ANGIOSPERM CLASSIFICATION

The classification of angiosperms is still very controversial, and two schemes are presented here – the first (Bentham & Hooker) as a means to LEARNING the families, the second (Angiosperm Phylogeny Group) as a presentation of the rudiments of an agreed EVOLUTIONARY TREE. Historically a number of schemes have been produced. Bentham & Hooker's ***Genera Plantarum*** (1862-1883) – comprising 200 families and 7,569 genera – pre-dated the publication of Charles Darwin's ***Origin of Species***, so this is essentially a non-evolutionary scheme. However, the arrangement of families was based on characters which provided a sequence from what they took as the most primitive to the most derived families – the **Scalae Naturae**. The classification was based on few, essential characters, and as a result is highly predictive – examination of these characters will place an unknown specimen into a particular category.

The Angiosperm Phylogeny Group (APG): Systematic research over the past 150 years has changed our view of plant classification, especially in the last 10 years, when major advances in DNA sequencing have provided a completely new avenue of approach. Numerous classifications and schemes have been published: Hutchinson (328 families), Cronquist (388), Takhtajan (592) Dahlgren (477), Thorne (454) Brummitt (445), and Reveal (612), each differ in the recognition of families and the overall scheme. As a result, families, orders and sub-classes are not comparable between any of these systems. Molecular studies are by no means final, and, contrary to what many reference books and journals might imply, a modern synthesis is far from stabilised. However, a consensus is now beginning to emerge. The combined work of many scientists under an umbrella grouping known as the Angiosperm Phylogeny Group (APG) has produced the rudiments of an agreed evolutionary tree.

BENTHAM & HOOKER CLASSIFICATION

1. DICOTYLEDONS – 2 cotyledons, Exogenous growth.

1.1. POLYPETALAE – petals separate

1) THALAMIFLORAE – Sepals, Petals and Stamens all attached to receptacle.

a) Ranales – Gynoecium apocarpous.
1. RANUNCULACEAE; **2. DILLENIACEAE**; **3. CALYCANTHACEAE**;
4. MAGNOLIACEAE; **5. ANNONACEAE**; **6. MENISPERMACEAE**; **7. BERBERIDACEAE**;
8. NYMPHACEAE.

b) Parietales – Parietal placentation. [**NOT Natural**. Convergent evolution: Papaveraceae close to Ranales; remainder scattered amongst Rosids]
9. SARRACENIACEAE; **10. PAPAVERACEAE**; **11. CRUCIFERAE**; **12. CAPPARACEAE**;
13. RESEDACEAE; **14. CISTACEAE**; **15. VIOLACEAE**; **16. CANELLACEAE**;
17. BIXACEAE.

c) Polygalineae – Ovary 2-3 septate.
18. PITTOSPORACEAE; **19. TREMANDRACEAE**; **20. POLYGALACEAE**.

d) Caryophyllineae – Axile placentation.
21. FRANKENIACEAE; **22. CARYOPHYLLACEAE**; **23. PORTULACACEAE**;
24. TAMARICACEAE.

e) Guttiferales – Stamens numerous; Calyx imbricate.
25. ELATINACEAE; **26. HYPERICACEAE**; **27. GUTTIFERAE**; **28. THEACEAE**;
29. DIPTEROCARPACEAE; **30. SARCOLAENACEAE**.

f) Malvales – Stamens numerous; Calyx valvate.
31. MALVACEAE; **32. STERCULIACEAE**; **33. TILIACEAE**.

2) DISCIFLORAE – Ovary superior, immersed in disk of flower.

a) Geraniales – Ovule pendulous, raphe ventral.
34. LINACEAE; **35. HUMIRIACEAE**; **36. MALPIGHIACEAE**; **37. ZYGOPHYLLACEAE**;
38. GERANIACEAE; **39. RUTACEAE**; **40. SIMAROUBACEAE**; **41. OCHNACEAE**;
42. BURSERACEAE; **43. MELIACEAE**; **44. DICHAPETALACEAE**.

b) Olacales – Ovule pendulous, raphe dorsal.
45. OLACACEAE; **46. AQUIFOLIACEAE**.

c) Celastrales – Ovule erect, raphe ventral.
47. CELASTRACEAE; **48. STACKHOUSIACEAE**; **49. RHAMNACEAE**; **50. VITACEAE**.

d) Sapindales – Ovule ascending, raphe ventral to reversed.
51. SAPINDACEAE; **52. MELIOSMACEAE** (=**Sabiaceae**); **53. ANACARDIACEAE**; **54. CORIARIACEAE**; **55. MORINGACEAE**.

