophyll lamina | pedicel)]^{R} ~ (strobilus axis)

Tomaxiella biforme (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (ovuliferous scale | ovule covering flap | ovuliferous scale lobe^{R}) > (bract)]^{R} ~ (strobilus axis)

Cupressaceae

All genera of extant Cupressaceae sensu stricto, unless otherwise noted, have the following pollen cone scoring: [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis). Even in Cupressaceae with highly reduced cones, we scored a strobilus axis as being present because a distinct axis is generally visible early in ontogeny. In some cases, the apex of the axis is further differentiated into a distinct columella.

†*Acanthostrobus edensis* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (ovuliferous scale) ~ (bract base | bract upturned lamina)]^{R} ~ (strobilus axis)

Callitris acuminatus: [[megasporangium ~ (integument | integument wing)]^{R} > (fertile bract)]^{R} + (sterile bract)^{R} ~ (columella | strobilus axis)
*The columella is a distinct part of some Cupressaceae; I score as an extension of the cone axis.

†*Archicupressus nihongii* (mega): [[megasporangium ~ (integument)]^{R} ~(bract complex constricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

Athrotaxis cupressoides (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Athrotaxis cupressoides (mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (bract complex constricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

Athrotaxis selaginoides (mega): [[megasporangium ~ (integument | integument wing^{R})]^{R} ~ (bract complex constricted base | bract complex blade)]^{R} ~ (strobilus axis)

†*Athrotaxites berryi* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Athrotaxis berryi* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex constricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

†*Athrotaxites yumenensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Athrotaxites yumenensis* (mega): [[megasporangium ~ (integument | integument wing^R)]^R ~ (bract complex constricted base | bract complex blade | bract complex spine)]^R ~ (strobilus axis)
*Ovules are discussed as attached to an ovuliferous scale, but it is not obviously a separate structure and I assume it is fused to the bract.

Austrocedrus chilensis: [[megasporangium ~ (integument | micropylar funnel | integument wing)]^R ~ (bract complex | bract complex prickle]^R ~ (columella | strobilus axis)
*Produces two ovules per fertile complex even though only one matures; I score clustering based on the entire ontogeny.

†*Austrohamia asfaltensis* (micro): [[microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R > (bract) ~(strobilus axis)]^R
*No description of cone enveloping bracteoles, as in extant *Cunninghamia*, although their lack could be preservational.

†*Austrohamia asfaltensis* (mega): [[megasporangium ~ (integument)]^R ~ (bract complex constricted base | bract complex blade | bract complex keel)]^R ~ (strobilus axis)

†*Austrosequoia novae-zeelandiae* (mega): [[megasporangium ~ (integument)]^R ~ (bract complex constricted base | bract complex swollen apophysis | bract apophysis medial ridge)]^R ~ (strobilus axis)

Callitris drummondii: [[megasporangium ~ (integument | integument wing^R)]^R > (bract)]^R ~ (columella | strobilus axis)

Callitris macleayana: [[megasporangium ~ (integument | micropylar funnel | integument wing^R)]^R ~ (bract)]^R ~ (columella | strobilus axis)

Calocedrus decurrens: [[megasporangium ~ (integument | micropylar funnel | integument wing^R)]^R ~ (bract | bract prickle)]^R + fused apical bract unit + sterile basal bract^R ~ (strobilus axis)
*This cone contains several differentiated types of bract, but I consider them to be the same BSU, as they are morphologically identifiable as cone scales.

†*Calocedrus shenxiangensis:* [[megasporangium ~ (integument | *micropylar funnel* | *integument wing*^{R})]^R ~ (bract | bract prickle)]^R + fused apical bract unit + sterile basal bract^R ~ (strobilus axis)

Chamaecyparis pisifera: [[megasporangium ~ (integument | integument wing^R)]^R ~ (bract)]^R ~ (strobilus axis)

Chamaecyparis thyoides: [[megasporangium ~ (integument | integument wing^R)]^R ~ (bract | bract prickle)]^R ~ (strobilus axis)

Cryptomeria japonica (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R + (sterile bract)^R ~ (strobilus axis)

Cryptomeria japonica (mega): [[megasporangium ~ (integument | integument wing) ~ (ovuliferous scale lobe)]^R > (bract complex constricted base | bract complex swollen apophysis | bract complex prickle)]^R ~ (strobilus axis)

†*Cunninghamia spp* (micro): [[microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R + (basal bracteole)^R ~ (strobilus axis) > (bract)]^R
*I score as a compound cone because the cluster is functionally terminal when mature, although eventually the vegetative axis continues to grow through it. Fossil and extant species score similarly.

Cunninghamia lanceolata (mega): [[megasporangium ~ (integument | integument wing^R) ~ (ovuliferous scale lobe)]^R ~ (bract constricted base | bract blade | bract keel)]^R ~ (strobilus axis)

†*Cunninghamia taylori* (mega): [[megasporangium ~ (integument | integument wing^R)]^R ~ (ovuliferous scale) ~ (bract constricted base | bract blade | bract marginal tooth^R)]^R ~ (strobilus axis)

*The scale is very slightly lobed, but I score as a single structure.

†*Cunninghamiostrobus hueberi* (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale pad) ~ (bract constricted base | bract blade)]^{R} ~ (strobilus axis)

†*Cunninghamiostrobus yubariensis* (mega): [megasporangium ~ (integument)]^{R} ~ (bract complex constricted base | bract complex blade | swollen seed attachment^{R} | abaxial transverse ridge)]^{R} ~ (strobilus axis)

†*Cupressoconus*: [[megasporangium ~ (integument | *wing*^{R})]^{R} > (bract constricted base | bract swollen apophysis)]^{R} ~ (strobilus axis)

Cupressus sempervirens: [[megasporangium ~ (integument)]^{R} > (bract constricted base | bract swollen apophysis)]^{R} ~ (strobilus axis)

Diselma archeri: [[megasporangium ~ (integument | micropylar tube | integument wing^{R})]^{R} > (bract)]^{R} ~ (columella | strobilus axis)

†*Drumhellera kurmanniae* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (sterile bract)^{R} ~ (strobilus axis)
*Similar to modern *Metasequoia*; pollen cones are borne on a specialized shoot but each cone is subtended by a vegetative leaf. I therefore do not score it as a compound fertile structure, but rather a vegetative branch system.

†*Elatides bommeri* (mega): [[megasporangium ~ (integument) ~ (ovuliferous scale lobe)]^{R} ~ (bract constricted base | bract blade)]^{R} ~ (strobilus axis)

†*Elatides williamsonii* (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bract)]^{R}

†*Elatides williamsonii* (mega): [[megasporangium ~ (integument | wing) ~ (ovuliferous scale lobe)]^{R} ~ (bract constricted base | bract spine | bract blade)]^{R} ~ (strobilus axis)

†*Elatides zhoui* (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bract)]^{R}

†*Elatides zhoui* (mega): [[megasporangium ~ (integument | wing)]^{R} ~ (ovuliferous scale) ~ (bract constricted base | bract blade)]^{R} ~ (strobilus axis)
*There is a very tiny raised micropyle that is basically an extension of the wing; I do not score as a separate part. The ovuliferous scales either occur as lobes or as an entire structure; I score as just one part.

Fitzroya cupressoides: [[megasporangium ~ (integument | micropylar tube | integument wing)]^{R} > (bract restricted base | bract swollen apophysis | bract prickle)]^{R} ~ (columella^{R} | strobilus axis)

Fokienia hodginsii: [[megasporangium ~ (integument | micropylar tube | integument wing)]^{R} > (bract)]^{R} ~ (strobilus axis)

Glyptostrobus pensilis (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Glyptostrobus pensilis (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (ovuliferous scale lobe^{R}) ~ (bract | prickle)]^{R} ~ (strobilus axis)

†*Glyptostrobus rubenosawaensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud bract)^{R}

†*Glyptostrobus rubenosawaensis* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (ovuliferous scale lobe^{R}) ~ (bract | prickle)]^{R} ~ (strobilus axis)

Hesperocyparis arizonica: [[megasporangium ~ (integument)]^{R} > (bract restricted base | bract swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

†*Homalcoia littoralis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (subtending bract)^{R}

†*Hubbardiastrobus cunninghamioides* (mega): [megasporangium ~ (integument) ~ (ovuliferous scale lobe)]^{R} ~ (bract constricted base | bract blade)]^{R} ~ (strobilus axis)

†*Hughmillerites vancouverensis* (mega): [[megasporangium ~ (integument) ~ (ovuliferous scale lobe)]^{R} ~ (bract constricted base | bract blade)]^{R} ~ (strobilus axis)

Juniperus communis (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Juniperus phoenicea: [[megasporangium ~ (integument | micropylar tube)]^{R} > (bract)]^{R} ~ (strobilus axis)

Juniperus virginiana: [megasporangium ~ (integument | micropylar tube) > (fused bract ring) ~ (strobilus axis)
*In some derived *Juniperus*, the single ovule is essentially covered by a single ring-like structure formed from fused bracts.

†*Krassilovidendron fecundus* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Krassilovidendron fecundus* (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (bract complex constricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

Libocedrus bidwillii: [[megasporangium ~ (integument | micropylar tube | integument wing^{R})]^{R} ~ (bract complex | ligulate protuberance)]^{R} ~ (columella | strobilus axis)

†*Mesocyparis borealis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Mesocyparis borealis* (mega): [[megasporangium ~ (integument | integument wing^{R} | micropylar tube)]^{R} > (bract complex | bract complex prickle)]^{R} ~ (columella | strobilus axis)

†*Mesocyparis umbonata* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Mesocyparis umbonata* (mega): [[megasporangium ~ (integument | integument wing^{R} | micropylar tube)]^{R} ~ (bract complex | bract complex prickle)]^{R} ~ (columella | strobilus axis)

Metasequoia glyptostroboides (micro): [[microsporangium^{R} ~ (sporophyll stalk | distal lamina)]^{R} + (sterile bract)^{R} ~ (strobilus axis)
*Borne on specialized shoots, but pollen cones are subtended by essentially vegetative leaves; we therefore do not score as a true compound strobilus but rather a vegetative shoot system (i.e., strobili are not repeated).

Metasequoia glyptostroboides (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract)]^{R} ~ (strobilus axis)
*The axis or peduncle bearing the cone has only slightly modified vegetative leaves on it; the bud scales at the base of the axis would therefore score as not part of the reproductive structure. Although bract is peltate, we score as a single wedge-shaped part rather than differentiated into a stalk and clear shield.

†*Metasequoia milleri* (micro): [[microsporangium^{R} ~ (sporophyll stalk | distal lamina)]^{R} + (sterile bract)^{R} ~ (strobilus axis)
*Score as extant *Metasequoia*, although architecture of the fertile shoots is not known.

†*Metasequoia milleri* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract)]^{R} ~ (strobilus axis)

Microbiota decussata: [megasporangium ~ (integument) > [(bract | bract prickle)]^{R} ~ (strobilus axis)
*Cone consists of a terminal ovule surrounded by whorl of bracts.

†*Mikasastrobus hokkaidoensis* (mega): [[megasporangium ~ (integument | wing)]^{R} ~ (ovuliferous scale) ~ (bract restricted base | bract blade | bract apical spine)]^{R} ~ (strobilus axis)

†*Morinostrobus fertilis* (micro): [[microsporangium^{R} ~ (sporophyll stalk | peltate head)]^{R} ~ (strobilus axis) > (bract)]^{R}

Neocallitropsis (Callitris) pancheri: [[megasporangium ~ (integument | micropylar funnel)]^{R} ~ (bract complex | bract complex prickle)]^{R} ~ (columella | strobilus axis)

Papuacedrus papuana: [[megasporangium ~ (integument | micropylar funnel | integument wing^{R})]^{R} ~ (bract complex | ligulate protuberance)]^{R} ~ (columella | strobilus axis)

†*Pentaconos dimunutus*: [[megasporangium ~ (integument | wing)]^{R} ~ (ovuliferous scale) ~ (bract blade | apical spine)]^{R} ~ (strobilus axis)

Pilgerodendron: [[megasporangium ~ (integument | micropylar funnel | integument wing^{R})]^{R} ~ (bract complex | ligulate protuberance)]^{R} ~ (columella | strobilus axis)

Platycladus uviferum: [[megasporangium ~ (integument | micropylar tube)]^{R} > (bract | bract prickle)]^{R} ~ (strobilus axis)

†Pollen cone type 2 (micro): [microsporangium^{R} ~ (sporophyll pedicel | sporophyll lamina)]^{R} ~ (strobilus axis)

†*Quasisequoia couttsiae* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

†*Quasisequoia florinii* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

†*Rhombostrobus cliffwoodensis* (mega): [[megasporangium ~ (integument | wing)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis)]^{R} ~ (strobilus axis)

†*Scitistrobus duncaanensis*: [[megasporangium ~ (integument) ~ (ovuliferous scale lobe)]^{R} ~ (bract base | bract upturned lamina)]^{R} ~ (strobilus axis)

†*Sequoia maguanensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud bract)^{R}

Sequoia sempervirens (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud bract)^{R}

Sequoia sempervirens (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis | bract complex prickle)]^{R} ~ (strobilus axis)

Sequoiadendron giganteum (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Sequoiadendron giganteum (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex | bract complex distal ridge | bract complex prickle)]^{R} ~ (strobilus axis)

†*Sewardiodendron laxum* (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (*bract*)]^{R}
*No description of bracts subtending the cones; although it seems likely they would have been present; I score them as possible.

†*Sewardiodendron laxum* (mega): [[megasporangium ~ (integument | micropylar tube) ~ (ovuliferous scale lobe)]^{R} ~ (bract restricted base| bract blade)]^{R} ~ (strobilus axis)

†*Sphenolepis kurriana* (mega): [[megasporangium ~ (integument)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis | bract complex spine)]^{R} ~ (strobilus axis)

†*Sphenolepis pecinovensis* (mega): [[megasporangium ~ (integument)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis | bract complex spine)]^{R} ~ (strobilus axis)

†*Stockeystrobus interdigitata* (mega): [[megasporangium ~ (integument | wing)]^{R} ~ (bract complex restricted base | peltate head)]^{R} ~ (strobilus axis)

†*Stutzeliastrobus bohemicus* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex)]^{R} ~ (strobilus axis)

†*Stutzeliastrobus foliatus* (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex | apical spine)]^{R} ~ (strobilus axis)

Taiwania cryptomerioides (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (sterile bract)^{R} ~ (strobilus axis) ~ (bract)]^{R}

Taiwania cryptomerioides/cf. cryptomerioides (mega): [[megasporangium ~ (integument | integument wing)]^{R} ~ (bract complex)]^{R} ~ (strobilus axis)

†*Taxodium* spp (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (sterile bract)^{R} ~ (strobilus axis)]^{R}
*Consists of occasional clusters of cones on a fertile axis. We consider the fertile axis to be a slightly modified vegetative shoot, because the bracts subtending the cones (or cone clusters) appear very similar to scale leaves on long shoots. Fossil and extant species score similarly.

†*Taxodium* spp (mega): [[megasporangium ~ (integument)]^{R} ~ (ovuliferous scale lobe^{R}) > (bract restricted base | bract distal shield | bract lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Tetraclinis articulata: [[megasporangium ~ (integument | micropylar tube | integument wing^{R})]^{R} > (bract | bract prickle)]^{R} ~(strobilus axis)

Tetraclinis salicornioides: [[megasporangium ~ (integument | *micropylar tube* | integument wing^{R})]^{R} > (bract | bract prickle)]^{R} ~(strobilus axis)

Thuja plicata: [[megasporangium ~ (integument | micropylar tube | integument wing^{R})]^{R} > (bract | bract prickle)]^{R} ~ (strobilus axis)

Thuja polaris (mega): [[megasporangium ~ (integument | *micropylar tube* | *integument wing*^{R})]^{R} > (bract | bract prickle)]^{R} ~ (strobilus axis)
*Seeds are not known; putative scoring as extant *Thuja*.

Thujopsis dolabrata: [[megasporangium ~ (integument | integument wing^{R})]^{R} > (bract restricted base | bract swollen apophysis)]^{R} ~ (strobilus axis)

† *"Widdringtonia" americana* (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)
*We do not regard this taxon as a representative of the modern genus.

