ANGIOSPERMAS
Filo ANTHOPHYTA ou MAGNOLIOPHYTA

Classificação das Embriófitas
Chase & Reveal 2009

Class Equisetopsida **=*Classe Embryopsida***
Subclass Anthocerotidae Engl., in H.G.A. E
Subclass Bryidae Engl., Syllabus: 47. Apr 1
Subclass Marchantiidae Engl., in H.G.A. E
Subclass Lycopodiidae Beketov, Kurs Bot. 1

[monilophytes] ***monilófitas***
Subclass Equisetidae Warm., Osnov. Bot.: 2
Subclass Marattiidae Klinge, Fl. Est-Liv-Ch
Subclass Ophioglossidae Klinge, Fl. Est-Liv
Subclass Polypodiidae Cronquist, Takht. &
Subclass Psilotidae Reveal, Phytologia 79:

[gymnosperms] ***gimnospermas***
Subclass Ginkgooidae Engl., in H.G.A. Engl
Subclass Cycadidae Pax, in K.A.E. Prantl,
Subclass Pinidae Cronquist, Takht. & Zimm
Subclass Gnetidae Pax, in K.A.E. Prantl, L

[angiosperms] ***angiospermas***
Subclass Magnoliidae Novák ex Takht., Sis

Bresinsky *et al.* 2012
(ed. 36 do Tratado Strassburger)

STREPTOPHYTA **13 subdivisões:**

- **Anthocerophytina**
- **Bryophytina**
- **Marchantiophytina**
- **Lycopodiophytina**
- **Equisetophytina**
- **Marattiophytina**
- **Filicophytina**
- **Psilophytina**
- **Spermatophytina:** **4 classes:**
  - **Ginkgopsida**
  - **Cycadopsida**
  - **Coniferopsida**
  - **Magnoliopsida**

Plantas floríferas (ANGIOSPERMAS) - fruto
220-270 mil espécies (300 mil)

Diversidade relativa das Embriófitas

Crepet & Niklas 2009

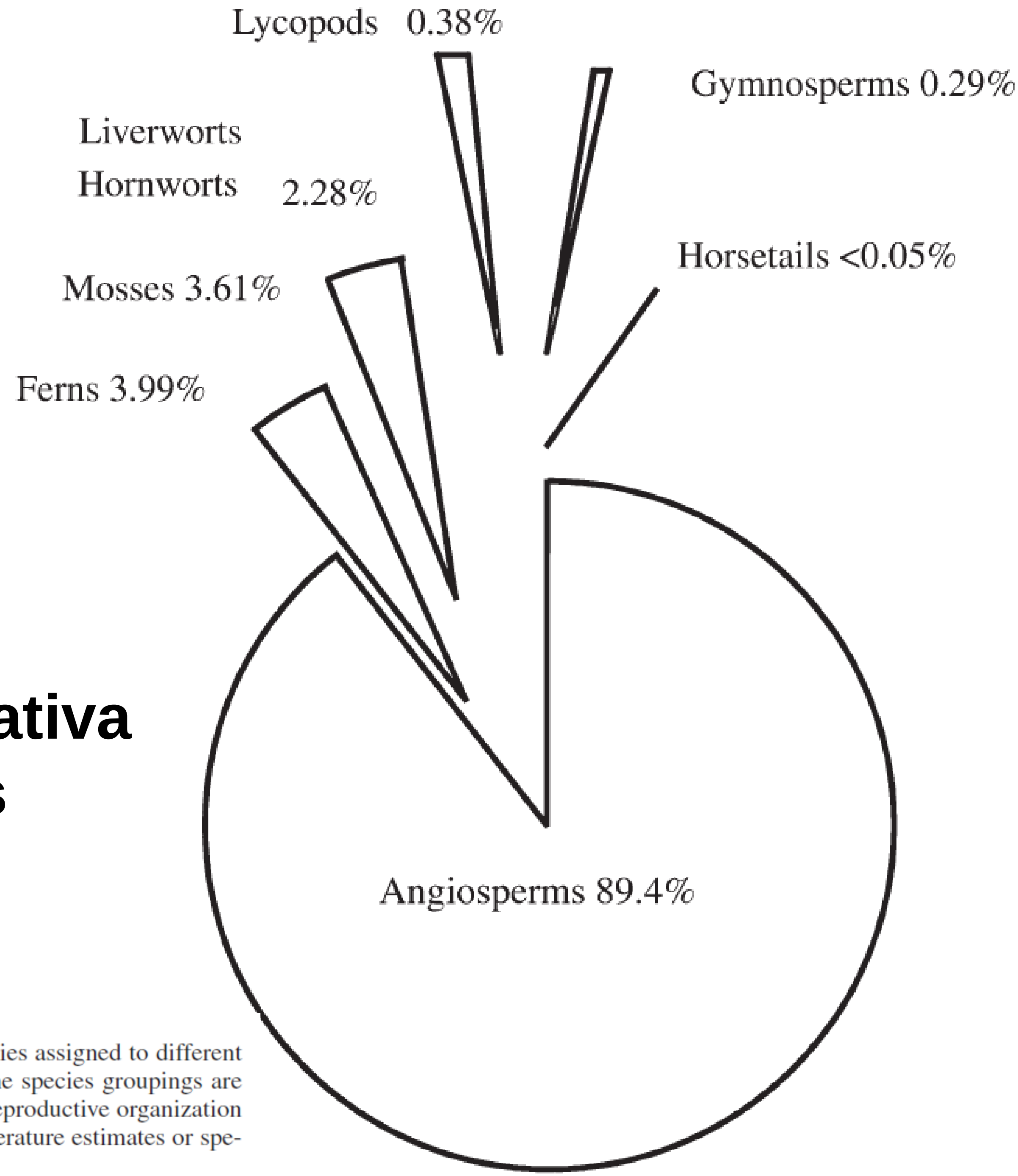
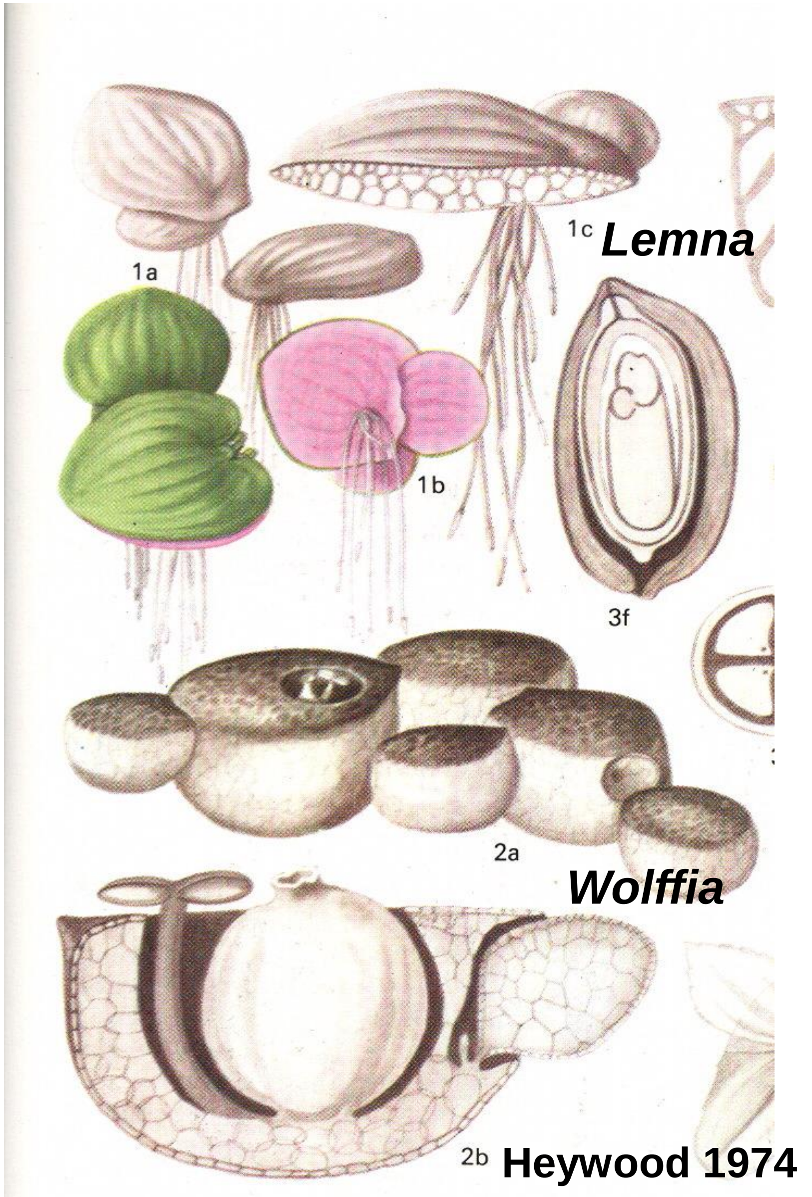