3) CALYCIFLORAE – Stamens fused to Calyx of flower

a) Rosales – Ovaries separate, rarely united. [**NOT Natural**: Saxifragales as Eudicots, Eurosids I, some Asterids]
56. CONNARACEAE; **57. LEGUMINOSAE**; **58. ROSACEAE**; **59. SAXIFRAGACEAE**; **60. CRASSULACEAE**; **61. DROSERACEAE**; **62. HAMAMELIDACEAE**; **63. BRUNIACEAE**; **64. HALORAGACEAE**.

b) Myrtales – Ovary syncarpous; divided into locules.[still form a natural group at the base of the Rosids]
65. RHIZOPHORACEAE; **66. COMBRETACEAE**; **67. MYRTACEAE**; **68. MELASTOMATACEAE**; **69. LYTHRACEAE**; **70. ONAGRACEAE**.

c) Passiflorales – Ovary syncarpous; Parietal placentation [more or less natural in the Eurosids I]
72. LOASACEAE; **73. TURNERACEAE**; **74. PASSIFLORACEAE**; **75. CUCURBITACEAE**; **76. BEGONIACEAE**; **77. DATISCACEAE**.

d) Ficoidales – Ovary syncarous; sub-basal placentation [the basal placentation is critical in placing these families among the Caryophyllids]
78. CACTACEAE; **79. AIZOACEAE**.

e) Umbellales – Ovary syncarpous; 1 ovule per locule. [**not wholly natural**; these families belong amongst the basal Asterids]
80. UMBELLIFERAE; **81. ARALIACEAE**; **82. CORNACEAE**.

1.2. GAMOPETALAE – petals fused

1) INFERAE – Ovary inferior; stamen no. = petal no.

a) Rubiales – Stamens epipetalous; locules 2-many; ovules 1-many.
83. CAPRIFOLIACEAE; **84. RUBIACEAE**.

b) Asterales – Stamens epipetalous; locule 1; ovule 1.
85. VALERIANACEAE; **86. DIPSACACEAE**; **87. CALYCERACEAE**; **88. COMPOSITAE**.

c) Campanulales – Stamens free; locules 2-6; ovules many.
89. STYLIDACEAE; **90. GOODENIACEAE**; **91. CAMPANULACEAE**.

2) HETEROMERAE – Ovary superior; stamens opposite petals or double the petal no.

a) Ericales – Stamens double petal no.; Ovary 2-many locules.
93. ERICACEAE; **93. CLETHRACEAE**; **95. EPACRIDACEAE** (=**Ericaceae**); **96. DIAPENSIACEAE**; **97. LENNOACEAE** (=**Boraginaceae**).

b) Primulales – Stamens opposite petals; Ovary 1-locule; Axile placentation.
98. PLUMBAGINACEAE; **99. PRIMULACEAE**; **100. MYRSINACEAE**.

c) Ebenales – Stamens opposite petals; Few large seeds.
101. SAPOTACEAE; **102. EBENACEAE**; **103. STYRACACEAE**.

3) BICARPELLATAE – Ovary superior, with 2 carpels.

a) Gentianales – Corolla regular; leaves opposite.
104. OLEACEAE; **105. SALVADORACEAE**; **106. APOCYNACEAE**; **107. ASCLEPIADACEAE**; **108. LOGANIACEAE**; **109. GENTIANACEAE**.

b) Polemoniales – Corolla regular; leaves alternate.
110. POLEMONIACEAE; **111. HYDROPHYLLACEAE**; **112. BORAGINACEAE**; **113. CONVOLVULACEAE**; **114. SOLANACEAE**.

c) Personiales – Corolla irregular to oblique; ovules many.
115. SCROPHULARIACEAE; **116. GLOBULARIACEAE** (=**Plantaginaceae**);
117. LENTIBULARIACEAE; **119. GESNERIACEAE**; **120. BIGNONIACEAE**;
121. PEDALIACEAE; **122. ACANTHACEAE**.

d) Lamiales – Corolla irregular to oblique; 1-2 ovules.
123. MYOPORACEAE; **125. VERBENACEAE**; **126. LABIATAE**; **127. PLANTAGINACEAE**.

1.3. MONOCHLAMYDEAE – only 1 kind of perianth (not petals + sepals)

This division was never intended to be natural – it was merely to help identify these single-perianthed plants. Some are basal families (*Aristolochia*, *Piper*) with unusual flower structures, whilst others are highly derived, with sepals or petals lost during evolution. Biochemistry solved the question of the placement of many of these families.

1) Curved embryos [The curved embryos & seeds make these part of the Caryophyllids]
128. NYCTAGINACEAE; **130. AMARANTHACEAE**; **131. CHENOPODIACEAE**;
133. BATIDACEAE; **134. POLYGONACEAE**.

2) Many-seeded aquatics (? Caryophyllids / Palaeoherbs)
135. PODOSTEMACEAE; **136. NEPENTHACEAE**; **137. RAFFLESIACEAE**.

3) Microscopic seeds (? Paleotrees/Palaeoherbs)
138. ARISTOLOCHIACEAE; **139. PIPERACEAE**; **140. CHLORANTHACEAE**;
141. MYRISTICACEAE; **142. MONIMIACEAE**.