Widdringtonia cedarburgensis: [[megasporangium ~ (integument | micropylar tube)]^{R} > (bract | bract prickle)]^{R} ~ (columella | strobilus axis)

Widdringtonia nodiflora: [[megasporangium ~ (integument | micropylar tube | integument wing^{R})]^{R} > (bract | bract prickle)]^{R} ~ (columella | strobilus axis)

Xanthocyparis nootkatensis: [[megasporangium ~ (integument | integument wing^{R})]^{R} > (bract | bract prickle)]^{R} ~ (columella | strobilus axis)

†*Yubaristrobus nakajimae* (mega): [[megasporangium ~ (integument)]^{R} ~ (bract complex restricted base | bract complex swollen apophysis)]^{R} ~ (strobilus axis)

Pinaceae

Abies koreana (micro): [microsporangium^{R} ~ sporophyll pedicel]^{R} ~ (strobilus axis) > (bud scale)^{R}

Abies koreana (mega): [megasporangium ~ (integument | micropylar funnel)]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract | bract wing^{R})]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Abies milleri* (mega): [megasporangium ~ (integument | *micropylar funnel*)]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract | bract wing^{R})]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Amboystrobus cretacicum* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*Fragmentary cone; whether it produced bud scales is unknown, but is scored as likely based on other Pinaceae.

Cathaya argyrophylla (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Cathaya argyrophylla (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)

Cedrus libani (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Cedrus libani (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Cedrus angusta* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Eathiestrobus mackenziei* (mega): [[megasporangium ~ integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*Bud scales and micropylar arms are possible given other Pinaceae; they would not have been preserved if present.

Keteleeria davidiana (micro): [[microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis)]^{R} > (bud scale)^{R}

Keteleeria davidiana (mega): [megasporangium ~ (integument | micropylar funnel)]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract | bract wing^{R})]^{R} ~ (strobilus axis)

†*Larix altoborealis* (mega): [megasporangium ~ (integument | *micropylar stigma*)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract | apical tooth)]^{R} ~ (strobilus axis)

Larix laricina (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina nub)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Larix laricina (mega): [megasporangium ~ (integument | micropylar stigma)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract | bract wing^{R})]^{R} ~ (strobilus axis)

†*Obirastrobus kokubunii* (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)
*Ovuliferous scale is described as having wing-like lateral margins. I consider these to be continuous with the ovuliferous scale rather than distinct elements.

Picea abies (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Picea abies (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Picea farjonii* (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract | bract lobe^{R}]^{R} + rudimentary bract^{R} ~ (strobilus axis)
*We do not consider the bracts in the transition zone between the cone and axis to be separate organs, although they are morphologically distinct.

†*Picea nansenii* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pinus* pollen cone (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}
*Distal microsporophyll lamina is not described as in not obvious in illustration.

Pinus albicaulis (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}
*For *Pinus*, we did not score the umbo as a separate MET unless it was raised into a separate geometric structure (i.e., the umbo was mucronate). Otherwise, we considered the feature to simply reflect different texture due to a period of dormancy.

†*Pinus arnoldii* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Pinus arnoldii* (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Pinus lindgrenii* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pinus florrisantii* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | *seed wing*^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*Here the umbo is visible but appears reduced and flat; we did not score it as a separate MET.

†*Pinus mutoi* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*Neither bud scales or micropylar arms are preserved, but they are assumed based on assignment to *Pinus*.

Pinus nigra (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Pinus nigra (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Pinus pinea (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ ((ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Pinus prekesiya* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo | *seed wing*^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

Pinus radiata (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis + inflated apophysis | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}
*Some *Pinus* species have distinctive degrees of apophysis expansion, and these can be quite abrupt on the cone. Here we score the typical apophyses and the strongly inflated apophyses that can simultaneously occur on some *P. radiata* cones as two distinct METs. This distinction is likely functionally significant, and we score as additional morphological differentiation.

Pinus strobus (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Pinus strobus (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Pinus yorkshirensis* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | ovuliferous scale apophysis | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pityostrobus argonnensis* (mega): [*megasporangium* ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | inflated ovuliferous scale apophysis | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*For *Pityostrobus*, micropylar features and (bud scale)s are unlikely to have been preserved. I add them as possible parts.

†*Pityostrobus californiensis* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pityostrobus hallii* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pityostrobus jonhalus* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pityostrobus palmeri* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale base | inflated ovuliferous scale apophysis | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}

†*Pityostrobus stockeyae* (mega): [megasporangium ~ (integument | micropylar tube)]^{R} ~ (ovuliferous scale | ovuliferous scale mucro | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)]^{R}

†*Pseudoaraucaria heeri* (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale base | upturned ovuliferous scale distal blade | ovuliferous scale umbo | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)

Pseudolarix amabilis (micro): [[microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis)]^{R} > (bud scale)^{R}

Pseudolarix amabilis (mega): [megasporangium ~ (integument | micropylar funnel)]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)

†*Pseudolarix wehrii* (mega): [megasporangium ~ (integument | *micropylar funnel*)]^{R} ~ (ovuliferous scale restricted base | ovuliferous scale blade | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis)
*Lack of bud scales is based on extant *Pseudolarix* (which has vegetative leaves on the basal portion of the fertile axis)

Pseudotsuga menziesii (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Pseudotsuga menziesii (mega): [megasporangium ~ (integument | micropylar stigma)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract | bract wing^{R})]^{R} ~ (strobilus axis) ~ (bud scale)^{R}

†*Schizolepidopsis canicularis* (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (bract scale complex base | ovuliferous scale lobe^{R} | seed wing^{R}) > (free bract tip)]^{R} ~ (strobilus axis)

†*Schizolepidopsis liasokeuperianus* (mega): [[megasporangium ~ (integument | micropylar tube)]^{R} ~ (bract scale complex base | ovuliferous scale lobe^{R} | seed wing^{R}) > (free bract tip)]^{R} ~ (strobilus axis)
*Seed and wing morphology scored as *S. canicularis*

†*Tsuga cf.dumosa* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract | bract lobe)]^{R} ~ (strobilus axis) > (*bud scale*)^{R}
*Micropyle and bud morphology uncertain; we score as *T. heterophylla* as a baseline, but include possible micropylar arms.

Tsuga heterophylla (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Tsuga heterophylla (mega): [megasporangium ~ (integument)]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

Tsuga mertensiana (mega): [megasporangium ~ (integument | micropylar arm^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}

†*Tsuga swedea* (mega): [megasporangium ~ (integument | *micropylar arm*^{R})]^{R} ~ (ovuliferous scale | seed wing^{R}) > (bract)]^{R} ~ (strobilus axis) > (bud scale)^{R}
*Described as most similar to *T. mertensiana*, which forms the basis of the scoring here. The presence of micropylar arms is not known for certain, however.

Podocarpaceae

In a number of Podocarpaceae genera, the integument is almost completely fused to the epimatium and the micropyle is the only region of the integument that could be said to be a distinct part. For these taxa, we do not score the integument as a distinct MET. For most Podocarpaceae, we score the epimatium + the ovule as subtended by a bract, rather than borne on the bract, although this distinction is often obscured by growth.

Acmopyle pancheri (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis)

Acmopyle pancheri (mega): [megasporangium ~ (integument | micropylar funnel) ~ (epimatium) ~ (fertile fleshy bract) + sterile fleshy bract^{R} + (scale bract)^{R} ~ (strobilus axis)
*Epimatium does not completely envelope the seed, but it is fused and adnate to it. Fertile fleshy bract is identical in morphology to other fleshy bracts on the strobilus.

Afrocarpus gracilior (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bud bract)^{R}]^{R}
*Compound cone axes in *Afrocarpus* are similar in size to primary cone axes; not scored as separate AEs.

Afrocarpus gracilior (mega): megasporangium ~ (micropyle) ~ (epimatium) > (bract)^{R} ~ (strobilus axis)
*There is some differentiation among bracts on the strobilus, but we do not consider it to rise to the level of separate parts.

†*Bellingshausium willeyii* (mega): [megasporangium ~ (integument) ~ (scale complex)]^{R} ~ (fleshy strobilus axis)

Dacrycarpus dacrydioides (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Dacrycarpus dacrydioides (mega): megasporangium ~ (micropyle) ~ (epimatium) ~ (bract crest) ~ [dry bract tip | fleshy bract lobe]^{R} ~ (strobilus axis)

*Several fleshy bracts are fused together to make the receptacle; we score them as lobes of a single fused structure. The sterile tips are basically the aborted ovule plus a nonfleshy bract tip; I score them simply as a separate tip on the fused bract complex. These are quite distinct from the sclerified bract portion that subtends the ovule+epimatium. All are scored as separate METs but as the same BSU, as they are all bracts.

†*Dacrycarpus guipingensis* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Dacrycarpus guipingensis* (mega): megasporangium ~ (micropyle) ~ (epimatium) ~ (bract crest) ~ [dry bract tip | fleshy bract lobe]^{R} ~ (strobilus axis)

†*Dacrycarpus puertae* (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

†*Dacrycarpus puertae* (mega): megasporangium ~ (micropyle) ~ (epimatium) ~ (bract crest) ~ [dry bract tip | fleshy bract lobe]^{R} ~ (strobilus axis)
*Both pollen and seed cones scored as identical to modern *Dacrycarpus*, as per description.

Dacrydium araucarioides (mega): [megasporangium ~ (integument) ~ (epimatium) > (bract)]^{R} + bract^{R} ~ (strobilus axis)
*Sterile and fertile bracts appear identical.

Dacrydium cupressinum (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Dacrydium cupressinum (mega): megasporangium ~ (integument) ~ (epimatium) > [(fleshy fertile bract base | fertile bract tip)]^{R} ~ (strobilus axis)
*Sterile and fertile bracts appear identical.

Falcatifolium falciforme (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Falcatifolium papuanum (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (fertile axis)]^{R} ~ fertile axis ~ (bract)^{R}
*Fertile structure consists of ramified pollen cone axes; I do not consider the various axes separate parts.

Falcatifolium taxoides (mega): megasporangium ~ (micropyle) ~ (epimatium) > (fleshy bract)^{R} ~ (strobilus axis)
*Only one of the fleshy bracts is fertile.

†*Friisia lusitanica* (mega): [megasporangium ~ (micropyle) ~ (parenchymatous epimatium | ovuliferous scale) > (bract)]^{R} ~ (strobilus axis)

Halocarpus bidwillii (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Halocarpus bidwillii (mega): [megasporangium ~ (integument) ~ (epimatium | swollen epimatium lip) > (bract)]^{R} + bract^{R} ~ (strobilus axis)

†*Harrisiocarpus gucikii* (mega): [megasporangium ~ (integument | micropylar tip) ~ (*epimatium*) > (bract)]^{R} ~ (strobilus axis)
*Structure of this taxon is somewhat difficult to interpret. The putative bract and epimatium were described as almost fully fused; I therefore tentatively score them as separate parts and organs.

Lagarostrobus franklinii (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Lagarostrobus franklinii (mega): [megasporangium ~ (integument) ~ (epimatium) > (bract)]^{R} ~ (strobilus axis)

Lepidothamnus intermedius (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Lepidothamnus intermedius (mega): megasporangium ~ (integument | curved micropyle$^!$) ~ (epimatium) > (fleshy bract)^R ~ (strobilus axis)

Manoao colensoi (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Manoao colensoi (mega): [megasporangium ~ (integument) ~ (epimatium) ~ (fertile bract)]^R + (sterile bract)^R ~ (strobilus axis)
*In this taxon, the sterile and fertile bracts are distinctly different. In *Manao*, like *Microcachrys*, the epimatium is distinctly borne on the bract, rather than adaxial to it.

†*Masculostrobus rajmahalensis* (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

†*Mehtaia rajmahalensis* (mega): megasporangium ~ (integument | curved micropylar tube) > (bract)]^R ~ (strobilus axis)

Microcachrys tetragona (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Microcachrys tetragona (mega): [megasporangium ~ (integument) ~ (epimatium) ~ (fertile bract)]^R ~ (strobilus axis)

†*Morenostrobus fertils* (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Nageia nagi (micro): [[microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis) > (bract)]^R > bud bract^R
*Secondary cone axes in *Nageia* are similar in size to the primary cone axis; not scored as separate elements. Bracts forming the bud are generally similar to those subtending the strobili.

Nageia nagi (mega): megasporangium ~ (micropyle) ~ (epimatium) > (fertile bract) + (sterile bract)^R ~ (strobilus axis)
*In this taxon, the sterile and fertile bracts are distinctly different.

Nageia wallichiana (mega): megasporangium ~ (micropyle) ~ (epimatium) > (fleshy bract)^R ~ (strobilus axis)

†*Nipanioruha granthia* (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

†*Nipanioruha granthia* (mega): [megasporangium ~ (integument | curved micropylar tube) ~ (ovuliferous scale | seed covering flap/epimatium) ~ (bract | distal keel)]^R ~ (strobilus axis)
*Ovuliferous scale appears to be borne on the bract, not in a direct axillary position.

†*Nipaniostrobus sahnii* (mega): [megasporangium ~ (integument | curved micropylar tube) ~ (ovuliferous scale | covering flap/epimatium) > (bract)]^R ~ (strobilus axis)
*Ovuliferous scale is described as axillary, but the overall cone morphology is said to be identical to *Nipanioruha*; we therefore score the scale as being borne on the bract.

Parasitaxus ustus (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Parasitaxus ustus (mega): megasporangium ~ (micropyle) ~ (epimatium) > (bract)^R ~ (strobilus axis)
*Images from Patrick Knopf suggest reproductive structure is a small fertile shoot with a single fertile scale and sterile bracts that are identical in form to the fertile bract.

Pherosphaera fitzgeraldii (micro): [microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Pherosphaera fitzgeraldii (mega): [megasporangium ~ (integument | micropylar funnel) > (bract)]^{R} ~ (strobilus axis)

Phyllocladus toatoa (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) ~ (bud bract)^{R}

Phyllocladus toatoa (mega): [megasporangium ~ (integument | micropylar funnel) ~ (aril) > (cone bract)]^{R} ~ (strobilus axis) > (bract)

Phyllocladus trichomanoides (micro): [[microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis)]^{R}
*Cones appear to be borne in clusters at the base of branches; not certain if an additional bud scale is present.

†Podocarp pollen cone (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis)

Podocarpus brassii (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) ~ (bud bract)^{R}

Podocarpus dispermus (mega): [megasporangium ~ (micropyle) ~ (epimatium) > (fleshy bract)]^{R} ~ (strobilus axis)

Podocarpus gnidioides (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis) > bract^{R}]^{R}
*Bud and bract scales in this species are similar in morphology

Podocarpus macrophyllus (mega): megasporangium ~ (micropyle) ~ (epimatium) > (fleshy bract)^{R} ~ (strobilus axis)

Podocarpus neriifolius (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis) > (bud bract)^{R}

Podocarpus polyspermus (mega): [megasporangium ~ (micropyle) ~(epimatium) > (fleshy bract)]^{R} + (sterile bract)^{R} ~ (strobilus axis)
*A member of Section Longifoliolatus, which has two reduced sterile bracts below the main fertile bracts.

Podocarpus salignus (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} ~ (strobilus axis)]^{R} > (bud bract)^{R}

Prumnopitys andina (mega): [megasporangium ~ (integument/epimatium) > (bract)]^{R} ~ (strobilus axis)
*In this taxon, the epimatium is completely fused to the micropyle; they are a single part.

Prumnopitys ferruginea (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis) > bract^{R}
*Bud bracts and sterile bracts form a more or less continuous gradation and are not scored as separate parts.

Prumnopitys ferruginea (mega): megasporangium ~ (micropyle) ~ (epimatium | nub) > (long bract)^{R} + (scale bract)^{R} ~ (strobilus axis)

Prumnopitys taxifolia (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} ~ (strobilus axis) > (bract)^{R}]^{R} ~ strobilus axis

Retrophyllum minus (micro): [microsporangium^{R} ~ (sporophyll pedicel | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis)

Retrophyllum minus (mega): megasporangium ~ (micropyle) ~ (epimatium) > (bract)^{R} ~ (strobilus axis)

Saxegothaea (micro): [microsporangium^{R} ~ (sporophyll pedicel)]^{R} + (bract)^{R} ~ (strobilus axis)

Saxegothaea conspicua (mega): [megasporangium ~ (integument) ~ (epimatium) ~ (bract restricted base | swollen bract apophysis)]^{R} + (bract)^{R} ~ (strobilus axis) > (bract)^{R}

*Bud bracts are similar to basal sterile bracts and are scored as the same structure.

†*Sitholeya rajmahalensis* (mega): megasporangium ~ (integument) > (bract)^R ~ (strobilus axis)

†*Squamastrobus tigrensis* (micro): microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis)

Sciadopityaceae

†*Sciadopityostrobus kerae* (mega): [[megasporangium ~ (integument)]^R ~ (ovuliferous scale lobe)^R ~ (bract complex restricted base | swollen apophysis)]^R ~ (strobilus axis)

Sciadopitys verticillata (micro): [[microsporangium^R ~ (sporophyll pedicel | distal lamina)]^R ~ (strobilus axis) > (bract)]^R ~ strobilus axis

Sciadopitys spp (mega): [[megasporangium ~ (integument | seed wing)]^R ~ (ovuliferous scale | ovuliferous scale lobes^R) ~ (bract)]^R ~ (strobilus axis) > (bud bract)^R
*Distinct ovuliferous lobes are present early in ontogeny, so I score them as separate parts even if they more or less become fused into one structure later.