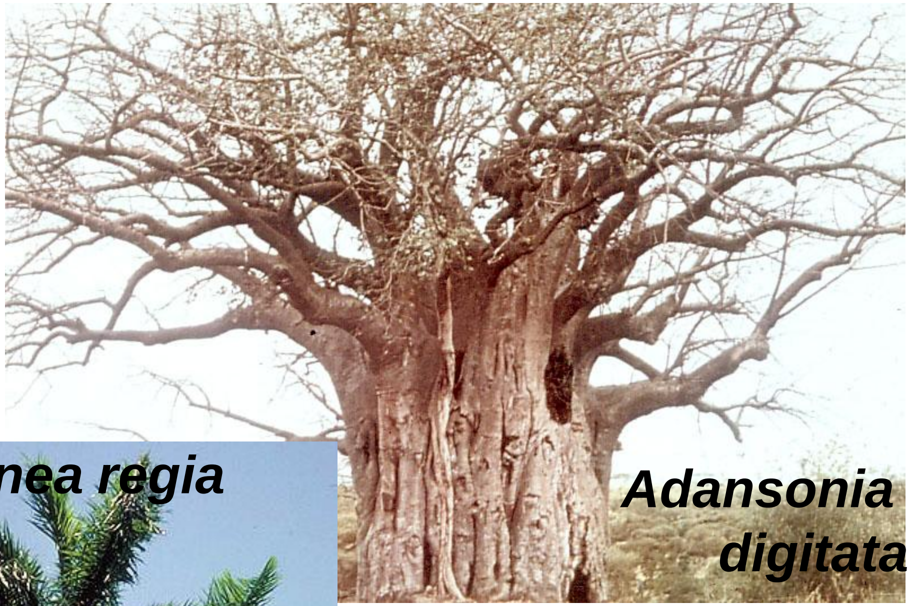
Fig. 1. Percentage distribution of extant species assigned to different embryophyte plant groups. For convenience, some species groupings are polyphyletic and thus represent a grade-level of reproductive organization (e.g., gymnosperms). Data taken from primary literature estimates or species compendia (see Niklas, 1997).