4) Daphnales (? Paleotrees/Eudicots/Rosids)
143. LAURACEAE; **143. HERNANDIACEAE**; **144. PROTEACEAE**;
145. THYMELAEACEAE; **146. PENAEACEAE**; **147. ELAEGNACEAE**.

5) Achlamydosporaceae (? Eudicots/Asterids)
148. LORANTHACEAE; **149. SANTALACEAE**; **150. BALANOPHORACEAE**.

6) Unisexulaes (? Eudicots/Rosids)
151. EUPHORBIACEAE; **152. BALANOPACEAE**; **153. URTICACEAE**;
154. PLATANACEAE; **155. LEITNERIACEAE**; **156. JUGLANDACEAE**; **157. MYRICACEAE**;
158. CASUARINACEAE; **159. BETULACEAE**.

7) Ordines anomalus (? Paleoherbs/Rosids)
160. SALICACEAE; **162. EMPETRACEAE**; **163. CERATOPHYLLACEAE**.

2. MONOCOTYLEDONS – 1 cotyledon, Endogenous growth.

1) Microscopic seeds
167. HYDROCHARITACEAE; **168. BURMANNIACEAE**; **169. ORCHIDACEAE**.

2) Inferior ovaries
170. ZINGIBERACEAE; **171. BROMELIACEAE**; **172. HAEMODORACEAE**;
173. IRIDACEAE; **174. AMARYLLIDACEAE**; **175. VELLOZIACEAE**;
176. DIOSCOREACEAE.

3) Corolla-like flowers
177. STEMONACEAE; **178. LILIACEAE**; **179. PONTEDERIACEAE**; **180. PHILYDRACEAE**;
181. XYRIDACEAE; **182. MAYACACEAE**; **183. COMMELINACEAE**; **184. RAPATEACEAE**.

4) Calyx-like flowers
185. FLAGELLARIACEAE; **186. JUNCACEAE**; **187. PALMAE**.

5) Perianth-less flowers
188. PANDANACEAE; **189. CYCLANTHACEAE**; **190. TYPHACEAE**; **191. ARACEAE**;
192. LEMNACEAE.

6) Apocarpous
193. TRIURIDACEAE; **194. ALISMATACEAE**; **195. JUNCAGINACEAE**.

7) Glumaceous flowers
196. ERIOCAULACEAE; **197. CENTROLEPIDACEAE**; **198. RESTIONACEAE**;
199. CYPERACEAE; **200. GRAMINEAE**.