Taxaceae

Amentotaxus argotaenia (micro): [[microsporangium^R ~ (sporophore stalk)]^R ~ (strobilus axis element) > (bract)]^R ~ (strobilus axis element) > bract^R
*The bracts at the base of the entire structure appear similar to the bracts that subtend each cone.

Amentotaxus argotaenia (mega): megasporangium ~ (integument) ~ (aril) + (bract)^R ~ (fertile axis)

Austrotaxus spicata (mega): megasporangium ~ (integument | micropylar beak) ~ (aril) + (bract)^R ~ (fertile axis)

Cephalotaxus harringtonii (micro): [[microsporangium^R ~ (sporophore stalk | distal lamina)]^R ~ (fertile axis element) > (bract)]^R + bract ~ fertile axis element
*The basal bracts of the compound cone axis grade into the subtending cone bracts; scored as the same part.

Cephalotaxus harringtonii (mega): [[megasporangium ~ (integument | micropylar beak) ~ (aril)]^R > (bract)]^R ~ (strobilus axis)

†*Marskea thomasiana* (mega): [megasporangium ~ (integument | micropylar tube) ~ (aril) + (bract)^R ~ (fertile axis)]^R

†*Paleotaxus* (mega): [megasporangium ~ (integument) ~ (*aril*) + (bract)^R ~ (fertile axis)]^R
*Interpreted as having an aril, although I see no clear evidence for this.

Pseudotaxus rediviva (micro): [microsporangium^R ~ (sporophore stalk) > (bract)]^R + bract^R ~ (strobilus axis)
*Sterile bracts that grade into the bud scales are similar to the bracts that subtend the sporophores; I score them as the same part.

Pseudotaxus chienii (mega): megasporangium ~ (integument) ~ (aril) + (bract)^R ~ (fertile axis)

Taxus baccata (micro): [microsporangium^R ~ (sporophore stalk)]^R + (bract)^R ~ (strobilus axis)

Taxus baccata (mega): megasporangium ~ (integument | micropylar beak) ~ (aril) + (bract)^R ~ (fertile axis)]^R

Torreya californica (mega): [megasporangium ~ (integument | micropylar beak) ~ (aril) + (bract)^R ~ (fertile axis)]^R

Torreya nucifera (micro): [microsporangium^{R} ~ (sporophore stalk | distal lamina)]^{R} + (bract)^{R} ~ (strobilus axis)

Torreya taxifolia (micro): [microsporangium^{R} ~ (sporophore stalk)]^{R} + (bract)^{R} ~ (strobilus axis)

18. Gnetales

Most recent analyses place Gnetales within crown conifers sister to Pinaceae. Whatever their true relationships, reproductive structures of the group are difficult to score consistently. Generally, they consist of fertile axis systems producing a variety of more or less modified bracts, which makes delimiting specific METs difficult. This is especially the case for fossil members, which generally are not preserved in enough detail to fully characterize their reproductive structures.

†*Cariria orbiculiconiformis* (mixed): [[megasporangium ~ (integument | micropylar tube)]^{R} > (ovule covering bract)^{R} > (bract)^{R} ~ (fertile axis)]^{R} + microsporangium > (sterile appendage)^{R} > (bract)^{R} ~ (fertile axis)
* Microsporangial morphology and attachment are unclear; we score as the simplest possibility proposed by the authors: a single pollen-producing organ surrounded by sterile appendices. The bract and axis subtending the pollen-producing organs are similar in basic morphology to those subtending the ovulate organs.

†*Chengia laxispicata* (mega): [[megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope) > (bract)]^{R} ~ (fertile axis)]^{R} > (*basal bract*)^{R}
*Cones appear variable in their position; some are solitary individuals while others are clusters subtended by modified leaves that are arguable distinct enough to count as basal bud-like bracts. We therefore score as potentially having a second bract type.

†*Drewria potomacensis* (mega): [[megasporangium ~ (integument | micropylar tube) > (bract)^{R} > (bract)]^{R} ~(fertile axis)]^{R}
*The seeds appear to be subtended by multiple sets of bracts/bracteoles. They do not appear to be overwhelming different from one another and we score as the same element type and organ.

†*Eamsia chinensis* (micro): [[microsporangium^{RR} + (bract^{R}) ~ (fertile axis)]^{R}

Ephedra antisyphilitica (micro): [[microsporangium^{R} ~ stalk]^{R} ~ (antherophore) > (bract cup) > (fertile bract)]^{R} ~ (fertile axis) > (bud scale)^{R}
*In general with *Ephedra* pollen cones, bud scales sometimes appear as morphologically distinct from other bracts and sometimes they appear to form a gradient. We generally score as distinctive, but allow the possibility that they should be considered identical.

†*Ephedra archaeorhytidosperma* (mega): [megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope | ridge^{R}) > (bract cup) > (small sterile bract)^{R} ~ (fertile axis)]^{R}
*It is unclear if the subtending bracts for a completely fused cup, although they are depicted that way in the reconstruction.

†*Ephedra carnosa* (mega): megasporangium ~ (integument$^{!}$ | micropylar tube) ~ ("second integument" bract envelope)]^{R} > (fleshy bract)^{R} ~ (fertile axis) > (*bud scale*)^{R}
*Cone is broken without showing the base; basal bud bracts are likely given other *Ephedra* taxa.

Ephedra chilensis (micro): [microsporangium^{RR} ~ (antherophore) > (bract cup) > (fertile bract)]^{R} ~ (fertile axis) > (bud scale)^{R}]^{R}

Ephedra distachya (micro): [microsporangium^{RRR} ~ (antherophore) > (bract cup) > (fertile bract)]^{R} ~ (fertile axis) > (bud scale)^{R}

Ephedra foeminea (micro): [microsporangium^{RR} ~ (antherophore) > (bract cup) > (fertile bract)]^{R} + [megasporangium ~ (integument | micropylar tube) > ("second integument" bract envelope)]^{R} > fertile bract^{R} ~ (fertile axis) > (bud scale)^{R}
*Ovule functions only to release a droplet; does not produce a viable megasporangium. The fertile bracts subtending the two ovule complexes are nearly identical to the typical fertile bracts, albeit slightly fused together. We score as the same organ and element.

Ephedra girardiana (mega): megasporangium ~ (integument | micropylar tube) ~ (second integument" bract envelope) + (fleshy bract)^{R} ~ (fertile axis) > (bud bract)^{R}
*In many *Ephedra* seed cones, the bud bracts for a continuous gradient with the sterile bracts. But in those with fleshy bracts, the organs become distinctive over their ontogeny.

Ephedra nevadensis (mega): [megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope)]^{R} + (fleshy bract)^{R} ~ (fertile axis) > (bud bract)^{R}

Ephedra trifurca (mega): megasporangium ~ (integument | micropylar tube) ~ (second integument" bract envelope) + (sterile bract)^{R} ~ (fertile axis) > bud bract^{R}
*Here the bud scales and sterile bracts for a continuous series, as the sterile bracts stay papery and do not become distinctive and fleshy.

Gnetum gnemon (micro): [[megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope)]^{R} + [microsporangium^{R} ~ (sporangiophore) > ("perianth" bract pair)]^{R} > (sterile cup)]^{R} ~ (fertile axis)

Gnetum gnemon (mega): [[megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope) ~ ("third integument" bract envelope)]^{R} ~ (sterile bract cup)]^{R} ~ (fertile axis)

†*Siphonospermum simplex* (mega): megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envelope) ~ (*"third integument" bract envelope*) ~ (fertile axis)
*There appear to be two separate envelopes, as in Gnetum, but preservation is not great. We therefore allow the possibility of just two.

Welwitschia mirabilis (micro): [megasporangium ~ (integument | micropylar tube | flared "stigma") + [microsporangium^{RR} ~ (sporangiophore element^{R} | sporangiophore tube) > (bracteole "perianth") > (lateral bracteole)^{R} > (cone bract)]^{R} ~ (fertile axis) > (fertile axis bract)]^{R}
*For both micro and megasporangiate *Welwitschia*, we do not score the cones as being repeated in any organized way; there is evidently quite a bit of variability in higher order branching.

Welwitschia mirabilis (mega): [[megasporangium ~ (integument | micropylar tube) ~ ("second integument" bract envlope) > (bracteole)^{R} > (cone bract)]^{R} ~ (fertile axis) > (fertile axis bract)]^{R}

19. Bennettitales†

The Bennettitales are the only group in this analysis where different interpretations of organ identity change the MET and BSU numbers. In one interpretation ("interpretation 1" below; [*39*]) of Bennettitalean ovules, they possess a nucellar plug that extrudes from their micropyle. If true, this plug is a feature of the megasporangium (= the nucellus in seed plants) and is thus not scored as a morphological element of the reproductive structure in our analysis. In another intepretation ("interpretation 2" below; [*40*]), the "nucellar plug" is considerd to be a thin inner integument (= the true integument). In this case, the ovules are surrounded by an additional organ with a cupulate identity, a structure which is interpreted as the sole integument in "interpretation 1". We score ovulate bennettitalean structures both ways to allow for either interpretation; error bars (e.g., Fig. 1A) reflect this uncertainty. In general, we default to "interpretation 1" because it is the less complex interpretation and follows our generally conservative approach with regards to MET numbers.

Cycadeoidea dacotensis/macafferyi (mega; interpretation 1): [megasporangium ~ (integument sheild | micropylar tube | ovule stalk)]^{R} + (interseminal scale)^{R} + ([{microsporangium^{RR} ~ pinnate sporophyll element}^{R} | microsporophyll base | swollen microsporophyll apex]^{R} ~ fused microsporophyll base) + (perianth bract)^{R} ~ (fertile axis)

Cycadeoidea dacotensis/macafferyi (mega; interpretation 2): [megasporangium ~ (integument | integument tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scale)^{R} + ([{microsporangium^{RR} ~ pinnate sporophyll element}^{R} | microsporophyll base | swollen microsporophyll apex]^{R} ~ fused microsporophyll base) + (perianth bract)^{R} ~ (fertile axis)

Cycadolepis plant (*Bennetticarpus* + *Haitingeria*) (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + (interseminal scale)^{R} + ([[microsporangium^{R} ~ microsporophyll lobe]^{R} | microsporophyll)]^{R} + (perianth bract)^{R} ~ (fertile axis)

Cycadolepis plant (*Bennetticarpus* + *Haitingeria*) (mega; interpretation 2): [megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scale)^{R} + ([[microsporangium^{R} ~ microsporophyll lobe]^{R} | microsporophyll)]^{R} + (perianth bract)^{R} ~ (fertile axis)
*For both interpretations, there is no direct evidence of a micropylar tube, although the authors consider that it was likely retracted. I score as present given that the ovules are completely surrounded by interseminal scales and it is difficult to imagine how pollination would have been accomplished without this kind of structure.

Lunzia austriaca (micro): ([microsporangium^{RR} ~ (microsporophyll | sporophyll lobe^{R})]^{R} ~ (bract cup | cup lobe^{R} | cup stalk)
Vardekloeftia (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | seed rib^{R} | ovule stalk)]^{R} + (interseminal scale)^{R} ~ (fertile axis)

Vardekloeftia sulcata (mega; interpretation 2): [megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule “seed” rib^{R} | cupule stalk)]^{R} + (interseminal scale)^{R} ~ (fertile axis)

Welsbergia bursigera (micro): [microsporangium^{RR} ~ (sporophyll)]^{R} ~ (fertile petiole)

Weltrichia givulescui (micro): ([microsporangium^{RR} ~ fertile lobe]^{R} | inward lobe^{R} | cup | resinous sac^{R} | stalk)

Weltrichia setosa (micro): ([microsporangium^{RR} ~ fertile lobe | bristle^{R}]^{R} | inward lobe^{R} | cup | stalk)

Weltrichia sol (micro): [microsporangium^{RR} ~ (pedicel element)]^{R} ~ (microsporophyll lobe^{R} | cup | resinous sac^{R} | stalk)

Weltrichia spectabilis (micro): [microsporangium^{RR} ~ (pedicel element)]^{R} ~ (microsporophyll lobe^{R} | cup | stalk)

Weltrichia whitbiensis (micro): ([microsporangium^{RR} ~ microsporophyll lobe]^{R} | cup | stalk)

Westersheimia pramelreuthensis (mega; interpretation 1): [[megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + (interseminal scales)^{R} ~ (fertile axis element)]^{R} ~ fertile axis element
*These reproductive structures consist of multiple “gynoecia” borne on a fertile axis. We consider the axes supporting the ovules to be the same MET as the main fertile axis, following how we scored taxa with ramifying fertile axis systems in general.

Westersheimia pramelreuthensis (mega; interpretation 2): [[megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scales)^{R} ~ (fertile axis element)]^{R} ~ fertile axis element

Williamsonia bockii/harrisiana/nizhonia (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + (interseminal scale)^{R} + (perianth bract)^{R} ~ (fertile axis)

Williamsonia bockii/harrisiana/nizhonia (mega; interpretation 2): [megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scale)^{R} + (perianth bract)^{R} ~ (fertile axis)

Williamsonia leckenbyi (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + (interseminal scale^{R} | corona) + (perianth bract)^{R} ~ (fertile axis)

Williamsonia leckenbyi (mega; interpretation 2): [megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scale^{R} | corona) + (perianth bract)^{R} ~ (fertile axis)

Williamsonia netzahualcoyotlii (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + [(interseminal scale stalk | armored scale head)]^{R} + (perianth bract)^{R} ~ (fertile axis)

Williamsonia netzahualcoyotlii (mega; interpretation 2): [megasporangium ~ (integument^{I} | micropylar tube) ~ (cupule | cupule stalk)]^{R} + [(interseminal scale stalk | armored scale head)]^{R} + (perianth bract)^{R} ~ (fertile axis)
*Bracts are not known for this taxon, but we them score as present based on other *Williamsonia*.

Williamsoniella coronata (mega; interpretation 1): [megasporangium ~ (integument | micropylar tube | ovule stalk)]^{R} + (interseminal scale^{R} | corona) + ([{microsporangium^{RR} ~ microsporphyll lobes}^{R} ~ microsporophyll | microsporophyll stalk)]^{R} + (perianth bract)^{R} ~ (fertile axis)

Williamsoniella coronata (mega; interpretation 2): [(megasporangium ~ (integument | micropylar tube) ~ (cupule | cupule stalk)]^{R} + (interseminal scale^{R} | corona) + ([{microsporangium^{RR} ~ microsporphyll lobes}^{R} ~ microsporophyll | microsporophyll stalk)]^{R} + (perianth bract)^{R} ~ (fertile axis)

Angiosperms

Angiosperms are often difficult to score because of their complexity; their reproductive structures can show highly intricate three-dimensional shapes that preclude an easy atomization into parts and they may also show complicated hierarchical arrangements of structures. Angiosperm fossils are also often fragmentary, and many fossils could not be scored for organization characters because it is unclear whether they were borne in an inflorescence. Detailed explanation for specific taxa are provided below, but here we detail a few idiosyncracies of how we scored angiosperms.

We scored the second integument as one repeated MET or BSU, although the second integument is not thought to be homologous to the first integument and is usually considered a separate organ. But within the framework of our scoring scheme, which does not incorporate homology, the integuments would be considered as a single, repeated part type. We score it as akin to repeated bracts, as in the bracts subtending the ovules of *Taxus*, for example. We note that scoring the second integument as a separate MET or BSU would only further increase the complexity of angiosperms, and thus would not change the overal pattern of complexity through time that emerges from our analysis.

Within syncarpous ovaries, we generally scored septa, which are ultimately derived from fusion of individual carpel walls, as separate METs. Some taxa also display a very distinct central column where septa join, but we did not score this as a separate part; instead, we considered it part of the ground tissue of the ovary wall. Some taxa also produce multi-part placenta structures, and we generally divided these into parts as we would any other reproductive structure. Lastly, whether the ovule produced a funiculus is often difficult to score. Here we only scored funiculi as separate METs if they were clearly distinct, stalk-like structures. If the funiculus was morphologically continuous with a larger enveloping second integument, we did not consider it a separate MET. In cases where the funiculus grows into an aril, we considered the entire structure as one MET, analogous to the way a conifer cone scale was considered one MET over its ontogeny regardless of any shape changes. Likewise, the wall of the ovary is considered the same MET as the fruit wall.