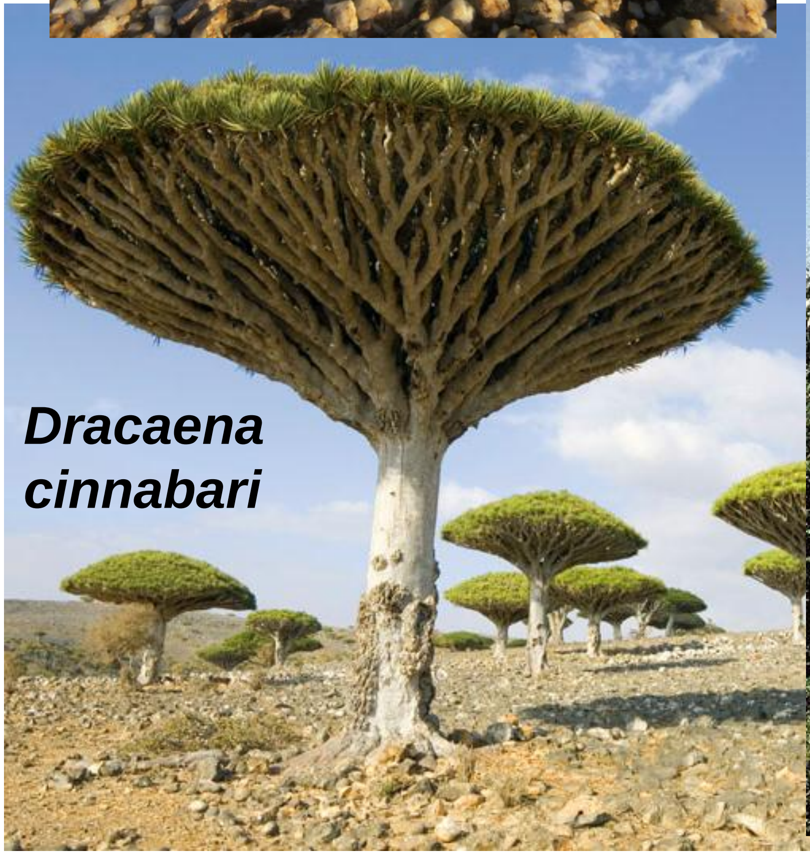
Eucalyptus globulus, **Myrtaceae**

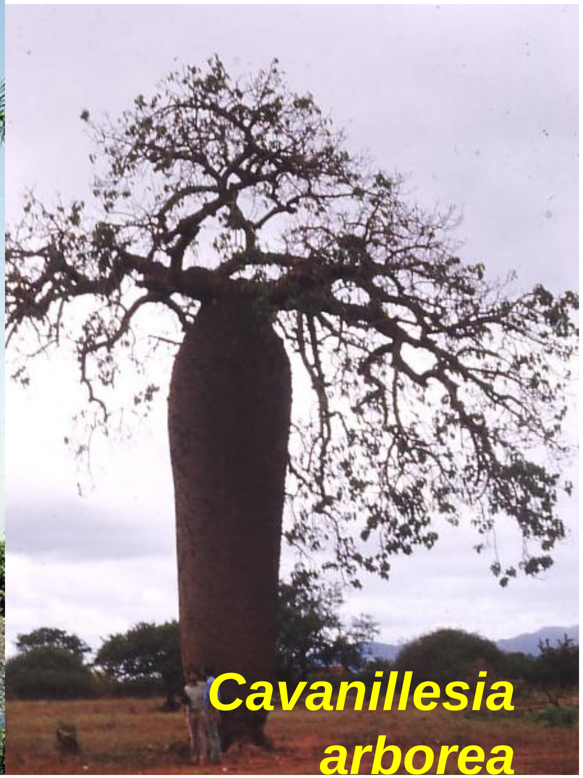


Araceae

DIVERSIDADE de hábitos







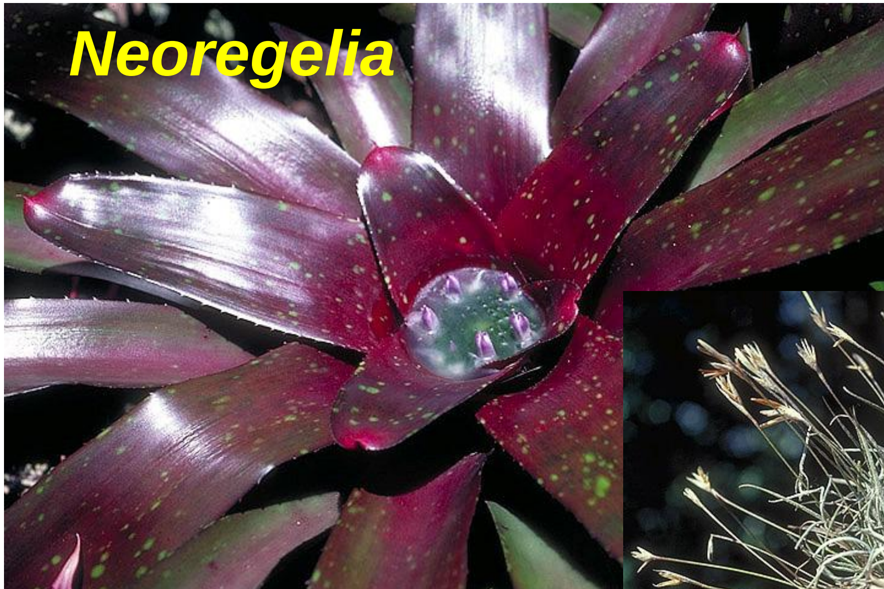
Carnegia gigantea

CACTACEAE

Ferocactus

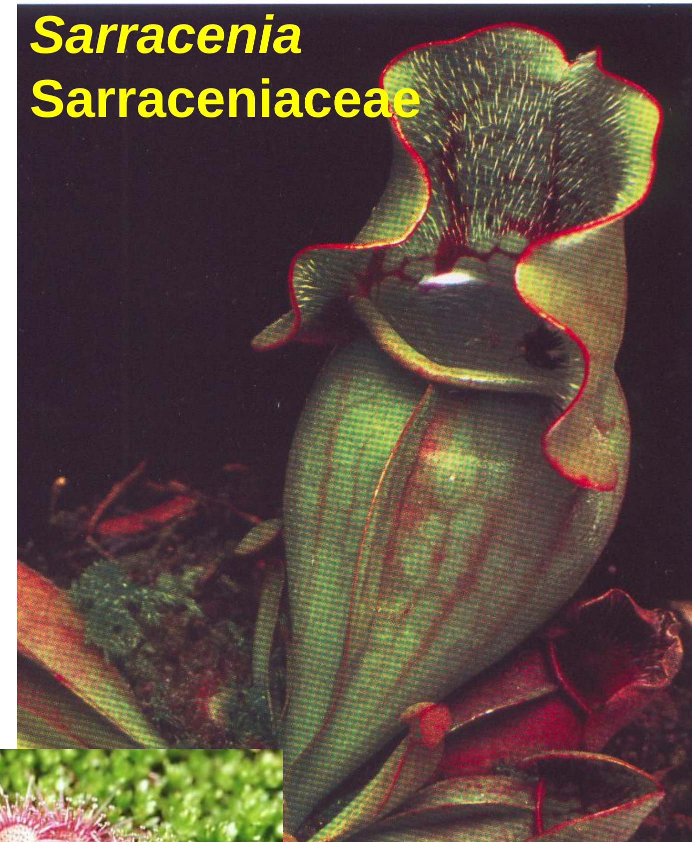
Opuntia

DIVERSIDADE
de formas de vida e habitats