ANGIOSPERM PHYLOGENY GROUP

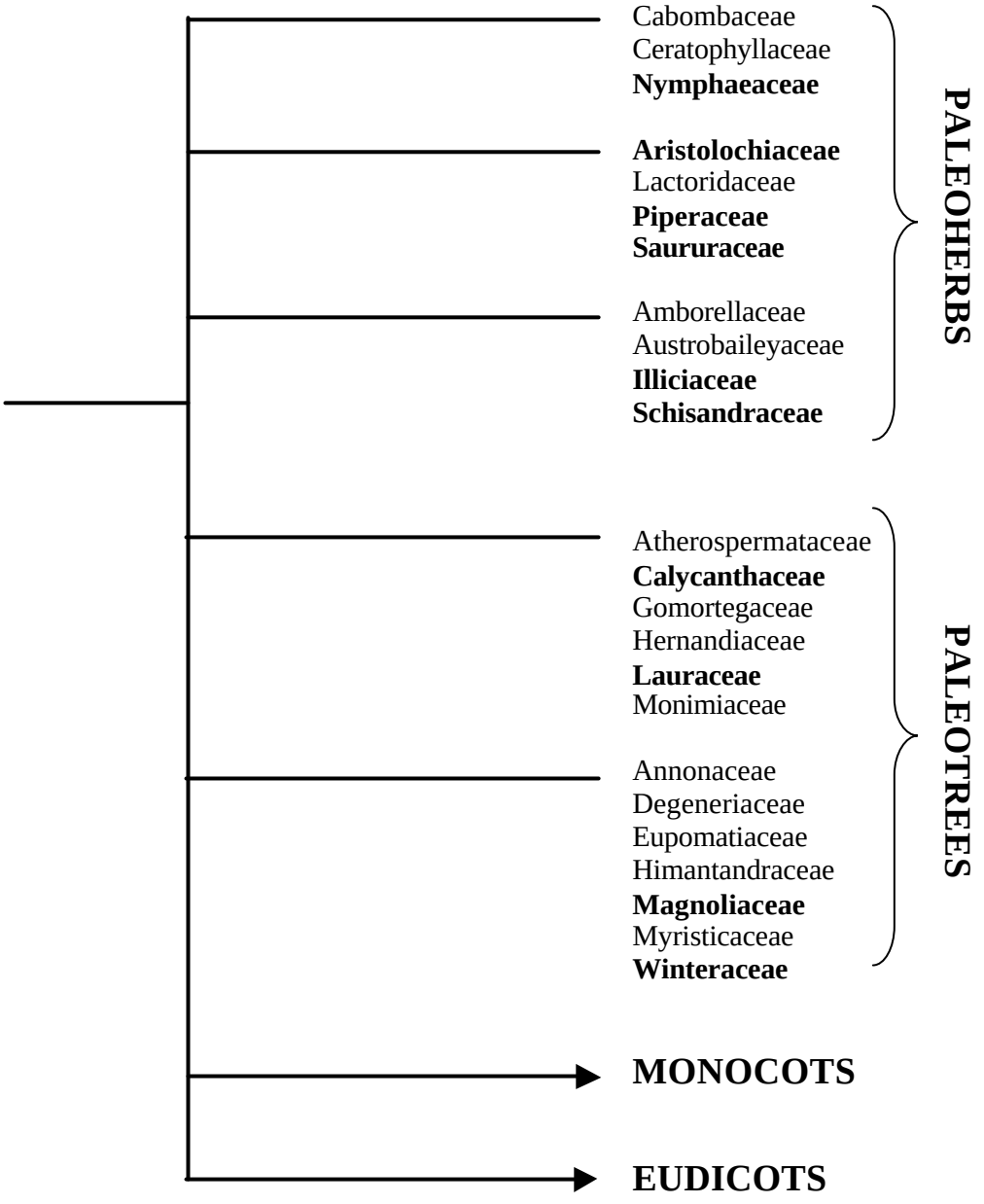
AN APPROXIMATE EVOLUTIONARY TREE

The branching lines demonstrate how closely related different families are. Each group of families are arranged alphabetically, those families in bold are grown at Glasnevin, those underlined represent order names (which end in –ales). Arrows indicate continuations to other pages.

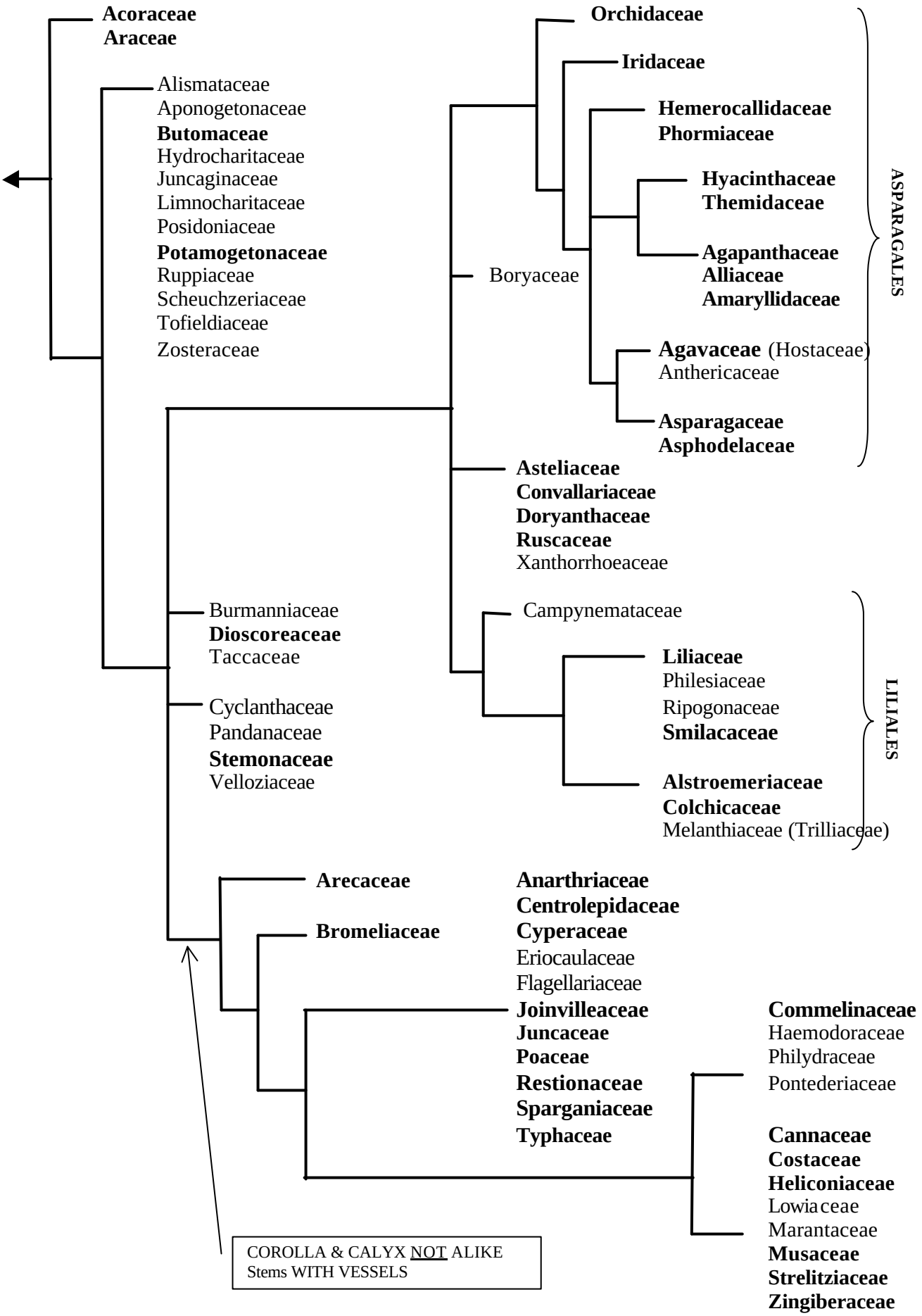
One important revelation of the new synthesis is that there are not just Monocots and Dicots as two classes of Angiosperms, rather the earliest evolution of flowering plants led to four basic lineages:–