20. ANA-grade Angiosperms

Amborella trichopoda (micro): [[microsporangium^{RR} ~ (staminode)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*We scored the inflorescence as ramified flower stalks.

Amborella trichopoda (mega): [[megasporangium ~ (integument)^{R} ~ (carpel | stigma)]^{R} > [microsporangium^{RR} ~ (staminode)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*We score the inflorescence here as simply repeated flower stalks, without a different AE for the inflorescene axis. Pollen sacs are nonfunctional, but still represent a visible part.

Austrobaileya scandens (mixed): [[megasporangium ~ (integument)^{R}]^{R} ~ (carpel | carpel stalk | style/stigma)]^{R} > [microsporangium^{RR} ~ (staminode)]^{R} > (tepal)^{R} ~ (flower stalk)
*This taxon shows a morphological gradient from petaloid to filamentous staminodes, and from bract-like to petaloid tepals; we score them as a single part each. Funiculus is not differentiated from the outer integument.

Barclaya longifolia (mixed): [microsporangium^{RR} ~ (filament)]^{R}) > (corolla tube | free petal^{R}) + [(megasporangium ~ (integument^{R} | seed spine^{R} | funiculus)]^{RR} ~ (ovary-receptacle | septum^{R} | carpellary appendage^{R}) > (sepal)^{R} ~ (flower stalk)
*The seed operculum here is more of an anatomical structure than an obvious morphological feature.

Brasenia schreberi (mixed): [[(megasporangium ~ (integument^{R})]^{R} ~ (carpel | style | stigma)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} ~ (flower stalk)
*Ovule funiculus is continuous with outer integument; we do not score as a separate element. As in *Barclaya*, the operculum on the seed is not readily apparent as a distinct morphological element.

Cabomba caroliniana (mixed): [[megasporangium ~ (integument^{R} | micropylar lid | tubercle^{R}]^{R} ~ (carpel | carpel stalk | style | stigma)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > [(tepal | nectiferous appendage^{R})]^{R} > tepal^{R} ~ (flower stalk)
*Ovule funiculus appears continuous with outer integument; we do not score as a separate part. The inner whorl tepals have nectiferous appendages while the outer do not; we do not score the outer whorl as separate element types because they are otherwise identical to the inner.

Euryale ferox (mixed): [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} + [megasporangium ~ (integument^{R} | funiculus/aril)]^{RR} ~ (ovary-receptacle | carpel tip/stigma^{R} | septum^{R} | receptacle nub | spine^{R}) ~ (flower stalk)
*The filament can vary from terete to petaloid, but shows a continuous gradient; it is therefore scored as one element type.

Illicium lanceolatum (mixed): [megasporangium ~ (integument^{R}) ~ (carpel | style/stigma)]^{R} > [microsporangium^{RR} ~ (staminode)]^{R} > (tepal)^{R} ~ (flower stalk)

Kadsura japonica (micro): [microsporangium^{RR} ~ (staminode stalk | staminode shield)]^{R} > (tepal)^{R} ~ (flower stalk)

Kadsura japonica (mega): [[megasporangium ~ (integument^{R})]^{R} ~ (carpel | stigma surface)]^{R} > (tepal)^{R} ~ (flower stalk)

†*Microvictoria svitkoana* (mixed): [microsporangium^{RR} ~ fertile staminode]^{R} + (sterile staminode)^{R} + (sepaloid tepal)^{R} + (petaloid tepal^{R}) + [megasporangium ~ (integument^{R} | *funiculus*]^{RR} ~ (ovary/receptacle | paracarpel/stylar process^{R} | sterile column | column tip) ~ (flower stalk)
*The fertile and sterile staminodes appear distinctly different, but we score the paracarpels and stylar processes/carpellar appendages as a morphological gradient of the same structure.

†*Monetianthus mirus* (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} + [megasporangium ~ (integument^{R} | funiculus]^{RR} ~ (ovary | septum^{R} | stigmatic projection^{R} | apical nub) ~ (flower stalk)
*Fossils show ovules with at least one integument and apparent funiculus-type attachment. We score as a double integument based on other Nymphaealaes.

Nuphar luteum (mixed): [(megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | stigmatic disk | stigma crest^{R}) > [microsporangium^{RR} ~ (staminode)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Sepals grade from petal-like to bract-like.

Nymphaea thermarum (mixed): [microsporangium^{RR} ~ (filament/staminode)]^{R} + (tepal)^{R} + [megasporangium ~ (integument^{R} | funiculus | aril)]^{RR} ~ (ovary-receptacle | apical nub | {stigma ~ carpel lobe}^{R} | septum^{R}) ~ (flower stalk)
*Gradation from sepaloid tepals to petaloid tepals; we score as one element. Anthers may be borne on a gradient from petaloid tepals to thin filaments; we score as one element. There appears to be a clear distinction between an elongate funiculus and the ring-like aril in the mature ovule of Nymphaea in general.

Ondinea purpurea (mixed): [microsporangium^{RR} ~ (filament)]^{R} + [megasporangium ~ (integument^{R} | funiculus/aril)]^{RR} ~ (ovary | septum^{R} | carpel lobe^{R} | {apical nub ~ stalk}) > (sepal)^{R} > (floral stalk)
*We score the ovule as in other Nypheaceae, where the aril is the same element as the funiculus.

Schisandra chinensis (micro): [microsporangium^{RR} ~ (staminode)]^{R} > (tepal)^{R} ~ (flower stalk) > (*bracteole*)

Schisandra glabra (micro): [microsporangium^{RR} ~ (staminode stalk | staminode shield)]^{R} > (tepal)^{R} ~ (flower stalk) > (bracteole)

Schisandra glabra (mega): [[megasporangium ~ (integument^{R})]^{R} ~ (carpel | stigma surface)]^{R} > (tepal)^{R} ~ (flower stalk) > (bracteole)

†Staminate flower (micro): [[microsporangium^{RR} ~ (staminode)]^{R} + (*filament organs*)^{R} + (innter tepal)^{R} + (*outer tepal*)^{R} ~ (flower stalk)
*Difficult to tell if the inner and outer tepals should be separate parts due to preservation. We score as a possibility. The filament organs may be highly modified tepals or may be stamens with anthers not preserved.

Trimenia papuana (micro): [[microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} ~ (flower stalk) > (bract)]^{R}

Trimenia papuana (mega): [megasporangium ~ (integument^{R}) ~ (ovary | stigma)] + [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*As in *Amborella*, the flower stalks are not clearly different from the inflorescence axis, so we score as a ramified branching system.

Trithuria australis (mixed): [[microsporangium^{RR} ~ staminode]^{R} + [megasporangium ~ (integument^{R} | raised micropyle) ~ (carpel | rib^{R} | stalk | stigmatic papilla^{R})]^{R} > (involucral bract)^{R} ~ (stalk)
*Prophylls are described as vegetative leaves and not included in reproductive structure. The funiculus does not seem distinct from the outer integument.

Victoria cruziana (mixed): [microsporangium^{RR} ~ (staminode)]^{R} + (petal)^{R} + (sepal)^{R} + (paracarpel)^{R} + [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary-receptacle | apical nub | septum^{R} | carpellary appendage^{R} | spine^{R}) ~ (flower stalk)
*Continuous gradient from petaloid staminodes to filamentous; we score as one part.

21. Unplaced fossils

†*Mabelia archaia*: (micro): [microsporangium^{RR} ~ (filament)]^{R} > (calyx | tepal lobe^{R}) > (*flower stalk*) > (*bract*)
*Inflorescence is not known; we do not score for arrangement.

†*Princetonia allenbyensis* (mixed): ~ [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | free carpel^{R} | style^{R} | *stigma*^{R} | septum^{R} | placenta lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (*sepal*)^{R} > (flower stalk)]^{R}
*The details of perianth are not preserved, although perianth was present based on scars. We score differentiated sepals as a possibility. A funiculus is also not clearly present from illustrations, athough the presence of a distinct hilum lobe in the seeds suggests it likely was.

†*Zlatkocarpus pragensis* (mega): [megasporangium ~ (integument^{R} | *funiculus*) ~ (ovary | stigma) > (floral cup)]^{R} ~ (inflorescence axis)

22. Magnoliids and Chloranthaceae

†*Archaeanthus llinnenbergeri* (mixed): [[megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (carpel | stigma)]^{R} + [microsporangium^{RR} ~ (filament)]^{R} > (inner tepal)^{R} > (outer tepal)^{R} ~ (flower stalk) > (stipule scale lobe)^{R}
*Ovule morphology scored as modern Magnoliaceae; presence of funiculus in particular is not known.

Aristolochia serpentaria: (mixed): [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (utricle | tube | limb | internal limb flap) > (ovary | ovary ridge^{R} | septum^{R} | style | microsporangium^{RR} | stigma lobe^{R}) ~ (flower stalk) > (bract)

Asimia triloba (mixed): [[megasporangium ~ (integument^{R} | funiculus$^{!}$]^{R} ~ (carpel | stigma)]^{R} > [microsporangium^{RR} ~ (filament | apical shield)]^{R} > (petaloid tepal)^{R} > (sepaloid tepal)^{R} ~ (flower stalk)

Calycanthus floridus (mixed): [megasporangium ~ (integument^{R} | funiculus) ~ (carpel | style)]^{R} + (staminode)^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (petaloid tepal)^{R} ~ (receptacle cup) ~ (flower stalk)
*Apical nub on the stamen is really just an extension of the filament; not scored as a separate element.

Canella winteri (mixed): [[megasporangium ~ (integument^{R} | funiculus]^{RR} ~ (ovary | stigma) > microsporangium^{RR} ~ (androecium tube) > (petal)^{R} > (sepal)^{R} + (bracteole)^{R} ~ (flower stalk)]^{R}

†*Canrightia resinifera* (mixed): [[megasporangium ~ (integument)^{R}]^{R} ~ (ovary | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (hypanthium) > (bract) ~ (*flower/inflorescence axis*)
*Inflorescence is not known, but it is reasonable to suspect that these small flowers were borne in an inflorescence. We score as a possibility for MET analysis, but do not score for arrangement characters.

†*Cascolaurus burmitis* (micro): [microsporangium^{RR} ~ (filament)]^{R} + staminal gland^{R} > (petaloid tepal)^{R} > (sepaloid tepal)^{R} ~ (flower stalk)
*Perianth is described as consisting of two types of tepals. Here we felt there was clear morphological distinction between the two parts, with no gradiation in form between them, to justify two separate METs and BSUs. Likely borne in an infloresence, but more morphology of any possible axis unknown; not scored for arrangement characters.

†*Chloranthistemon alatus* (mixed): [microsporangium^{RR} ~ (staminode | staminode hood) + [microsporangium^{R} ~ (staminode | staminode hood)]^{R} + megasporangium ~ (integument)^{R} ~ (ovary | stigma) > (bract)]^{R} ~ (inflorescence axis)
*Stamen repetition is complicated to score; each flower has one central stamen with two thecae, and two laterals with one. We score as a repeated structure primarily using the most complicated central stamen.

†*Chloranthistemon endressii* (mixed): [microsporangium^{RR} ~ (staminode^{R} | staminode hood) + megasporangium ~ (integument)^{R} ~ (ovary | stigma) > (bract)]^{R} ~ (inflorescence axis)

Chloranthus spicatus (mixed): microsporangium^{RR} ~ (staminode cup | staminode lobe^{R}) + megasporangium ~ (integument)^{R} ~ (ovary | stigma) > (bract)]^{R} ~ (inflorescence axis element) > (bract)]^{R}
*The bract subtending the flowers does not appear substantially different than that subtending the inflorescence axis; scored as the same element type.

Cinnamomum camphora (mixed): [microsporangium^{RR}/stamina gland ~ (filament)]^{R} + megasporangium ~ (integument^{R}) ~ (ovary | style | stigma) ~ (calyx | free tepal^{R}) + (bracteole)^{R} ~ (flower stalk)]^{RR}
*The Lauraceae appear to have funiculi that are more or less continuous with the outer integument. The staminal glands can also be borne on the fertile filaments; there appear to be three parts (the filaments, the anthers, and the stamina glands) that can be arranged in different combinations. We score a simplified version.

†*Cronquistiflora sayrevillensis* (mixed): [[megasporangium ~ (integument^{R} | wing | funiculus/aril]^{R} ~ (carpel | stigma)]^{R} > [microsporangium^{RR} ~ (staminode)]^{R} > (perianth bract)^{R} ~ (flower stalk)

Degeneria vitiensis (mixed): [megasporangium ~ (integument^{R} | *funiculus/seed stalk*)]^{R} ~ (carpel | stigmatic crest) > [(staminode base | staminode head)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} > (flower stalk) + (bracteole)^{R}
*It is somewhat hard to tell, but the funiculus does not appear distinct from the outer integument. The mature seeds appear stalked, but we believe this is due to exposed vasculature caused by the breakdown of the fruit wall. We score as a possible structure.

†*Detrusandra mystagoga* (mixed): [[megasporangium ~ (integument^{R} | wing | funiculus/aril]^{R} ~ (carpel | stigma lobe^{R})]^{R} > (pistillode)^{R} > [microsporangium^{RR} ~ (laminar stamen)]^{R} > (tepal)^{R} + (bract)^{R} ~ (flower stalk)
*Ovules are not figured, but they are described similarly to *Cronquistifolia* and are scored as such.

Drimys winterii (mixed): [[megasporangium ~ (integument)^{R}]^{R} ~ (carpel | stigma)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk) > (flower bract)]^{R}
*Inflorescence axis and its subtending bract are considered the same parts as the flower stalk and bract. The funiculus is barely distinct in the mature ovule, but we do not score as a separate part.

Eupomatia laurina (mixed): [microsporangium^{RR} ~ (filament)]^{R} > (staminode)^{R} > (calyptra cap) + [megasporangium ~ (integument^{R})]^{RR} ~ (ovary-receptacle | septum^{R} | stigma^{R}) > (flower stalk)
*The funiculus is barely distinct in the mature ovule; we do not score as a separate part.

Galbulimima belgraveana (mixed): [[megasporangium ~ (integument)^{R}]^{R} ~ (carpel^{R} | stigma^{R} | fruit wall) > staminode^{R} + [microsporangium^{RR} ~ (staminode)]^{R} > (calyptra cap) ~ (flower stalk) + (bracteole)^{R}
*Carpels are initially free but later fuse into a single fruit with lobes corresponding to the carpels. Inner staminodes are identical to the fertile ones. Typically has one ovule but two does occur; scored as two.

Gomortega keule (mixed): [[microsporangium^{RR} ~ (filament | gland^{R})]^{R} + (perianth lobe)^{R} + megasporangium ~ (integument)^{R}]^{R} ~ (ovary | septum | style | stigma lobe^{R}) ~ (flower stalk) + (bracteole)^{R} > (bract)]^{R}
*The bract and bracteoles are tiny structures that are similar morphologically. Perianth parts grade into petaloid stamens with poorly developed anthers. We score the more differentiated filamentous stamens as a separate structure.

†*Hedyosmum*-like (micro): [microsporangium^{RR} ~ (filament | distal shield)]^{R} ~ (inflorescence axis) > (*bract*)^{R}
*Bract is not preserved, but reasonable to assume it existed. We do not know if the inflorescence was reiterated; arrangement is not scored.

Hedyosmum racemosum (micro): [[microsporangium^{RR} ~ (filament | distal shield)]^{R} ~ (inflorescence axis) > (bract)^{R}]^{R}

Hedyosmum racemosum (mega): [[megasporangium ~ (integument)^{R} ~ (carpel | stigma) > (tepal cup | tepal lobe^{R})]^{R} > (flower subtending bract-fruit lobe)^{R} > (subtending bract) ~ (inflorescence axis)]^{R}
*Multiple reduced flowers become incorporated into a kind of fruit from the swelling of their subtending bracts

Hortonia angustifolia (mixed): [megasporangium ~ (integument)^{R} ~ (carpel | stigma)]^{R} > (staminode)^{R} > [(microsporangium^{RR} ~ (filament | apical bulge | basal gland^{R})]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*Although the sepaloid and petaloid tepals are quite distinct, there is a continuous gradation between them and they are scored as the same element.

Illigera composite (mixed): [[microsporangium^{R} ~ (filament)]^{R} + (tepal)^{R} + megasporangium ~ (integument)^{R} ~ (carpel | fruit wing^{R} | style | stigma ring) ~ (flower stalk) > (bract)]^{RR}
*We score the inflorescence axes and flower stalk as the same element

†*Jamesrosea burmensis*: [microsporangium^{R} ~ (filament | sagitate appendage^{R})]^{R} + [(sagitate appendage ~ (filament)]^{R} + [megasporangium ~ (integument^{R}) ~ (carpel | style | stigma)]^{R} ~ (calyx | free tepal^{R}) ~ (flower stalk)
*Sterile staminodes consisting of a filament with sagitate heads are also present. Because they are made of the same elements as the fertile stamens, I do not score them as separate elements. One ovule per carpel is

known, but details are scored following other Lauraceae. It is reasonable to assume that these small flowers were borne in an inflorescence of some kind, but not known for certain.