Bromeliaceae

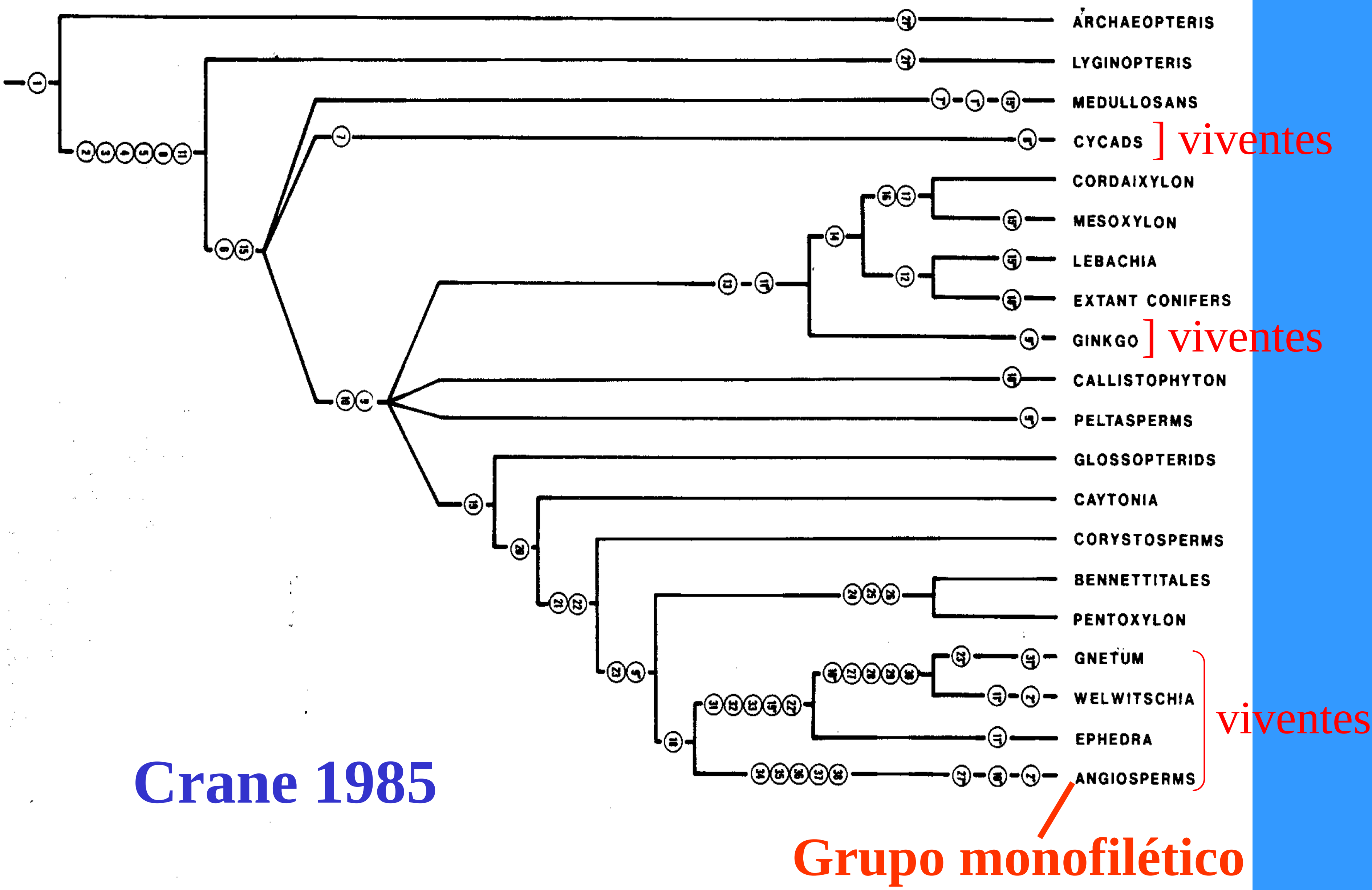
Hydrocharitaceae



Droseraceae

Flores unissexuadas

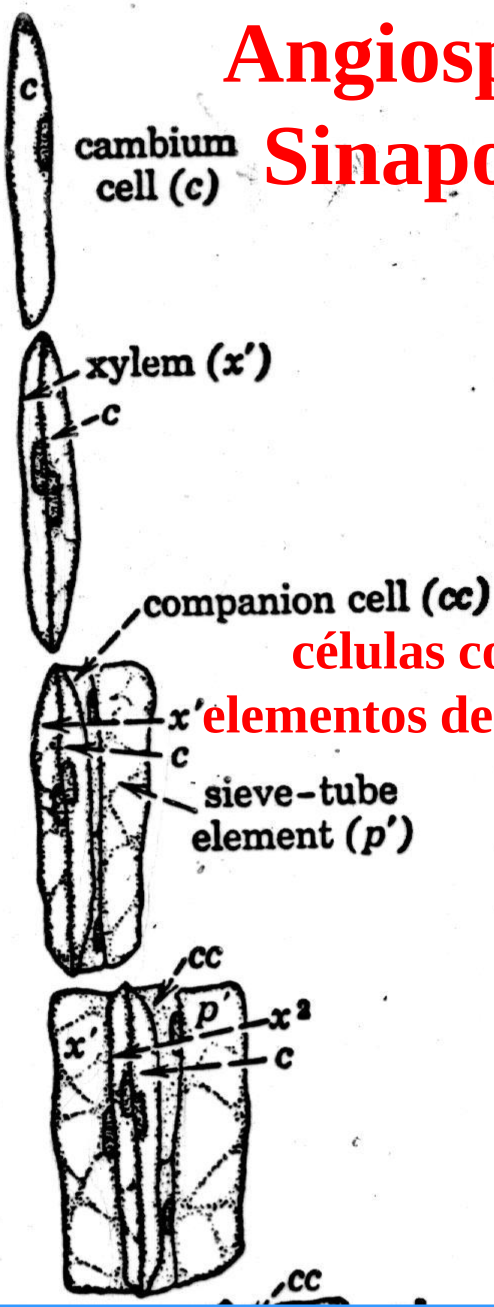
EUPHORBIACEAE



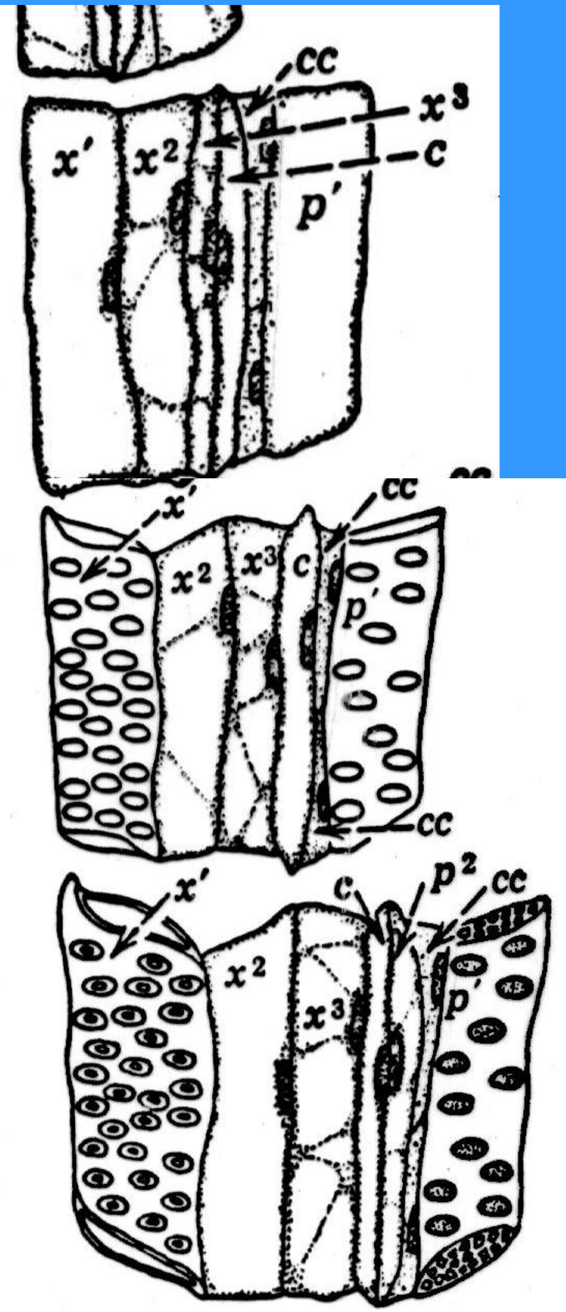
ARCHAEOPTERIS
LYGINOPTERIS
MEDULLOSANS
CYCADS
] viventes
CORDAIXYLON
MESOXYLON
LEBACHIA
EXTANT CONIFERS