- ??PALEOHERBS, represented by Waterlilies, Aristolochiaceae, Piperaceae, Schisandra.
- ??PALEOTREES, represented by Magnoliaceae, Winteraceae, Lauraceae.
- ??MONOCOTS, the traditional Monocots.
- ??EUDICOTS, so called because they are 'proper' or 'true' dicots without the paleo-s above.

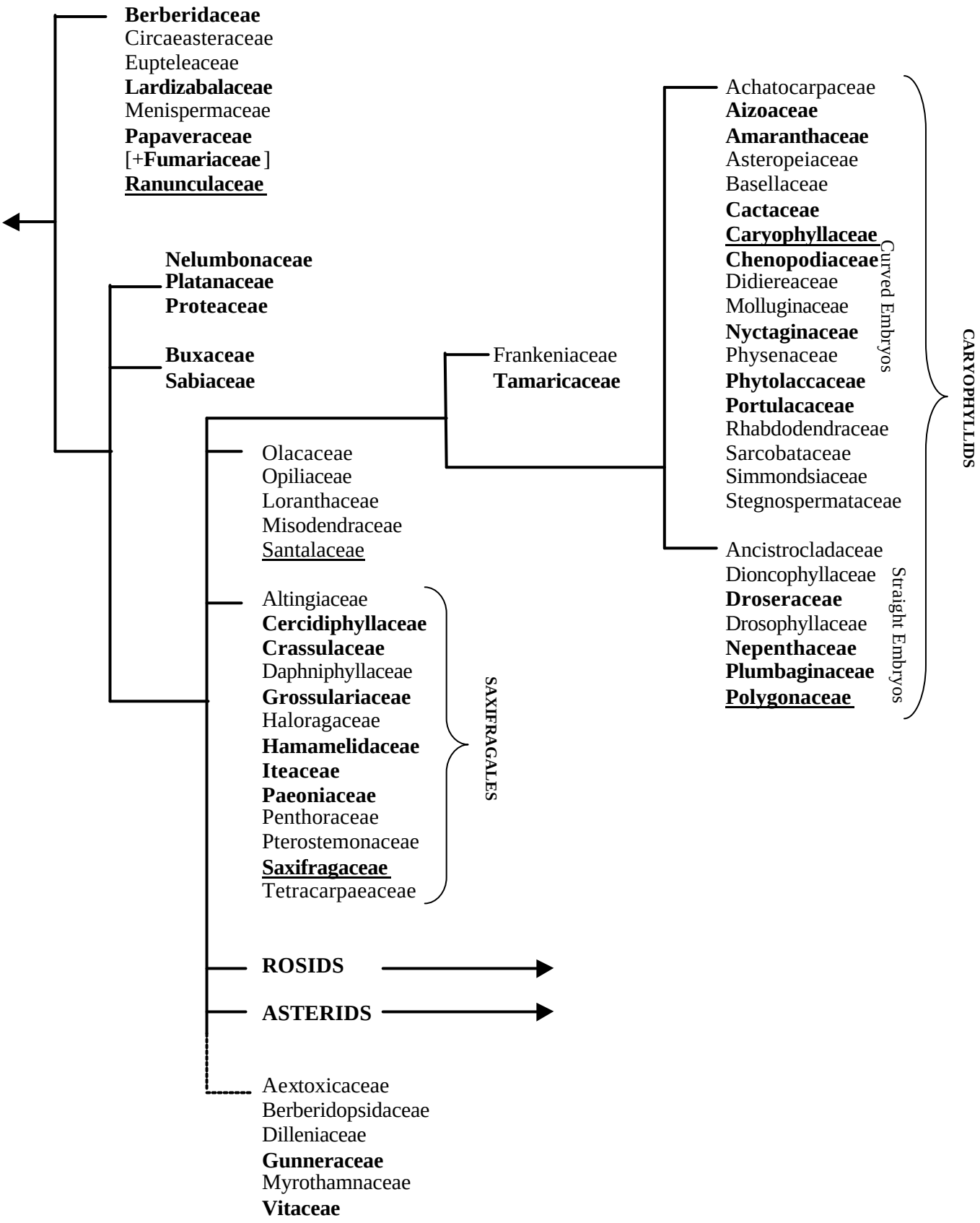
A pattern of groupings is discernible within the Eudicots: The most ancient grouping in this lineage are indeed the Ranunculaceae, which have always been traditionally viewed as the progenitors of all other flowering plants, then a number of distinct basal groups such as the Caryophyllids and Saxifragales can be distinguished, followed by two very distinctive groups, the Rosids and Asterids. Within these latter two groups we can recognise a similar pattern of evolutionary 'left-overs' – basal groups – and distinguished more clearly from these, clusters of closely-related families, which are termed Eu-Rosids and Eu-Asterids respectively.