†*Jerseyanthus calycanthoides* (mixed): [megasporangium ~ (integument^{R} | *funiculus*) ~ (carpel | style)]^{R} + [microsporangium^{RR} ~ (filament | apical extension^{R})]^{R} + [(staminode stalk | staminode blade)]^{R} + (tepal)^{R} ~ (floral cup) ~ (flower stalk)
*Ovules are not known; we score as Calycanthaceae with a funiculus as possible and solitary flowers.

Magnolia grandifolia (mixed): [[megasporangium ~ (integument^{R} | funiculus/obturator]^{R} ~ (ovary | style-stigma crest)]^{R} + [microsporangium^{RR} ~ (filament stalk | apical extension)]^{R} + (tepal)^{R} + (stipule)^{R} ~ (flower stalk)

†*Mauldinia mirabilis* (mixed): [[[megasporangium ~ (integument)^{R} ~ (ovary | style | stigma) ~ [microsporangium^{R} ~ (filament element^{R} | staminal gland^{R})]^{R} > (inner tepal)^{R} > (outer tepal)^{R}]^{R} + (scale tip)^{R} ~ (lateral unit lobe)]^{RR} ~ (inflorescence axis)
*Staminal glands are only present on some stamens via forked filaments, but are listed here as a single structure for simplicity. Ovule features are scored based on Lauraceae in general, but are not known with certainty.

Myristica fragrans (micro): [[microsporangium^{RR} ~ (androphore) > (perianth tube | tepal tip^{R}) ~ (flower stalk) > (bract)]^{R}

Myristica fragrans (mega): megasporangium ~ (integument^{R} | aril) ~ (ovary | stigma lobe^{R}) > (perianth tube | tepal tip^{R}) > (bracteole) ~ (flower stalk) > bract]^{R}
*The bracteole and bract and very similar in morphology; scored as same element.

†*Persea avita* (mixed): megasporangium ~ (integument)^{R} ~ (ovary | style)] > [microsporangium^{RR} ~ (filament | gland^{R})]^{R} > (inner tepal)^{R} > (outer tepal)^{R} ~ (flower stalk) > (bracteole)
*Staminodes are assumed to exist but not observed, and staminodes in Lauraceae are generally morphologically similar to filaments; we therefore do not score staminodes as separate parts here. Bracteoles are assumed to occur based on comparison to extant *Persea*.

Piper aduncum (mixed): [megasporangium ~ (integument) ~ (ovary | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (bract)]^{R} ~ (spadix axis)

†*Pragocladus lauroides:* [[[megasporangium ~ (integument)^{R} ~ (ovary | style | stigma) ~ [microsporangium^{R} ~ (filament element^{R} | staminal gland^{R})]^{R} > (inner tepal)^{R} > (outer tepal)^{R}]^{R} > (cup bract)]^{R} ~ (primary bract)]^{R} ~ (inflorescence axis element)]^{R}
*Gynoecium is not known, but we score as *Mauldinia*, which has an otherwise similar flower structure.

Sarcandra chloranthoides (mixed): [[megasporangium ~ (integument)^{R} ~ (ovary | stigma) > (microsporangium^{RR} ~ staminode) > (bract)]^{R} ~ (inflorescence axis element) > bract]^{R}
*Bracts subtending the flowers and individual inflorescence branching units appear similar in morphology.

Saururus cernuus (mixed): [[megasporangium ~ (integument^{R})]^{R} ~ (ovary | tubercle^{R} | style/stigma crest)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (bract | bract pedicel)]^{R} ~ (inflorescence axis)

†*Saururus tuckerae* (mixed): [[megasporangium ~ (integument^{R})]^{R} ~ (ovary | *tubercle^{R}* | style/stigma crest)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (bract)]^{R} ~ (inflorescence axis)
*Fruits are not known; tubercles are scored as possible given extant members.

†*Setitheca lativalva* (micro): [[microsporangium^{R} ~ (filament | apiculate tip)]^{R} + (tepal)^{R} ~ (receptacle disk) ~ (flower stalk)
*Described as having basal appendages on filaments, but they are not obvious morphological elements. Higher order clustering is unknown and arrangement characters are not scored.

Siparuna composite (micro): [[microsporangium^{R} ~ (filament)]^{R} ~ (floral tube | free tube tip^{R}) ~ (flower stalk)]^{R}

Siparuna composite (mega): [megasporangium ~ (integument | *funiculus*) ~ (ovary | style/stigma)]^{R} ~ (floral tube | free tube tip^{R}) ~ (flower stalk)]^{R}
*Depicted as having a funiculus stalk, but no apparent from the sections. We score as possible.

†*Tinaflora beardiae* (mixed): megasporangium ~ (integument^{R}) ~ (carpel | style/stigma) > [(sagittate head | staminode stalk)]^{R} > [microsporangium^{RR} ~ (filament | glandular appendage^{R})]^{R} > (free tepal^{R} | hypanthium disk) > (flower stalk)

†*Treptostemon domingensi* (micro): [(microsporangium^{RR} ~ filament | gland^{R})]^{R} > (staminode | gland^{R})^{R} > (tepal)^{R} ~ (flower stalk)
*Staminodes are described as morphologically distinct from the stamens, although the basal glands on both appear similar and are not scored as separate METs.

†*Virginianthus calycanthoides* (mixed): [[megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (carpel)]^{R} + [microsporangium^{RR} ~ (lamina | distal expansion)]^{R} + (tepal)^{R} + (bract)^{R} ~ (floral cup | cup ridge^{R}) ~ (flower stalk)
*Ovules are not known in detail; we score as Calycanthaceae with funiculus scored as possible.

†*Virola dominicana* (micro): [(microsporangium^{RR} ~ (androphore)] > (calyx | calyx lobe^{R}) ~ (flower stalk)

23. Monocots

Acorus calamus (mixed): [megasporangium ~ (integument^{R} | stalk-funiculus]^{RR} ~ (ovary | free carpel lobe^{R} | septae^{R} | placenta lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R}]^{R} ~ (spadix axis)

Agapanthus africanus (mixed): [[megasporangium ~ (integument^{R} | wing | funiculus)]^{RR} ~ (ovary | septum^{R} | stigma) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | petal lobe^{R}) ~ (flower stalk)]^{R} > (inflorescence bract)^{R} ~ (scape axis)

Alpinia speciosa (mixed): microsporangium^{RR} ~ (anther tube | filament) ~ (scale staminode)^{R} + (labellum staminode) ~ (corolla tube | free petal^{R}) > (calyx | free sepal^{R}) + nectary^{R} + [megasporangium ~ (integument^{R} | funiculus/aril)]^{RRR} ~ (ovary | style | stigma lobe^{R} | septum^{R} | placenta^{R}) ~ (flower stalk)]^{R} ~ (inflorescence axis)

Arisaema dracontium (mixed): [megasporangium ~ (integument)^{R}]^{R} ~ (ovary | stigma)]^{R} + [microsporangium^{RR} ~ (filament)]^{R} > (inflorescence axis) > (spathe)

†Aroid inflorescence (micro): [microsporangium^{RR} ~ (filament | inflated head)]^{R} > (inflorescence axis) > (*spathe*)

Billbergia pyramidalis (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | ovary lobe^{R} | septum^{R} | style^{R} | stigma^{R}) > [microsporangium^{RR} ~ (filament) ~ (petal | phlange^{R})]^{R} > (calyx | free sepal^{R})]^{R} ~ (inflorescence axis) + (bract)^{R}

Callisia graminea (mixed): [[megasporangium ~ (integument^{R} | seed coat rib^{R}]^{RR} ~ (ovary | septum^{R} | style | stigma) > [microsporangium^{RR} ~ (filament | hair^{R})]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)]^{R} > (bract)^{R}

Costus speciosus (mixed): [microsporangium^{RR} ~ (broad filament | petaloid staminode) > (stamnode lip) > (corolla tube | free petal^{R}) > (calyx tube | free sepal^{R}) + [[megasporangium ~ (integument^{R} | aril | operculum]^{RR} ~ (ovary | septum^{R} | style | upper stigma flap^{R} | lower stigma flap^{R}) > (bract)]^{R} ~ (inflorescence axis)

Cyperus esculentus (mixed): [[megasporangium ~ (integument^{R} | funiculus) ~ (ovary | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (bract)]^{R} ~ (spikelet axis)]^{R} ~ (inflorescence axis)

†*Dasylarynx anomalus* (mixed): [megasporangium ~ [integument^{R} | *funiculus*]$^{?}$ ~ (ovary | style) > (staminode)^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (corolla tube) > (sepal)^{R} ~ (flower stalk)

Dietes grandifolia (mixed): [[microsporangium^{RR} ~ (staminode)]^{R} + (petal/sepal | beard)^{R} + [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | ovary lobe^{R} | septum^{R} | style arm^{R} | stigmatic flap^{R} | style crest^{RR}) ~ (spathe)^{R}]^{R} ~ (inflorescence axis)
*In this iris, the petals and sepals are not very different in their morphology, although the sepals contain a beard.

Dioscorea floridana (micro): [[(vestigial ovary | vestigial ovary lobe^{R}) > [microsporangium^{RR} ~ (filament) ~ (tepal)]^{R} > (bract)]^{R} ~ (inflorescence axis element) > bract]^{R}
*Various bracts on the inflorescence appear identical.

Dioscorea floridana (mega): [[(staminode) ~ (tepal)]^{R} + [megasporangium ~ (integument^{R} | wing)]^{RR} ~ (ovary | ovary lobe^{R} | septum^{R} | stigmatic crest^{R}) > (bract)]^{R} ~ (inflorescence axis)

Encyclia tampensis (mixed): [[microsporangium^{RR} ~ (caudicle)]^{R} + [megasporangium ~ (integument)^{R}]^{RR} ~ (ovary | placenta lobe^{R} | column | distal column phlange^{R} | stigma | anther cap) > (dorsal labellum lobe^{R} | median labellum lobe | labellum guide lobe^{R}) + (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*Consider the inflorescence as a ramified flower stalk. We do not consider the funiculus to be separate from the outer integument.

Eragrostis cilianensis (mixed): [[megasporangium ~ (integument)^{R} ~ (ovary | style^{R} | stigma brush^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (lodicule)^{R} > (palea-lemma-glume)^{R}]^{R} ~ (spikelet axis)]^{R} > (inflorescence axis)]^{R}
*We score the glumes, lemmae, and palae as morphologically similar and not as separate METs or BSUs

Eriocaulon compressum (mixed inflorescence): [[megasporangium ~ (integument)^{R}]^{R} ~ (ovary lobe^{R} | style | stigma lobe^{R}) > (petal/sepal | nectary gland)^{R} ~ (flower stalk) > floral bract]^{R} + [[microsporangium^{RR} ~ filament]^{R} > (petal/sepal | nectary gland)^{R} ~ (flower stalk) > floral bract]^{R} + (inflorescence bract)^{R} ~ (receptacle head) ~ (inflorescence axis)
*Petals, sepals, and subtending floral bracts are all fairly similar to each other in morphology; we score as the same part type.

Hemerocallis fulva (mixed): [[megasporangium ~ (integument^{R} | funiculus]^{RR} ~ (ovary lobe^{R} | septum^{R} | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} ~ (perianth tube | free tepal^{R}) ~ (flower stalk) > (bracteole)]^{R}
*Inflorescence axis does not appear any different than the flower stalks; considered a ramified axial system with flower stalks as an element.

Juncus marginatus (mixed): [[megasporangium ~ (integument)^{R}]^{RR} ~ (ovary | placenta lobe^{R} | stigma^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} > (bract)]^{R} ~ (inflorescence axis)]^{R}

Lemna minor (mixed): megasporangium ~ (integument)^{R} ~ (ovary | stigmatic cup) > [microsporangium^{RR} ~ (filament)]^{R} > (reduced spathe)

Lilium catesbaei (mixed): [[megasporangium ~ (integument^{R} | wing | funiculus)]^{RR} ~ (ovary | septum^{R} | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > [(constricted tepal base | tepal blade)]^{R} ~ (flower stalk) > (bract)

Narthecium ossifragum (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septa^{R} | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract^{R})]^{R} ~ (inflorescence axis)
*We score the subtending bract and the small bracteole as the same structure; the bracteole also does not appear to be present all the time.

Polygonatum biflorum (mixed): [[megasporangium ~ (integument^{R} | *funiculus*)]^{RR} ~ (ovary | septum^{R} | style | stigma) > [(microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | tepal tip^{R}) ~ (flower stalk)]^{R}
*Funiculus unclear; we score as likely.

Pontederia cordata (mixed): [megasporangium ~ (integument^{R} | funiculus) ~ (ovary | septum^{R} | style) > [microsporangium^{RR} ~ (filament)]^{R} ~ (calyx tube | free tepal^{R} | acrescent perianth teeth^{R})]^{R} ~ (inflorescence axis) > (spathe)

†*Pseudhaplocricus hexa* (micro): [microsporangium^{RR} ~ (filament)]^{R} > (petal limb | petal claw)^{R} > (sepal)^{R} ~ (*flower stalk*)
*Flower stalk or pedicel described, but unclear in illustrations. Petals are described as clawed. Disk-like tissue connecting filaments is not scored as a separate MET because the structure was not geometrically distinct.

Sagittaria lancifolia (mixed): [[megasporangium ~ (integument^{R} | funiculus) ~ (ovary | fruit wing | stigma crest)]^{R} ~ (receptacle head) > (petal)^{R} > (sepal)^{R} ~ (flower stalk) > (bract)]^{RR} + [[microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk) > (bract)]^{RR} ~ (inflorescence axis)
*We scored the monoecious morph here, as it would be the most complex.

Scheuchzeria palustris (mixed): [[megasporangium ~ (integument^{R} | funiculus$^{!}$]^{R} ~ (carpel | stigma crest^{R})]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{R}
*Gradation in inflorescence axis size to be indistinguishable from the flower stalk; we score as the same part.

Serenoa repens (mixed): [[megasporangium ~ (integument)^{R}]^{R} ~ (ovary lobe^{R} | stylodium) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) > (sepal)^{R} ~ (inflorescence axis)]^{R} > (bract)]^{R} (primary inflorescence axis)
*Flowers are borne on a ramified set of inflorenscence axes, which are in turn borne on a major axis that is much thicker.

Smilax auriculata (micro): [[microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis)

Smilax auriculata (mega): [[megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | septum^{R} stigma crest^{R})] > (staminode) > (tepal)^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis)

Strelitzia reginae (mixed): [microsporangium^{RR} ~ (filament)]^{R} ~ (laterial petal tube | lateral petal blade^{R}) + (adaxial petal) + (sepal)^{R} + [megasporangium ~ (integument^{R} | aril)]^{RR} ~ (ovary | septum^{R} | style | stigma lobe^{R})]^{R} > (inflorescence bract) ~ (scape axis)

Tofieldia pusila (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RRR} ~ (ovary lobe^{R} | placenta crest^{R} | stylodium^{R})]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk) > (calyculus scale)^{R}]^{R} ~ (inflorescence axis)
*Three fused carpels, but the fusion is not enough to erase their origin. Ovary remains deeply lobed to the base, so we consider the structure to be a repeated ovary lobe that then transitions into a simple style/stigma.

Triglochin striata (mixed): [[megasporangium ~ (integument^{R})]^{R} ~ (ovary lobe^{R} | stigma tuft^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis)

Trillium maculatum (mixed): [[megasporangium ~ (integument^{R} | funiculus | aril)]^{RR} ~ (ovary lobe^{R} | septum^{R} | style^{R} | stigma crest^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)

†*Trithrinax dominicana* (mixed): [[megasporangium ~ [integument^{R} | *funiculus*]$^{?}$ ~ (carpel | *septum* | style/stigma)]^{R} > [(microsporangium^{RR} ~ (broad filament base | filament tip)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Apparent stub of flower stalk illustrated. Carpels described as three, closely addressed; here we primarily score as repeated separate carpels, but we allow the possibility that they were fused into an ovary creating internal septa.

Typha latifolia (mixed inflorescence): [microsporangium^{RR} ~ (filament | head)]^{R} + hair^{R}]^{R} + (ensheathing bract) + [(megasporangium ~ (integument^{R} | seed cap) ~ (carpel | style | stigma) + hair^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis)

Xyris platylepis (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary lobe^{R} | septa^{R} | style trunk | style branch^{R} | stigma^{R}) > (microsporangium^{RRR} ~ filament^{R} | staminode stalk^{R} | staminode plume^{RR}) > (petal)^{R} > (sepal)^{R}]^{R} ~ (inflorescence axis)
*Stamens and staminodes appear to be partially fused to petals to create one larger structure.