GINKGO
] viventes
CALLISTOPHYTON
PELTASPERMS
GLOSSOPTERIDS
CAYTONIA
CORYSTOSPERMS
BENNETTITALES
PENTOXYLON
GNETUM
WELWITSCHIA
EPHEDRA
ANGIOSPERMS
viventes
Grupo monofilético

Crane 1985

Angiospermas - Sinapomorfias



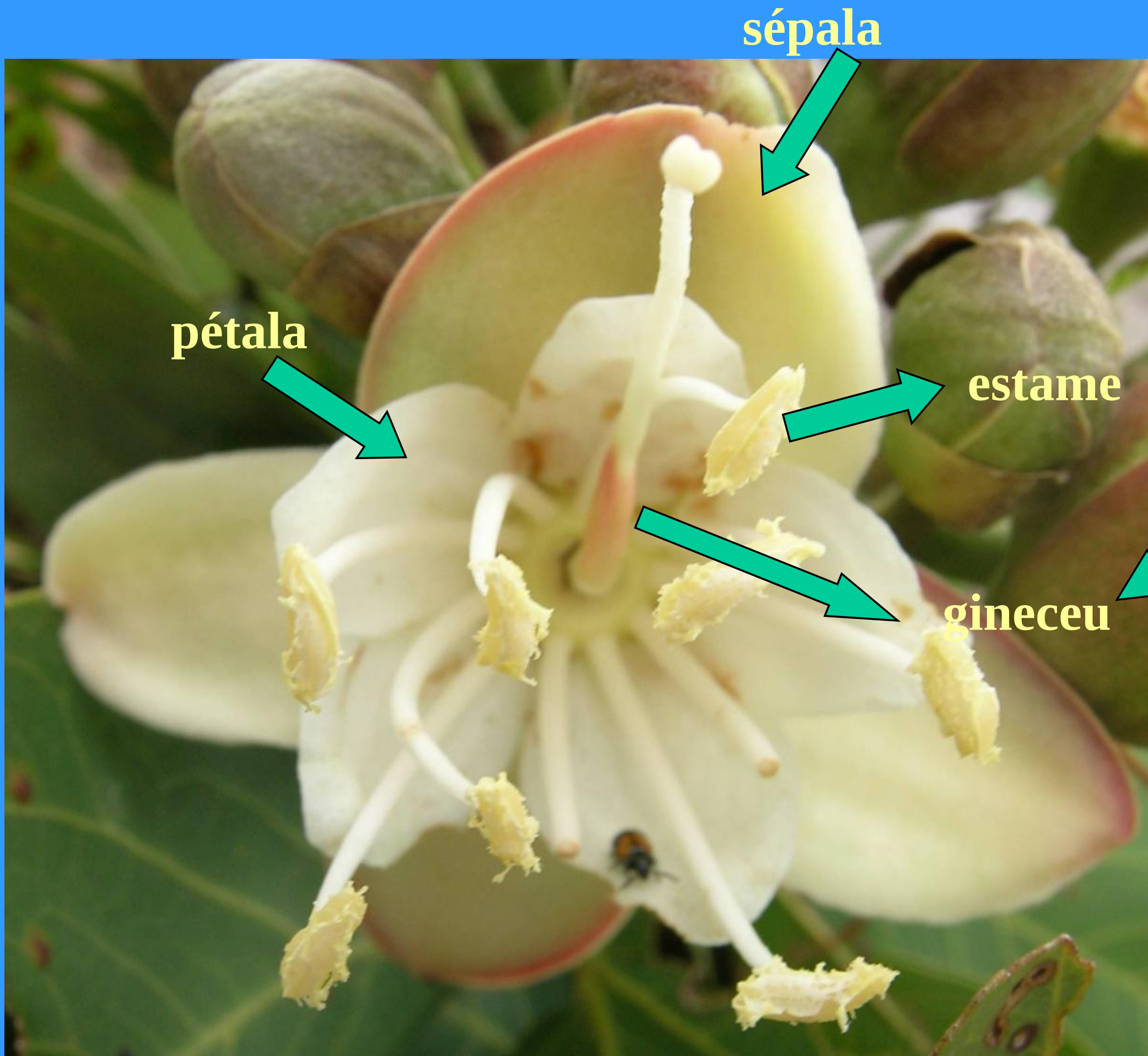
células companheiras;
elementos de tubo crivado anucleados