MONOCOTS

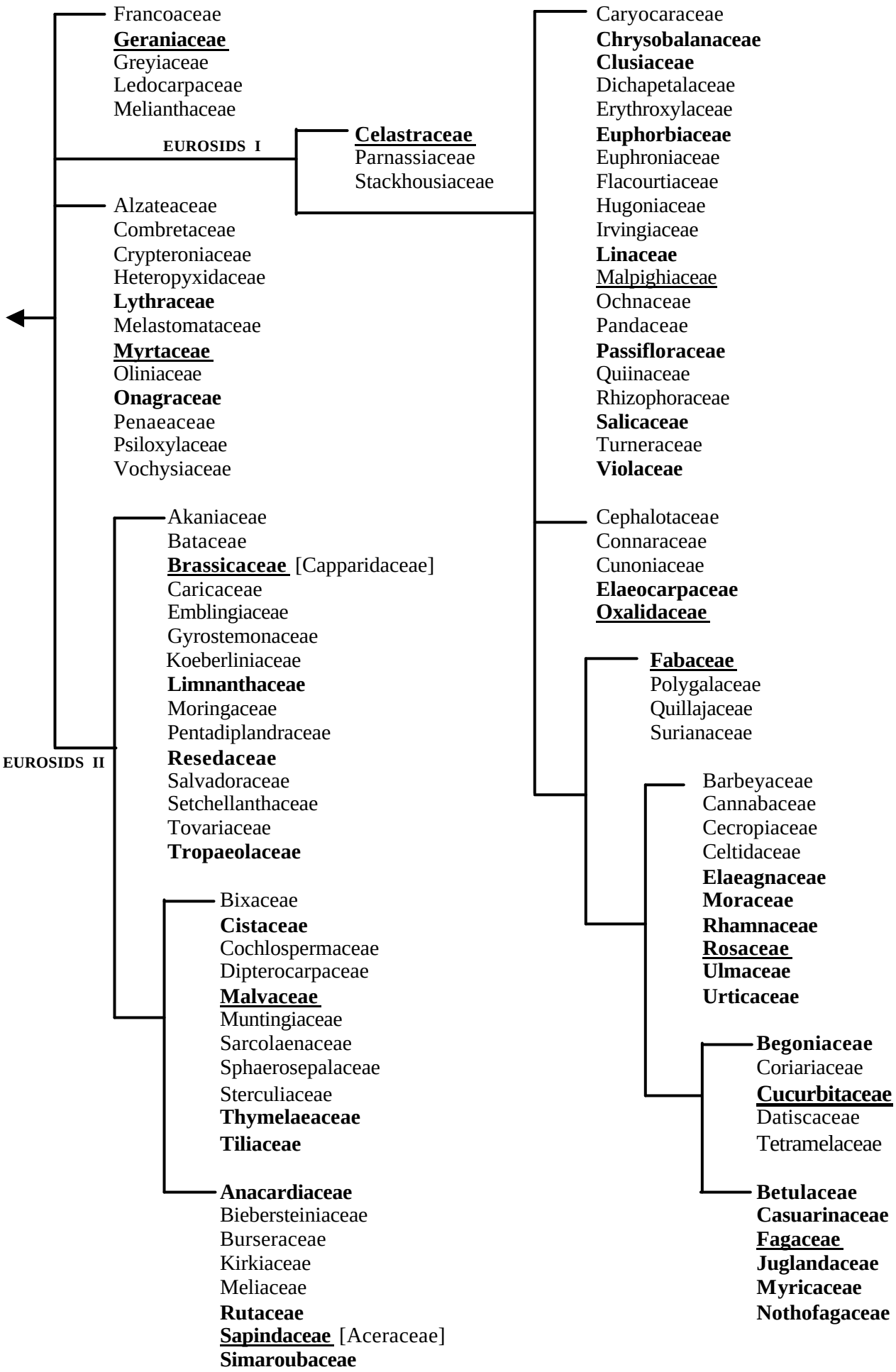

Acoraceae
Araceae
Alismataceae
Aponogetonaceae
Butomaceae
Hydrocharitaceae
Juncaginaceae
Limnocharitaceae
Posidoniaceae
Potamogetonaceae
Ruppiaceae
Scheuchzeriaceae
Tofieldiaceae
Zosteraceae
Orchidaceae
Iridaceae
Hemerocallidaceae
Phormiaceae
Hyacinthaceae
Themidaceae
Agapanthaceae
Alliaceae
Amaryllidaceae
Boryaceae
Agavaceae (Hostaceae)
Anthericaceae
Asparagaceae
Asphodelaceae
ASPARAGALES
Asteliaceae
Convallariaceae
Doryanthaceae
Ruscaceae
Xanthorrhoeaceae
Burmanniaceae
Dioscoreaceae
Taccaceae
Cyclanthaceae
Pandanaceae
Stemonaceae
Velloziaceae
Campynemataceae
Liliaceae
Philesiaceae