Zephryanthes treatii (mixed): [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | tepal tip^{R}) + [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary lobe^{R} | septum^{R} | style | stigma lobe^{R}) ~ (flower stalk) > (bract)

24. Eudicots

Basal Eudicots

Argemone albiflora (mixed): [megasporangium ~ (integument^{R} | funiculus/aril)]^{RR} ~ (ovary | placenta lobe^{R} | prickle^{R} | stigma crest) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal | spine^{R})^{R} ~ (flower stalk)
*Aril is not really distinguishable from the funiculus; scored as a single structure.

Buxus sempervirens (mixed): [megasporangium ~ (integument^{R} | aril)]^{RR} ~ (ovary | septum^{R} | nectary lobe^{R} | style^{R} | stigma^{R}) > (flower bract)^{R} > [(pistilode) > microsporangium^{RR} ~ (filament)]^{R} > (phyllome)^{R} > (flower bract)]^{R} + (bract)^{R} ~ (inflorescence axis)
*We regard the various inflorescence and floral bracts as the same element and the same part.

Ceratophyllum demersum (micro): [microsporangium^{R} ~ (filament | apical extension | apical horn^{R}]^{R} > (tepal)^{R} ~ (flower stalk)

Ceratophyllum demersum (mega): [megasporangium ~ (integument) ~ (ovary | style | seed horn^{R}) > (tepal)^{R} ~ (flower stalk)

Cocculus carolinus (micro): [[microsporangium^{R} ~ (filament)]^{R} > (petal)^{R} > (inner sepal)^{R} > (outer sepal)^{R} > (flower stalk) > (bract)]^{R} ~ (inflorescence axis)

Cocculus carolinus (mega): [[megasporangium ~ (integument^{R} | longitudinal seed ridge^{R} | transverse ridge^{R} | funiculus]^{R} ~ (ovary | ovary stalk | stylodium)]^{R} > (petal)^{R} > (inner sepal)^{R} > (outer sepal)^{R} > (flower stalk) > (bract)]^{R} ~ (inflorescence axis)

Didymeles integrifolia (micro): [microsporangium^{RR} ~ (filament) > (bract)]^{R} ~ (inflorescence axis element) > (bract)]^{R} ~ inflorescence axis + bract^{R}

Didymeles integrifolia (mega): [megasporangium ~ (integument^{R} | tube) ~ (carpel | stigma) > (scale organ) > (bract)]^{R} ~ (inflorescence axis element) > (bract)]^{R} ~ inflorescence axis + bract^{R}

Dysosma versipellis (mixed): megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | placenta crest | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)]^{R}

Euptelea pleiosperma (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (carpel | stalk | stigma crest | wing^{R})]^{R} > [microsporangium^{RR} ~ (filament)]^{R} ~ (flower stalk) > (bract)
*Inflorescence is mixed with leaves on a vegetative axis; therefore we do not score as a compound structure.

†*Kajanthus lusitanicus* (mixed): [[megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (ovary | stigma)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (inner perianth part)^{R} > (outer perianth part)^{R} ~ (*flower stalk*)
*Bitegmic ovules scored from extant Lardizabalaceae.

Leucospermum cordifolium (mixed): [megasporangium ~ (integument)^{R} ~ (ovary | style | stigma/pollen presenter) > (nectiferous bract)^{R} > microsporangium^{RRR} ~ (perianth tube | free perianth element) > (flower bract)]^{R} ~ (inflorescence axis) > (involcre bract)^{R}

†*Lijinganthus revoluta* (mega): [megasporangium ~ (integument^{R} | *funiculus*)]^{RR} ~ (ovary | septum^{R} | style | stigma) > (floral disc) > [microsporangium^{R} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Likely had multiple funiculate ovules in each locule, given its similarity to other eudicots, but this is not known. Likely borne in an inflorescence, but higher arrangement is unknown and arrangement is not scored.

Nelumbo nucifera (mixed): [megasporangium ~ (integument^{R}) ~ (carpel | stigma)]^{R} ~ (receptacle) > [microsporangium^{RR} ~ (filament | apical appendage)]^{R} > (tepal)^{R} ~ (flower stalk)
*Bud sepals and petals are not clearly differentiated; form a gradation.

Nigella damascena (mixed): [megasporangium ~ (integument^{R} | testa ridge^{R}]^{RR} ~ (ovary/fruit | carpel lobe^{R} | septum^{R} | style^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > [(tepal constricted base | tepal blade)]^{R}
*No obvious flower stalk, as the entire structure is borne direction on a vegetative axis subtened by vegetative leaves. Funiculus appears to be continuous with outer integument.

Platanus occidentalis (micro): [[microsporangium^{RR} ~ (filament | apical shield)]^{R} > (three-ridged organ)^{R} > (perianth organ)^{R}]^{R} ~ (inflorescence axis)

Platanus occidentalis (mega): [[[megasporangium ~ (integument^{R})]^{R} ~ (carpel | stylodium | fruit lip)]^{R} > (staminode)^{R} > (perianth organ)^{R}]^{R} ~ (inflorescence axis)
*Funiculus is not well developed; not scored here as a separate part.

†*Quadriplanatus georgianus* (micro): [[microsporangium^{RR} ~ (filament | apical thickening)]^{R} > (tepal)^{R}]^{R} ~ (inflorescence head)

†*Quadriplanatus georgianus* (mega): [[megasporangium ~ (integument)^{R}]^{R} ~ (ovary | carpel lobe/stigmatic surface^{R} | septum^{R}) > (tepal tip^{R} | tepal tube)]^{R} ~ (inflorescence axis)

Sargentodoxa cuneata (mixed inflorescence): [(vestigial carpel)^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk) > (bract)]^{R} + [[megasporangium ~ (integument)^{R} ~ (carpel | stylodium)]^{R} > [microsporangium^{RR} ~ (filament)]^{R} > petal^{R} > sepal^{R} ~ (flower stalk) > (bract)]^{R} ~ (inflorescence axis)
*For mixed inflorescences, we generally scored clearly vestigial organs in staminate or pistillate flowers as the same element and part as in the fully functional flowers. Inflorescence bud scales appear to also cover vegetative leaves; we therefore did not score as part of the reproductive structure.

†*Spanomera mauldinensis* (mixed): [[microsporangium^{RR} ~ (filament | conical extension)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{R} + [megasporangium ~ (integument^{R} | *aril/funiculus*)]$^{?}$ ~ (carpel | stigmatic crest^{R})]^{R} > (tepal)^{R} ~ inflorescence stalk
*Aril/funicular presence and ovule number scored based on extant Buxaceae, but ovule morphology is not known. Tepals of the staminate and pistillate flowers show a gradient in size, and are scored as the same element and part. We also score the flower stalk of the staminate flower as the same element as the broader inflorescence axis, following inflorescences in most other cases.

Trochodendron aralioides (mixed): [[megasporangium ~ (integument^{R} | funiculus | chalazzal extension)]^{RR} ~ (ovary lobe^{R} | septum^{R} | style^{R} | stigma^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (prophyll)^{R} ~ (flower stalk) > (bract)]^{R} ~ (inflorescence axis)
*Rudimentary tepals are not consistent structures, and are extremely small; we do not score them as parts.

Core Eudicots

Acanthus mollis (mixed): [[megasporangium ~ (integument)^{R}]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | fimbriate collar | petal lobe^{R}) > (lateral sepal)^{R} + (abaxial/adaxial sepal)^{R} + (bracteole)^{R} > (bract | bract spine^{R})]^{R} ~ (inflorescence axis)

†*Actinocalyx bohrii* (mixed): [megasporangium ~ (integument^{R} | reticulate seed ridge^{R} | *funiculus*]^{RR} ~ (ovary | septum^{R} | style^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | petal lobe^{R}) > (sepal)^{R} > (bracteole)^{R} ~ (*flower stalk*)
*Ovule morphology not known in detail.

†*Allonia decandra* (micro): [microsporangium^{RR} ~ (filament | apical extension)]^{R} > (petal)^{R} > (calyx | calyx lobe^{R}) ~ (flower stalk)
*Whether it was borne in an inflorescence is unknown

Ampelopsis arborea (mixed): [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum | stylodium | nectiferous disc element^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (calyx) ~ (flower stalk) > (bract)]^{RR}
*We score the inflorescence as a repeated clusters of flowers.

Amphilophium crucigera (mixed): [megasporangium ~ (integument^{R} | funiculus | seed wing)]^{R} ~ (ovary | intruding placenta/fruit septum | echinate pericarp projections^{R} | style | stigma flaps^{R}) > (ring nectary) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | petal lobe^{R}) > (calyx) ~ (flower stalk) > (bract)]^{R}

Anagallis arvensis (mixed): [megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | central placenta dome | placenta columella | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)

†*Antiquacupula sulcata* (mega): [microsporangium^{RR} ~ (expanded base | filament)]^{R} + nectary^{R} + (tepal)^{R} + (megasporangium ~ (integument^{R} | *funiculus*)]^{RR} ~ (ovary | ovary rib^{R} | septum^{R})]^{R} > (cupule bract^{R} | cupule stalk)
*Unclear how the staminate flowers of this taxon were borne; they are not scored. The exact repeating pattern of the cupule is not entirely clear; we score simply as a gradient of repeated bracts that subtend a number of flowers.

Arabidopsis thaliana (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > nectary element^{R} > (sepal)^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis)
*Style is extremely short; we do not score as a separate part. Inflorescence is somewhat difficult to score, but we simply score as repeated flowers without subtending bracts or cauline leaves. We score the inflorescence axis as a separate part because it is distinctly larger than the flower stalks and there does not appear to be any gradiation in diameter.

Arbutus unedo (mixed): [[megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum^{R} | ovary/fruit tubercle^{R} | style | stigma ring) > (nectary disk) > [microsporangium^{RR} ~ (filament | apical horn^{R})]^{R} > (corolla tube | petal tip^{R}) > (sepal)^{R} ~ (flower stalk) > (bract)]^{RR}
*Clustering of the inflorescence axis is somewhat difficult to score. We score as clusters of flowers, repeated around an inflorescence axis that is not a fundamentally different part than the flower stalks

†*Archaefagacea futabensis* (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} + (megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | style^{R} | stigma^{R}) ~ (flower stalk)
Ardisia crenata (mixed): [megasporangium ~ (integument^{R})]^{R} ~ (ovary | placenta stalk | placenta bulge | style/stigma) > [microsporangium^{RR} ~ (filament stalk | connective)]^{R} > (petal)^{R} > (sepal)^{R} > (flower stalk) > (bud bract)]^{RR}
*We score the inflorescence as a clustered repetition of flower stalks

Aster carolinanus: [microsporangium^{RR} ~ (filament)^{R} ~ (corolla tube | petal tip^{R}) + (bristle)^{R} + megasporangium ~ (integument) ~ (ovary/calyx | style | stigma lobe^{R})]^{R} + [(corolla tube | expanded petal) + (bristle)^{R} + (megasporangium ~ (integument) ~ (ovary/calyx | style | stigma lobe^{R})]^{R} > (bract)^{R} ~ (receptacle) ~ (inflorescence stalk)

†Asterid unnamed (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (nectary disk lobe)^{R} + (petal)^{R} + (sepal lobe)^{R} + (megasporangium ~ (integument^{R} | *funiculus*)]^{RRR} ~ (ovary | ovary/fruit rib^{R} | septum^{R} | placenta head^{R} | style^{R} | stigma^{R}) ~ (flower stalk)

†*Austrodiospyros cryptostoma* (micro): (vestigial gynoecium) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal) > (calyx | free sepal) ~ (flower stalk)

Begonia cucullata (mixed inflorescence): [microsporangium^{RR} ~ (filament | apical extension)]^{R} > (staminate tepal)^{R} > (flower stalk) > (bract)]^{R} + [(petal)^{R} + [megasporangium ~ (integument)]^{RRR} ~ (ovary | septum | placenta lobe^{RR} | ovary/fruit wing^{R} | style | stigma horn^{RR}) > (pistillate tepal)^{R} > (flower stalk) > (bract)]^{R}

*Presence of funiculus is unclear.

Betula alnoides (micro): [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} > (subbract)]^{R} > (bract)]^{R} ~ (inflorescence axis)
*The tepal and the "subbract" are not appreciably different in morphology; we score as the same part type

Betula alnoides (mega): [[[megasporangium ~ (integument)]^{R} ~ (ovary | fruit wing/tepal^{R} | stigma lobe^{R}) > (secondary bract)]^{R} > (bract)]^{R} ~ (inflorescence axis)

Boehmeria cylindrica (mixed inflorescence): [apical nub > [[microsporangium^{RR} ~ (filament)]^{R} > (staminate calyx | calyx lobe^{R}) + [megasporangium ~ (integument^{R}) > (ovary | style/stigma) > (pistillate calyx)]^{RR} ~ (inflorescence axis)

Bougainvillia sp. (mixed): megasporangium ~ (integument^{R} | funiculus) ~ (ovary | style/stigma) > [microsporangium^{RRR} ~ (filament^{R} | androecium tube) > (calyx tube | tepal lobe^{R}) > (involcre bract)]^{R} ~ (inflorescence stalk) + (bractole)^{R}

Callistemon citrinus (mixed): [(megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | placenta bulge^{R} | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} ~ (calyx | calyx lobe^{R})
*Flowers occur on a fertile zone of a branch; not scored as an inflorescence.

Capparis cynophallophora (mixed): [(megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (gynophore stalk | ovary | septum | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)

Carpobrotus edulis (mixed): microsporangium^{RRR} ~ (filament^{R} | stamen receptacle) + (petaloid staminode)^{R} + (fleshy calyx lobe | scale-like region)^{R} + [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (calyx/ovary | style/stigma^{R} | septum^{R}) ~ (flower stalk)

Cartrema americana (micro): [(vestigial ovary) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | petal lobe^{R}) > (calyx | sepal lobe^{R}) ~ (flower stalk) + (bracteole)^{R} ~ bract]^{R}
*We score inflorescence as a ramified system of flower stalks, which contain bracteoles. We score bracts on the inflorescence as the same structure as the bracteoles.

Cartrema americana (mega): [[megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > (corolla tube | petal lobe^{R}) > (calyx | sepal lobe^{R}) ~ (flower stalk) + (bracteole)^{R} ~ bract]^{R}

†*Castanopsis kaulii* (mega): [[[microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} + [megasporangium ~ (integument)]^{RR} ~ (ovary | septum^{R} | style/stigma^{R})]^{R} + (interseminal scale)^{R} > (cymule bract/bracteole)^{R}]^{R} ~ (inflorescence axis)
*Inflorescence axis not present but scored based on extant representatives. We score the main bracts and the bracteoles as the same MET with gradiation in size, and assume two ovules per locule for the family in general.

†*Catalpa hispaniolae* [megasporangium ~ [integument^{R} | funiculus | seed wing^{R}]$^{?}$ ~ (ovary | style | *stigma lobe*^{R}) > [(microsporangium^{RR} ~ filament)]^{R} ~ (corolla tube | free petal^{R}) > (calyx | free calyx lobe^{R}) ~ (flower stalk)
*Stigma described as unlobed but scored as potential additional part in comparison with extant *Catalpa*.

Catharanthus roseus (mega): [megasporangium ~ (integument | funiculus)]^{R} ~ (ovary^{R} | placenta crest^{R} | style | stigma head collar | stigma head lobe^{R}) > gland^{R} > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | expanded upper portion of tube | free petal^{R}) > (sepal)^{R} ~ (flower stalk)

Citrus reticulata (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | style | stigma) > (nectary disk) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk) > (bract)]^{R}

Clusia rosea (mixed): [[megasporangium ~ (integument^{R} | funiculus | aril)]^{RR} ~ (ovary | septum^{R} | stigma pad^{R}) > microsporangium^{R} ~ (androecium ring) > (petal)^{R} > (sepal)^{R} + (bract)^{R} ~ (flower stalk)

†*Comopellis presbya* (mixed): (floral disc | disc appendage^{R}) + [microsporangium^{R} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} + [megasporangium ~ [integument^{R} | funiculus]$^{?}$ ~ (ovary/hypanthium cup | free ovary portion | stigma) ~ (flower stalk) > (*bract*)
*Morphology somewhat unclear; gynoecium appears to be partially free and partially fused into a hypanthium; scoring based on comparison with extant Rhamnaceae. Extant members typically have a bract subtending the flower stalk; scored here as a possibility.