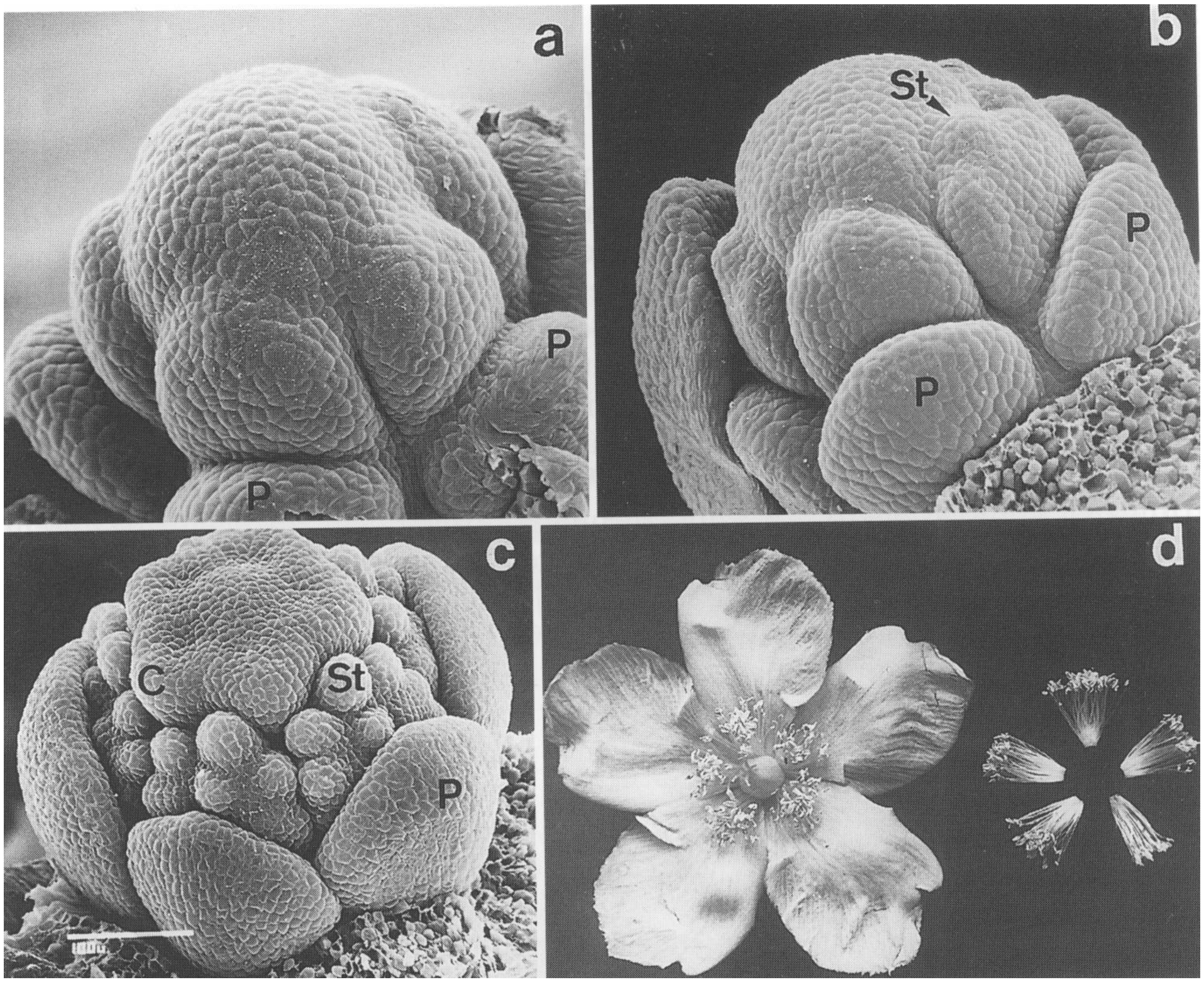
Robbins & Weiser 1950

jatobá **FLOR**

Hymenaea stigonocarpa



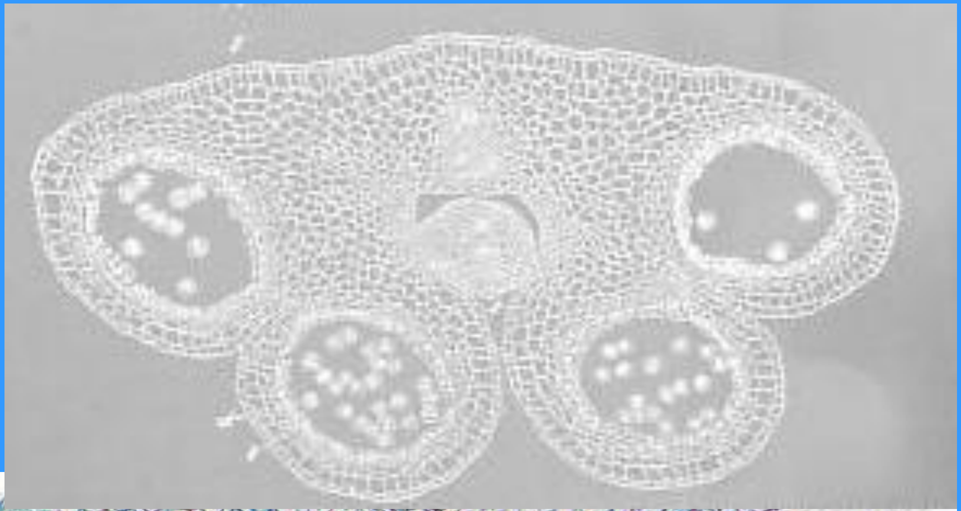
FLOR = estróbilo heterosporangiado com internós muito curtos