Ripogonaceae
Smilacaceae
Alstroemeriaceae
Colchicaceae
Melanthiaceae (Trilliaceae)
LILIALES
Arecaceae
Bromeliaceae
Anarthriaceae
Centrolepidaceae
Cyperaceae
Eriocaulaceae
Flagellariaceae
Joinvilleaceae
Juncaceae
Poaceae
Restionaceae
Sparganiaceae
Typhaceae
Commelinaceae
Haemodoraceae
Philydraceae
Pontederiaceae
Cannaceae
Costaceae
Heliconiaceae
Lowiaceae
Marantaceae
Musaceae
Strelitziaceae
Zingiberaceae
COROLLA & CALYX NOT ALIKE
Stems WITH VESSELS

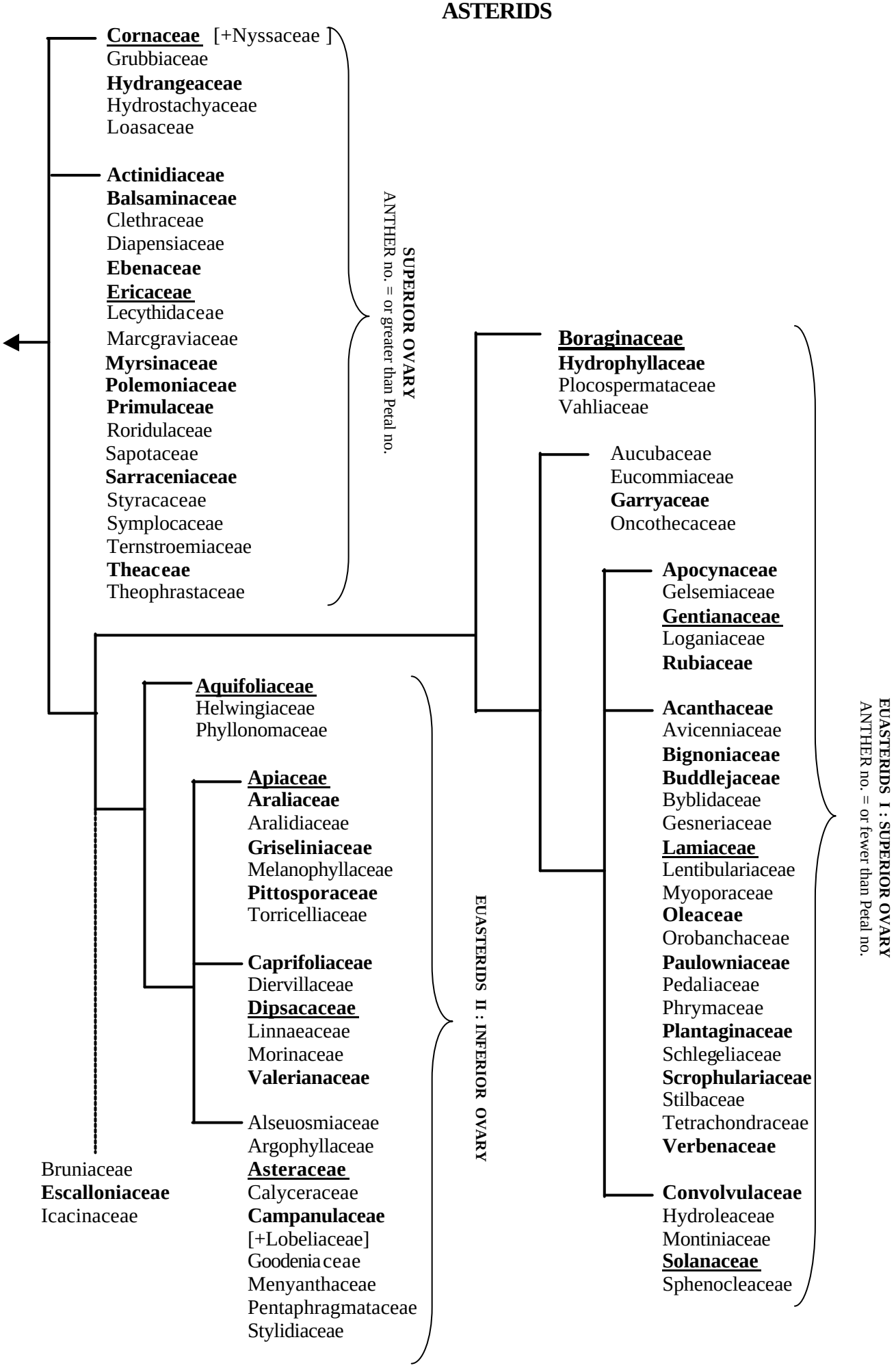
EUDICOTS (Tricolpate Pollen)



Note: Underlined family names represent Order names for the groups. i.e. Caryophyllales, Polygonales etc.