Cornus florida (mixed): (nectary disk) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal tip)^{R} + [megasporangium ~ (integument | funiculus)]^{R} ~ (ovary/calyx | septum | style | stigma) > (bract)]^{R} > (petaloid bract)^{R} ~ (inflorescence stalk)

Crotolaria spectablis (mixed): [[[megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | placenta | style | stigma) > microsporangium^{RRR} ~ (filament^{R} | androecium tube) > (keel petal) + (wing petal)^{R} + (banner petal)^{R} > (calyx tube | sepal tip^{R}) ~ (flower stalk) + (bracteole)^{R} > (bract)]^{R} ~ (inflorescence axis)

†*Dakotanthus cordiformis* (mixed): [[megasporangium ~ (integument^{R} | *funiculus*)]$^{?}$ ~ (ovary lobe^{R} | stigma/style^{R}) > (nectary disc lobe)^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R}]^{R} ~ (inflorescence axis)
*Ovule morphology is unknown but it scored as a typical eudicot.

Diodia teres (mixed): [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) + (sepal tip)^{R} + [megasporangium ~ (integument | funiculus)]^{R} ~ (ovary | septum | style | stigma lobe^{R})

†*Divisestylus spp.* (mixed): (microsporangium^{RR} ~ filament) + (petal)^{R} + (free calyx lobe)^{R} + [megasporangium ~ integument^{R} | *funiculus*]^{RR} ~(ovary/hypanthium | septum | style^{R} | stigma^{R}) ~ (flower stalk) ~ (*inflorescence axis*)

†*Dressiantha bicarpellata* (mixed): [megasporangium ~ integument^{R} | *funiculus*]$^{?}$ ~ (ovary | septum | style | stigma) > (staminode^{R} | staminodal tube) > [microsporangium^{RR} ~ (filament)]^{R} ~ (petal)^{R} + (sepal)^{R} + (bract)^{R} ~ (flower stalk)
*Ovules are not known, but are scored as eudicots generally. Style is described as single, but having a deep suture. We score this as a single ovary with a single style and stigma.

Dysphania ambrosioides (mixed): [megasporangium ~ (integument^{R} | funiculus) ~ (ovary | style lobe^{R} | papilla^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (calyx | tepal lobe^{R}) > (bract)]^{R} ~ (inflorescence axis)
*Bract is somewhere between an obvious bract and a vegetative leaf, but it is quite different than the leaves.

†*Ekrixanthera hispaniolae* (micro): (pistilode) > [(microsporangium^{RR} ~ (filament)]^{R} > (tepal claw | tepal blade)^{R} ~ (flower stalk)
*Only two of the tepals are clawed, the others are linear; linear tepals are morphologically similar to the base of the clawed petal and are not considered separate METs.

†*Endressianthus miraensis* (micro): [[[microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} > (bract/prophyll)^{R}]^{R} > (bract/prophyll)]^{R} ~ (inflorescence axis)

†*Endressianthus miraensis* (mega): [[(tepal nub)^{R} + [megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (ovary | septum | style/stigma^{R}) > (bract/prophyll)^{R}]^{R} > (bract/prophyll)]^{R} ~ (inflorescence axis)
*Number of ovules is not known, but since it is bicarpellate, we assume multiple were present.

†*Eoepigynia burmensis* (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (calyx lobe)^{R} + [megasporangium ~ (integument^{R} | *funiculus*)]$^{?}$ ~ (ovary | *septum^{R}* | style | stigma lobe^{R}) > (flower stalk)
*Ovary is described as syncarpus (hence a putative septum MET), but gynoecium structure is not known for certain; not scored for arrangement characters.

†Ericalean unnamed (mixed): [megasporangium ~ (integument^{R} | *funiculus*)]^{RR} ~ (ovary lobe^{R} | septum^{R} | placenta lobe^{R} | style | stigma lobe^{R}) > nectary lobe^{R} + [microsporangium^{RR} ~ (filament)]^{R} > (petal limb | petal claw)^{R} > (sepal)^{R} ~ (*flower stalk*)

†*Esgueiria spp.* (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (tepal)^{R} + [megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (ovary/receptacle | style | stigma lobe^{R}) ~ (flower stalk) > (*bract*)]$^{?}$
*Inflorescence fragments suggest that flowers were borne in clusters, but exact arrangement is unknown. Given their arrangement in an inflorescence, additional bracts are possible.

Euonymus americanus (mixed): [megasporangium ~ (integument^{R} | funiculus | caruncula)]^{RR} ~ (ovary | septum^{R} | style/stigma nub) + [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} ~ (floral disk | tubercle^{R}) ~ (flower stalk) > (bract)]^{R}
*The aril (caruncula) eventually engulfs the funiculus, but they are derived from separate parts and I score as separate METs.

Euphorbia tridentata (mixed inflorescence): [megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | septum^{R} | style | style lobe^{R} | stigma^{R}) ~ (flower stalk) + [microsporangium^{RR} ~ (filament/pedicel)]^{R} + (gland^{RR} | gland appendage^{R} | gland appendage base flap)]^{R} ~ (involucre cup | involucre bracteole^{R}) > (perianth organ)^{R} ~ (cyathium/infloresence stalk)

Ficus carica (mixed inflorescence): [megasporangium ~ (integument^{R} | funiculus) ~ (ovary | style | stigma lobe^{R}) > (tepal)^{R} ~ (flower stalk)]^{R} + [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk)]^{R} ~ (syncomium | ostiole bract^{R}) > (bud bract)^{R}

Frangula caroliniana (mixed): [[megasporangium ~ (integument^{R})]^{R} ~ (ovary | septum^{R} | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (petal)^{R} ~ (calyx | calyx lobe) ~ (flower stalk)]^{R} > (bud scale))^{R}

Fraxinus velutina (micro): [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk)]^{R} ~ (inflorescence axis element)]^{R} > (bud bract)^{R}

Fraxinus velutina (mega): [megasporangium ~ (integument)]^{R} ~ (ovary | septum | wing | style | stigma lobe^{R}) > (calyx) ~ (flower stalk)]^{R} ~ (inflorescence axis element)]^{R} > (bud bract)^{R}
*We score the inflorescences as clusters of flowers borne on ramifiying axial elements. Appears that the funiculus is thick and similar in morphology to integument.

Gelsemium sempervirens (mixed): [megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > (nectiferous disc) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) > (sepal)^{R} ~ (flower stalk)

Geranium carolinianum (mixed): [[megasporangium ~ (integument^{R})]^{RR} ~ (ovary lobe^{R} | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament blade)]^{R} > (nectar disk lobe)^{R} > (petal)^{R} > (sepal blade | sepal prickle)^{R} ~ (flower stalk)]^{R}

Gordonia lasianthus (mixed): [megasporangium ~ (integument^{R} | funiculus | seed wing)]^{RR} ~ (ovary | style | stigma lobe^{R}) > [microsporangium^{RRR} ~ (filament^{R} | stamen fascicle)]^{R} ~ (petal)^{R} > (sepal)^{R} ~ (flower stalk)

Guaiacum sanctum (mixed): [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary lobe^{R} | style/stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (petal claw | petal blade)^{R} > (sepal)^{R} ~ (flower stalk)

Gunnera dentata (micro): [[microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} > (flower bract)]^{R} ~ (spike axis) > (bract)]^{R} ~ (secondary inflorescence axis)

Gunnera dentata (mega): [[megasporangium ~ (integument^{R} | funiculus) + (sepal/petal)^{R} ~ (ovary | stylodium^{R}) > (flower bract)]^{R} ~ (spike axis) > (bract)]^{R} ~ (secondary inflorescence axis)

†*Hamamelidaceous unnamed* (micro): [{staminode filament | bulbuous apical projection}^{R} + microsporangium^{RRR} ~ {anther filament | inflated apical conive}^{R} | staminal tube) > (sepal cup | sepal lobe^{R})]^{R} ~ (inflorescence axis)

Hamamelis virginiana (mixed): [megasporangium ~ (integument^{R})]^{R} ~ (ovary | septum | stylodium lobe^{R}) > (staminode/nectary) + [microsporangium^{R} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)]^{R}

Hedera helix (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (reduced tepal)^{R} ~ [megasporangium ~ (integument | funiculus)]^{R} ~ (calyx/ovary | septum^{R} | style/stigma) ~ (flower stalk) > (bract)]^{R} ~ (inflorescence axis element) > (bract)]^{R}

Helianthemum corymbosum (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary lobe^{R} | placenta lobe^{R} | style | stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (reduced sepal)^{R} + (sepal)^{R} ~ (flower stalk) > (bracteole)]^{R}
*Inflorescences appear to consist of chasmogamous and cleistogamous flowers, but we score both as having identical parts. We score the inflorescence (which appears to be quite variable) as a simple repetition of flowers.

Hibiscus incantus (mixed): [megasporangium ~ (integument^{R} | funiculus)]^{RRR} ~ (ovary | style tube | style lobe^{R}| stigma disk^{R}) > (petal)^{R} + [microsporangium^{R} ~ (filament)]^{R} ~ (staminal tube) > (calyx | calyx lobe) > (epicalx bract)^{R} ~ (flower stalk)

Hippurus vulgaris (mixed): microsporangium^{RR} ~ (filament) + megasporangium ~ (integument | funiculus) + (reduced calyx) ~ (ovary | stigma)
*Flowers are subtended by a vegetative leaf; although arranged in whorls, the "inflorescence" is no different than the vegetative body.

Hydrangea quercifolia (mixed): [[microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal tip)^{R} + [megasporangium ~ (integument)]^{RR} ~ (ovary/receptacle | septum | placenta lobe^{R} | style^{R} | stigma crest^{R}) ~ (flower stalk)]^{R} + [microsporangium^{RR} ~ (filament)]^{R} + (sterile flower petal)^{R} + (sepal tip) ~ (flower stalk)]^{R} ~ (inflorescence axis)

Ilex sp (mixed): [[megasporangium ~ (integument | funiculus]^{R} ~ (ovary | septum^{R} | stigma) > [microsporangium^{RR} ~ (filament)]^{R} ~ (petal)^{R} > (calyx | tepal tip^{R}) ~ (flower stalk) > (bud bract)^{R}]^{R}

Ipomea pandurata (mixed): [megasporangium ~ (integument)]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > (nectiferous disk) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) > (sepal)^{R} ~ (flower stalk) > (bract)]^{R}
*Family is given as bitegmic, but *Ipomea* appears unitegmic.

Jasminum polyanthum (mixed): [megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (petal tip^{R} | corolla tube) > (calyx | sepal tip^{R}) ~ (flower stalk) > (bract)]^{R}

Juglans regia (micro): [[microsporangium^{R} ~ (filament)]^{R} > (tepal)^{R} > (bract lamina | bract pedicel)]^{R} ~ (inflorescence axis) > (bud bract)^{R}

Juglans regia (mega): [[megasporangium ~ (integument) ~ (ovary | packing tissue | septum | stigma)]^{R} > (tepal)^{R} > (bracteole ring | bract tip)]^{R} ~ (inflorescence axis) > (bud bract)^{R}

†*Klaprothiopsis dyscrita* (mixed): [microsporangium^{R} ~ (filament)]^{R} + (staminode)^{R} + (petal)^{R} + (calyx lobe) + [megasporangium ~ [integument | *funiculus*]$^{?}$ ~ (ovary/calyx | style | stigma) ~ (flower stalk)
*Inferior ovary; calyx tube is fused to ovary and scored as a single MET, as in other taxa.

†*Lasiambix dominicensis* (mixed): [megasporangium ~ [integument^{R} | *funiculus*]$^{?}$ ~ (ovary | style/stigma) > [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} ~ (calyx lobe^{R} | calyx)
*Stigma described as not distinct from style.

Limonium sinuatum (mixed): [[megasporangium ~ (integument^{R} | funiculus) ~ (ovary | style^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla | petal lobe^{R}) > (calyx tube | flare) ~ (flower bract)^{R}]^{R} ~ (inflorescence axis element) > (bract)]^{R}
*We score this as a cluster of flowers borne on an inflorescence element, which is then repeated many times as a basic bifurcating system.

Liquidambar styraciflua (mixed inflorescence): (aborted carpel)^{R} > [microsporangium^{RR} ~ (filament)]^{R} > (bract)^{R} ~ (infloresecene axis element) > (bract)]^{R} + [(phyllome)^{R} + [sterile anther ~ filament]^{R} + [megasporangium ~ (integument)^{R}]^{RR} ~ (ovary | septum | style^{R} | stigma crest^{R}) > (bract)]^{R} ~ (inflorescence axis element) > (bract)
*Structures that are clearly vestigial remains of organs developed on other flowers within the total reproductive structure we score as redundant parts. Individual staminate flowers are borne densely on an infloresencence element, such that their clustering is not longer visible; I score simply as one cluster of flowers, mixed with bracts. Flower and inflorescence bracts and bract-like organs appear to show a gradation in forms and are scored as a single type. Funiculus is reduced.

†*Lobocydas anomala* (mixed): [megasporangium ~ (integument^{R} | funiculus | *caruncula*)]^{RR} ~ (ovary lobe^{R} | septum^{R} | style | stigma) > [(microsporangium^{RR} ~ filament)]^{R} > (floral disc | disc lobe^{R}) > (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Flower stalk, funiculus, and multiloculate ovary inferred based on extant Celastraceae. Caruncula scored as a possibility, as it appears to be a more variable trait in the group.

Lonicera sempervirens (mixed): [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | petal lobe^{R}) + (calyx tooth)^{R} + [[megasporangium ~ (integument | funiculus)]^{RRR} ~ (ovary | septum^{R} | placenta head^{R} | style | stigma ring)]^{RR} ~ (inflorescence axis)

Malpighia glabra (mixed): [[megasporangium ~ (integument^{R})]^{R} ~ (ovary | septum^{R} | style^{R} | stigma^{R}) > [microsporangium^{RRR} ~ (filament^{R} | connective gland^{R} | androecium tube) > (petal claw | petal blade)^{R} > (sepal | sepal gland^{R})^{R} ~ (flower stalk) + (bracteole)^{R}]^{R} > (bracteole)^{R}

Melia azedarach (mixed): [[megasporangium ~ (integument^{R} | funiculus]^{RR} ~ (ovary | septum | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (androecium tube | apical extension^{R}) > (petal)^{R} > (sepal)^{R} + (bracteole)^{R} ~ (flower stalk)]^{RR}
*Inflorescence scored as clusters of multiple flowers

Melothria pendula (micro): [[microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (calyx tube | free sepal^{R}) ~ (flower stalk)
*We score the blunt central nub as an extension of the flower stalk.

Melothria pendula (mega): (petal)^{R} > (calyx tube | free sepal^{R}) ~ [megasporangium ~ (integument^{R} | funiculus]^{RR} > (ovary | style | stigma lobe^{RR} | nectary disk) ~ (flower stalk)

Microaltingia apocarpeia (mega): [[[megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (carpel | style/stigma]^{R} ~ (hypanthium | phyllome organ^{R})]^{R} ~ (inflorescence axis)
*We regard the style and stigma as not differentiated, but this could be due to preservation.

Myrica cerifera (micro): [[microsporangium^{RR} ~ (filament)]^{R} > (bract)]^{R} ~ (inflorescence axis)

Myrica cerifera (mega): [megasporangium ~ (integument) ~ (ovary | fruit vesicle^{R} | stigma lobe^{R}) > (bracteole)^{R} > (bract)]^{R} ~ (inflorescence axis)

Myriophyllum spicatum (mixed inflorescence): [megasporangium ~ (integument^{R} | funiculus) ~ (ovary lobe^{R} | stigma^{R}) > (bracteole)^{R} > (bract)]^{RR} + [microsporangium^{RR} ~ (filament)]^{R} > (perianth lobe)^{R} > (bracteole)^{R} > (bract)]^{RR} ~ (inflorescence axis)
*Scored a monoecious form.

Myrothamnus flabelliformis (micro): [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} > (bract)]^{R} ~ (inflorescence axis)

Myrothamnus flabelliformis (mega): [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | stylodium^{R} | stigma^{R}) > (tepal)^{R} > (bract)]^{R} ~ (inflorescence axis)

†*Normanthus miraensis* (mega): [[(tepal)^{R} > [microsporangium^{RR} ~ (filament)]^{R} + [megasporangium ~ (integument^{R} | *funiculus*)]^{R} ~ (ovary | ovary lobe^{R} | septum | style/stigma^{R}) > (bract/prophyll)^{R}]^{R} > (bract/prophyll)]^{R} ~ (inflorescence axis)
*Inflorescence structure is based on *Endressianthus*

Oenothera lacinata (mixed): (petal)^{R} + [microsporangium^{RR} ~ (filament)]^{R} ~ (calyx tube | nectiferous disk | free sepal^{R}) + [megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | septum^{R} | style | stigma lobe^{R})

Opuntia humifusa (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} + [(spine)^{R} > (bract)]^{R} + [megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary/receptacle | style | {stigma ~ free style lobe}^{R})
*Gradient from sepaloid tepals to petaloid tepals; scored as a single part type.