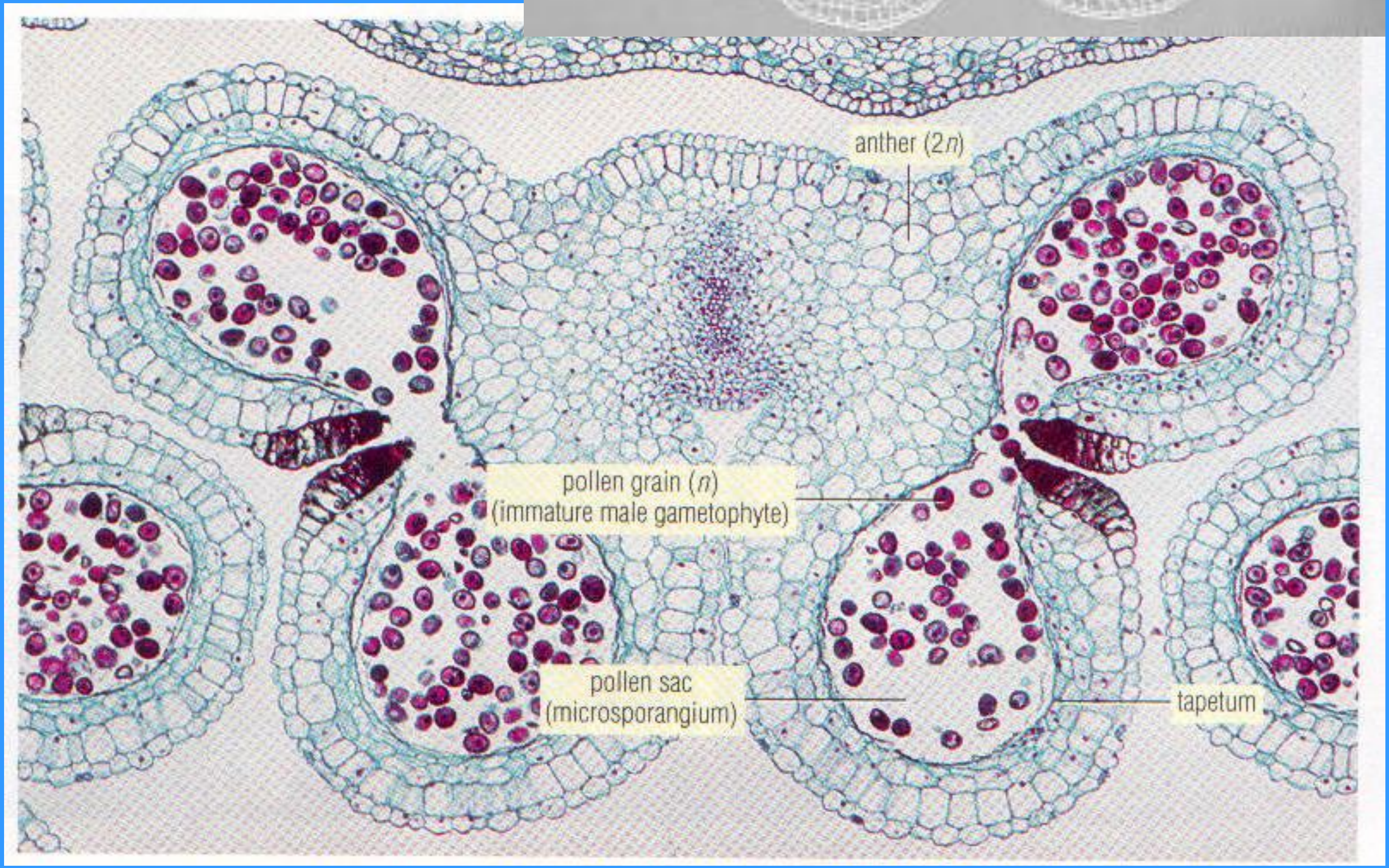


***Hypericum hookerianum*, Guttiferae** **Leins 2000**

Antera