ROSIDS


Francoaceae
Geraniaceae
Greyiaceae
Ledocarpaceae
Melianthaceae
EUROSIDS I
Celastraceae
Parnassiaceae
Stackhousiaceae
Alzateaceae
Combretaceae
Crypteroniaceae
Heteropyxidaceae
Lythraceae
Melastomataceae
Myrtaceae
Oliniaceae
Onagraceae
Penaeaceae
Psiloxylaceae
Vochysiaceae
Akaniaceae
Bataceae
Brassicaceae [Capparidaceae]
Caricaceae
Emblingiaceae
Gyrostemonaceae
Koeberliniaceae
Limnanthaceae
Moringaceae
Pentadiplandraceae
Resedaceae
Salvadoraceae
Setchellanthaceae
Tovariaceae
Tropaeolaceae
EUROSIDS II
Bixaceae
Cistaceae
Cochlospermaceae
Dipterocarpaceae
Malvaceae
Muntingiaceae
Sarcolaenaceae
Sphaerosepalaceae
Sterculiaceae
Thymelaeaceae
Tiliaceae
Anacardiaceae
Biebersteiniaceae
Burseraceae
Kirkiaceae
Meliaceae
Rutaceae
Sapindaceae [Aceraceae]
Simaroubaceae
Caryocaraceae
Chrysobalanaceae
Clusiaceae
Dichapetalaceae
Erythroxylaceae
Euphorbiaceae
Euphroniaceae
Flacourtiaceae
Hugoniaceae
Irvingiaceae
Linaceae
Malpighiaceae
Ochnaceae
Pandaceae
Passifloraceae
Quiinaceae
Rhizophoraceae
Salicaceae
Turneraceae
Violaceae
Cephalotaceae
Connaraceae
Cunoniaceae
Elaeocarpaceae
Oxalidaceae
Fabaceae
Polygalaceae
Quillajaceae
Surianaceae
Barbeyaceae
Cannabaceae
Cecropiaceae
Celtidaceae
Elaeagnaceae
Moraceae
Rhamnaceae
Rosaceae
Ulmaceae
Urticaceae
Begoniaceae
Coriariaceae
Cucurbitaceae
Datiscaceae
Tetramelaceae
Betulaceae
Casuarinaceae
Fagaceae
Juglandaceae
Myricaceae
Nothofagaceae


ASTERIDS
Cornaceae [+Nyssaceae]
Grubbiaceae
Hydrangeaceae
Hydrostachyaceae
Loasaceae
Actinidiaceae
Balsaminaceae
Clethraceae
Diapensiaceae
Ebenaceae
Ericaceae
Lecythidaceae
Marcgraviaceae
Myrsinaceae
Polemoniaceae
Primulaceae
Roridulaceae
Sapotaceae
Sarraceniaceae
Styracaceae
Symplocaceae
Ternstroemiaceae
Theaceae
Theophrastaceae
SUPERIOR OVARY
ANTHER no. = or greater than Petal no.
Boraginaceae
Hydrophyllaceae
Plocospermataceae
Vahliaceae
Aucubaceae
Eucommiaceae
Garryaceae
Oncothecaceae
Apocynaceae
Gelsemiaceae
Gentianaceae
Loganiaceae
Rubiaceae
Acanthaceae
Avicenniaceae
Bignoniaceae
Buddlejaceae
Byblidaceae
Gesneriaceae
Lamiaceae
Lentibulariaceae
Myoporaceae
Oleaceae
Orobanchaceae
Paulowniaceae
Pedaliaceae
Phrymaceae
Plantaginaceae
Schlegeliaceae
Scrophulariaceae
Stilbaceae
Tetrachondraceae
Verbenaceae
Convolvulaceae
Hydroleaceae
Montiniaceae
Solanaceae
Sphenocleaceae
EUASTERIDS I : SUPERIOR OVARY
ANTHER no. = or fewer than Petal no.
Aquifoliaceae
Helwingiaceae
Phyllonomaceae
Apiaceae
Araliaceae
Aralidiaceae
Griseliniaceae
Melanophyllaceae
Pittosporaceae
Torricelliaceae
Caprifoliaceae
Diervillaceae
Dipsacaceae
Linnaeaceae
Morinaceae
Valerianaceae
Alseuosmiaceae
Argophyllaceae
Asteraceae
Calyceraceae
Campanulaceae
[+Lobeliaceae]
Goodeniaceae
Menyanthaceae
Pentaphragmataceae
Stylidiaceae
EUASTERIDS II : INFERIOR OVARY
Bruniaceae
Escalloniaceae
Icacinaceae