Oxalis corymbosa (mixed): [[microsporangium^{RR} ~ (filament)]^{R} + [megasporangium ~ (integument^{R} | aril | funiculus)]^{RR} ~ (ovary lobe^{R} | style^{R} | stigma^{R}) > (petal)^{R} > (sepal)^{R} ~ (flower stalk)]^{R} > (bract)^{R}

Oxypolis filiformis (mixed): [[[microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal tip)^{R} + [megasporangium ~ (integument | funiculus)]^{R} ~ (ovary | style lobe^{R} | stigma^{R}) ~ (flower stalk)]^{R} > (bract)^{R}]^{R}
*We score the inflorescence as a cluster of flowers, subtended by bracts, which are then repeated.

†*Paleoclusia chevalieri* (mixed): [megasporangium ~ (integument^{R} | funiculus/aril]^{RR} ~ (ovary | stigma lobe^{R} | septum^{R}) + [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Two integuments scored based on modern Clusiaceae.

†*Paleoenkianthus sayrevillensis* (mixed): [megasporangium ~ (integument^{R} | *funiculus*]$^{?}$ ~ (ovary | ovary ridge^{R} | septum^{R} | style/stigma^{R}) + [microsporangium^{RR} ~ (filament | anther horn^{R})]^{R} > (corolla tube | free petal^{R}) > (sepal)^{R} ~ (flower stalk)

†*Paleorosa similkameenensis* (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (carpel | style | stigma)]^{R} + [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} ~ (receptacle) > (*flower stalk*)

†*Paradinandra suecica* (mixed): [megasporangium ~ (integument^{R} | *funiculus*]^{RRR} ~ (ovary | septum^{R} | placenta head^{R} | style/stigma^{R}) > (nectary disk) > [microsporangium^{RR} ~ (filament)]^{R} ~ (petal)^{R} > (sepal)^{R} > (bracteole)^{R} ~ (flower stalk) > (bract)

†*Parasaurauia allonensis* (mixed): [megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum^{R} | placenta lobe^{R} | style^{R}) > [microsporangium^{RR} ~ (filament)]^{RR} ~ (petal)^{R} > (sepal)^{R} ~ (flower stalk)
*Scored as unitegmic with a funiculus based on extant Actinidiaceae.

Passiflora incarnata (mixed): [megasporangium ~ (integument^{R} | funiculus | aril)]^{RR} ~ (ovary | style^{R} | stigma^{R}) + [microsporangium^{RR} ~ filament]^{R} + (inner corona element)^{RR} + (outer corona element)^{R} + (petal)^{R} + (sepal | awl)^{R} ~ (calyx cup) + (limen) ~ (flower stalk/androgynophore) + (flower bract)^{R}
*We considered the androgynophore stalk to be continuous with the floral stalk, as we did in flowers with axial receptacles like *Magnolia*, or in gymnosperm cones. The filaments of the annulus and inner corolla appear similar; we score them as two whorls of the same part.

†*Pentapetalum trifasciculandricus* (mixed): [megasporangium ~ (integument^{R} | *funiculus*)]^{RR} ~ (ovary | septum^{R} | style^{R}) > [microsporangium^{RR} ~ (filament)]^{RR} ~ (petal)^{R} > (sepal)^{R} ~ (flower stalk)

Phlox drummondii (mixed): [[megasporangium ~ (integument)]^{R} ~ (ovary | septum^{R} | style | stigma lobe^{R}) > (nectiferous disc) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | inflated corolla base | petal lobe^{R}) > (calyx | free sepal lobe^{R}) ~ (flower stalk)]^{R}

Phorodendron leucarpum (micro): [microsporangium^{R}] ~ (tepal)^{R} > (calyx/receptacle | central disk | central column)]^{RR} + (bract)^{R} ~ (inflorescence axis)

Phorodendron leucarpum (mega): megasporangium ~ (tepal)^{R} > (calyx/receptacle | central disk | stigma)]^{RR} + (bract)^{R} ~ (inflorescence axis)

Phytolacca americana (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary lobe^{R} | septum^{R} | stylodium^{R}) > (nectariferous disk) > [microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R} ~ (flower stalk) > (bract)^{R}]^{R} > (inflorescence axis)
*Not a substantial difference in inflorescence axis diameter versus flower stalk diameter; we score them as the same MET.

Piriqueta carolinana (mixed): [megasporangium ~ (integument^{R} | funiculus/aril)]^{RR} ~ (ovary | style^{R} | stigma brush element^{RR}) > [microsporangium^{RR} ~ (filament | gland)]^{R} > (petal)^{R} ~ (calyx | sepal tip^{R}) ~ (flower stalk)

Pittosporum tobira (micro): [[nonfunctional megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | style | stigma) + [(microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} ~ (flower stalk) > (bract)]^{RR}

Pittosporum tobira (mega): [[megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | style | stigma) + [(nonfunctional microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} ~ (flower stalk) > (bract)]^{RR}

Plantago lanceolata (mixed): [megasporangium ~ (integument)]^{R} ~ (ovary | septum | style | stigma) > [microsporangium^{RR} ~ (filament | inflated connective)]^{R} ~(corolla tube | free petal^{R}) > (sepal)^{R} > (bract)]^{R} ~ (inflorescence axis)
*The sepals and the subtending bract look essentially identical in most cases, but the bracts on basalmost flowers are distinct.

†*Platydiscus peltatus* (mega): [megasporangium ~ (integument^{R} | *funiculus*]^{RRR} ~ (carpel lobe^{R} | stigma lobe^{R} | septum^{R} | placenta head^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > nectary disc lobe^{R} > (petal)^{R} > (calyx/floral cup | sepal tip^{R}) ~ (flower stalk)
*Here we score the involute placentae as consisting of a septum terminating with a placenta head that bear the ovules on either side.

Polygala lutea (mixed): [megasporangium ~ (integument^{R} | funiculus | aril^{R})]^{R} ~ (ovary | septum | style | style lobe^{R} | sterile stigma | receptive stigma) + ([microsporangium^{RR} ~ (filament^{R} | androecium tube) ~ (corolla tube | lateral petal lobe | androecium hood | abaxial petal lobe^{RR}) > (sepal)^{R} > (bract)]^{R} ~ (inflorescence axis)

Polygonum punctatum (mega): [megasporangium ~ (integument^{R}) ~ (ovary | style | style lobe^{R} | stigma^{R}) > [microsporangium^{RR} ~ (filament)]^{R} + gland^{R} ~ (tepal)^{R} ~ (flower stalk) > (bract)]^{R} ~ (inflorescence axis)

Populus trichocarpa (micro): [[microsporangium^{RR} ~ (filament)]^{R} ~ (perianth cup) > (bract)]^{R} ~ (inflorescence axis) > (bud bract)^{R}

Portulaca pilosa (mixed): [megasporangium ~ (integument^{R} | funiculus | seed tubercle^{R})]^{RR} ~ (ovary | placenta stalk^{R} | style column | style lobe^{R} | stigma^{R}) + [microsporangium^{RR} ~ (filament)]^{R} ~ (petal | petal tip)^{R} ~ (bract/"sepal")^{R} ~ (flower stalk)

Populus trichocarpa (mega): [[megasporangium ~ (integument | funiculus)]^{R} ~ (ovary | pappus hair^{R} | stigmatic frill) ~ (perianth cup) > (bract)]^{R} ~ (inflorescence axis) > (bud bract)^{R}
*Inner integument is tiny and fused with outer integument; we do not score as a separate structure.

†*Prioria dominica* (mixed): [[megasporangium ~ [integument^{R} | funiculus]$^{?}$ ~ (ovary | style | *stigma*) > [microsporangium^{RR} ~ (filament)]^{R} > (sepal)^{R} > (bract)^{R} ~ (flower stalk)] ~ (*inflorescence axis*)
*Stigma not described by author and inflated stigmas are variable in extant genus. Inflorescence is not known, but it is reasonable to suspect that these small flowers were borne in an inflorescence, which is supported by comparison with extant *Prioria*. The inflorescence axes in extant *Prioria* are considerably larger than the flower pedicels, and we treat as an additional potential MET.

†*Protium callianthum* (micro): (pistilode lobe^{R} | stigmaloid lobe^{R}) > (floral disc) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (calyx) ~ (flower stalk)

Protofagacea allonensis (micro): [[microsporangium^{RR} ~ (filament)]^{R} > (tepal)^{R}]^{R} > (dichasium bract^{RRR} | dichasium peduncle)
*Likely pistillate cupules are known, but they are not preserved well enough to score.

†*Prunus cathybrownae* (mixed): [megasporangium ~ (integument)^{R}]^{R} ~ (ovary | style | stigma lobe^{R})) > [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} ~ (hypanthium | free tepal^{R}) ~ (flower stalk) > (bud bract)^{R}
*Bud bract scored following extant genus.

Prunus persica (mixed): [megasporangium ~ (integument)^{R}]^{R} ~ (ovary | style | stigma)) > [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} ~ (hypanthium | free tepal^{R}) ~ (flower stalk) > (bud bract)^{R}

Quercus sp. (micro): [[microsporangium^{RR} ~ (filament)]^{R} + (calyx | calyx lobe^{R}) > (bract) ~ (inflorescence axis) > (bud bract)^{R}]^{R}

Quercus gambelii (mega): [[megasporangium ~ (integument^{R})]^{RR} ~ (ovary | septum^{R} | style^{R} | stigma lobe^{R}) > (cupule | cupule bract tip^{R}) ~ (inflorescence axis)
*Does not appear to have a strongly developed, distinct funiculus

Rafflesia arnoldii (mixed): (perianth lobe^{R} | perianth tube | diaphragm) + (bud scale)^{R} + [microsporangium^{RR}]^{R} + [megasporangium ~ (integument | funiculus)]^{RR} > (receptacle | septum^{R} | central column stalk | column disk | rim phlange | process^{R})

Rhexia mariana (mixed): [megasporangium ~ (integument^{R} | funiculus | seed rim/operculum)]^{RR} + [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal^{R} | hypanthium tube) ~ (ovary | septum^{R} | placenta lobe^{R} | style | stigma) ~ (flower stalk)
*Flowers are basically subtended by modified vegetative leaves; we do not score as forming an inflorescence.

Rhizophora mangle (mixed): [microsporangium^{R} ~ (filament)]^{R} + (petal)^{R} + (sepal tip)^{R} + [megasporangium ~ (integument^{R})]^{RR} ~ (ovary/receptacle | septum | style | stigma lobe^{R}) > (bract)^{R} ~ (flower stalk) > (bract)]^{R}

Rhus copallina (micro): vestigial carpel > (nectar disk) > [microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} + (bracteole)^{R} ~ (flower stalk)]^{RRR}

Rhus copallina (mega): [megasporangium ~ (integument^{R} | funiculus)]^{R} ~ (ovary | septum | style lobe^{R} | stigma^{R}) > (nectar disk) > [vestigial microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} + (bracteole)^{R} ~ (flower stalk)]^{RRR}

Sapindus marginatus (mixed inflorescence): [megasporangium ~ (integument^{R}]^{R} ~ (ovary lobe | septum^{R} | style/stigma) > [microsporangium^{RR} ~ (filament)]^{R} > (disc lobe)^{R} > (petal | appendage^{R})^{R} > (tepal)^{R} ~ (flower stalk) > (bract)]^{RR}
*Functionally there are staminate and pistillate flowers, but they differ in the relative size of the organs rather than their basic parts, so I score them as similar. Flower stalks and inflorescence axes grade into one another.

Sabatia brevifolia (mixed): [[megasporangium ~ (integument | seed ridge^{R})]^{RR} ~ (ovary | placenta lobe^{RR} | stylodium^{R}) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) > (calyx | free sepal^{R}) ~ (flower stalk)

Sarracenia minor (mixed): [[megasporangium ~ (integument | funiculus)]^{RRR} ~ (ovary | septum^{R} | placenta lobe^{R} | style | stigma umbrella | umbrella lobe^{R}) >[microsporangium^{RR} ~ (filament)]^{R} > (petal)^{R} > (sepal)^{R} > (bract)^{R} ~ (flower stalk)

†*Scandianthus costatus* (mixed): (nectary lobe)^{R} + [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} + [megasporangium ~ (integument^{R} | *funiculus*]^{RR} ~ (ovary | ovary ridge^{R} | placenta^{R} | style^{R} | stigma^{R}) > (bract)^{R} ~ (*flower/inflorescence stalk*)
*No evidence of an inflorescence, but for these small flowers, it is reasonable to consider the possibility.

Sideroxylon languinosum (mixed): [megasporangium ~ (integument | funiculus)]^{R} ~ (ovary | style/stigma) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal/staminode^{R}) > (sepal)^{R} ~ (flower stalk)]^{R}

†*Silvanthemum suecicum* (mixed): [[microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal tip)^{R} + [megasporangium ~ (integument^{R} | *funiculus*]^{RR} ~ (ovary | placenta stalk^{R} | placenta crest^{R} | style^{R} | stigma^{R}) ~ (flower stalk) > (bract)]^{R}
*Inflorescence axis is not reconstructured as being fundamentally different than floral stalk; scored as same part and element type.

Solanum capsicoides (mixed): [megasporangium ~ (integument | funiculus)]^{RR} ~ (ovary | septum | {placenta head ~ placenta stalk}^{R} | style | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | free petal^{R}) > (calyx | calyx lobe^{R}) ~ (flower stalk) + (spine)^{R}

Stachys floridana (mixed): [[megasporangium ~ (integument)]^{R} ~ (ovary lobe^{R} | style | stigma lobe^{R}) ~ (nectiferous disc) + [microsporangium^{RR} ~ (filament)]^{R} ~ (corolla tube | stamen covering lobe | lower lip lobe^{R}) > (calyx | sepal lobe^{R})

Stellaria media (mixed): [[megasporangium ~ (integument^{R} | funiculus | tubercle^{R})]^{R} ~ (ovary | central column | style/stigma^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (petal lobe)^{RR} > (sepal)^{R} ~ (flower stalk)]^{R}
*Cluster of flowers subtended by only slightly modified leaf; we do not score as a flower bract.

†*Ticodendron palaios* (mega): [[megasporangium ~ [integument | funiculus]^{R} + (sepal)^{R} ~ (ovary | septum^{R} | style/stigma^{R}) > (bract)^{R} ~ (inflorescence axis)]^{R} > (bud scale)^{R}]$^{?}$
*Inferior ovaries with two styles and attached sepals, subtended by bracts and borne in compressed inflorescence. Scoring based on extant *Ticodendron*.

†*Trichilia glaesaria* (mega): [megasporangium ~ (integument^{R})]$^{?}$ ~ (ovary | *nectary disk* | septum | style | stigma) > (sterile microsporangium^{RRR} ~ (filament tube | acute lobe^{R}) > (petal)^{R} > (calyx | calyx lobe^{R}) ~ (flower stalk)
*Gynoecium parts scored based on extant genus and other Meliaceae. Nectary disk is present in some taxa and scored as a possibility here.

Triodanus perfoliata (mixed): [megasporangium ~ (integument | funiculus)]^{RR} + [microsporangium^{RR} ~ (filament)]^{R} + (petal)^{R} + (sepal)^{R} ~ (ovary | septum^{R} | style | stigma lobe^{R})

†*Trochanthera lepidota* (micro): [microsporangium^{RR} ~ (filament lobe)^{R} > (perianth sheath)]^{R} + (peltate bract)^{R} ~ (spherical receptacle) ~ (inflorescence axis)
*Partially fused filaments form a single column, which we score as repeated lobes.

†*Tropidogyne pentaptera* (mixed): [microsporangium^{RR} ~ (filament)]^{R} + (tepal)^{R} + [megasporangium ~ (integument^{R} | *funiculus*)]$^{?}$ ~ (ovary lobe^{R} | *septum* | style^{R}) > (flower stalk)
*Perianth is described as consisting of sepals, but no petals are preserved.

Ulmus alata (mixed): [[megasporangium ~ (integument)^{R} ~ (ovary | wing | stigma lobe^{R}) > [microsporangium^{RR} ~ (filament)]^{R} > (calyx | calyx lobe^{R}) ~ (flower stalk)]^{R} > (bud scale)^{R}

Viola septemloba (mixed): [[megasporangium ~ (integument^{R} | funiculus)]^{RR} ~ (ovary | style | stigma) > [microsporangium^{RR} ~ (filament | apical extension | spur)]^{R} > (petal^{R} | spur) > (sepal)^{R} ~ (flower stalk)
*One petal typically has a spur; we combined into a single part score that preserves the repetition.

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