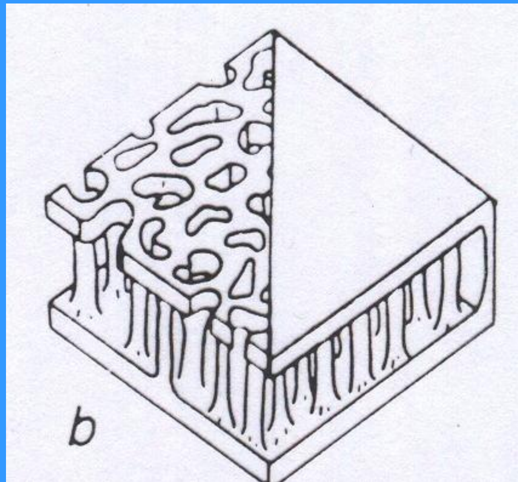
Lilium

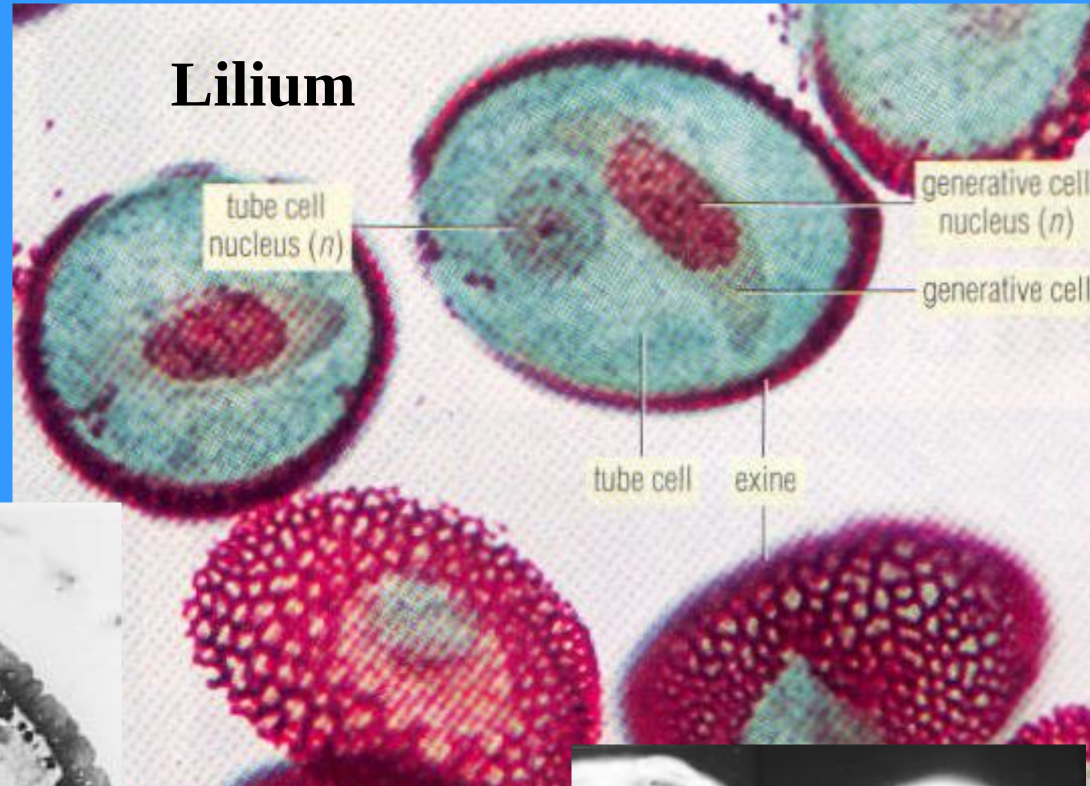


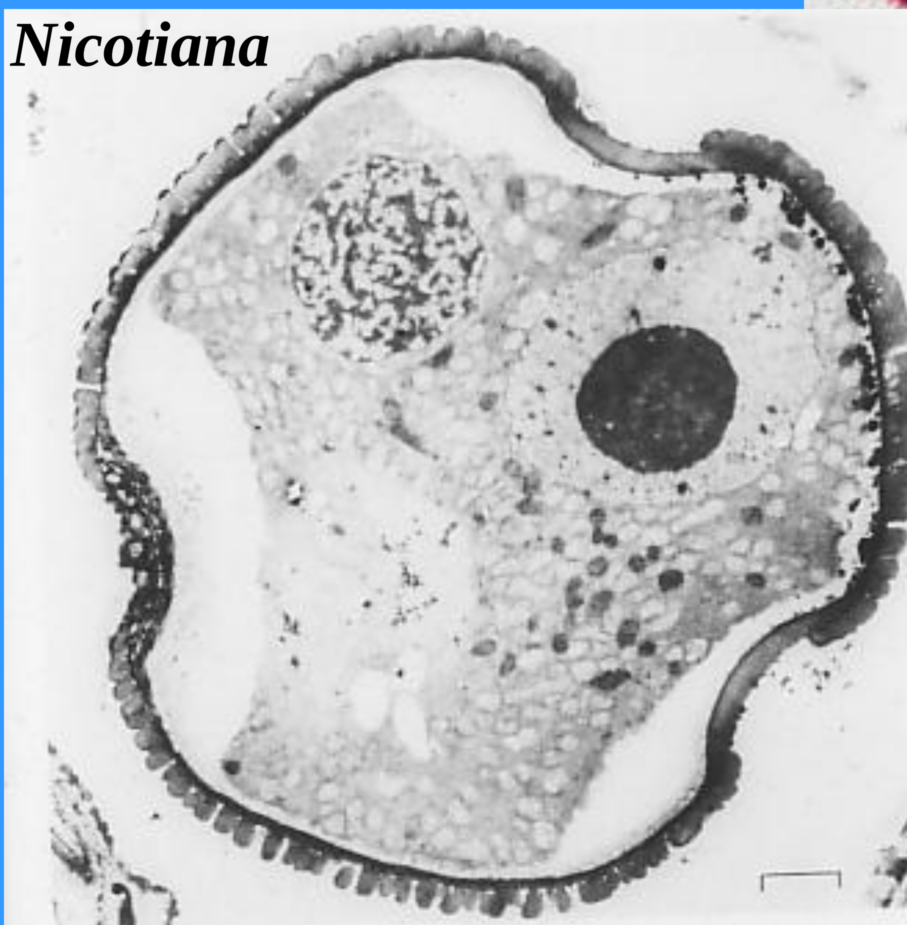


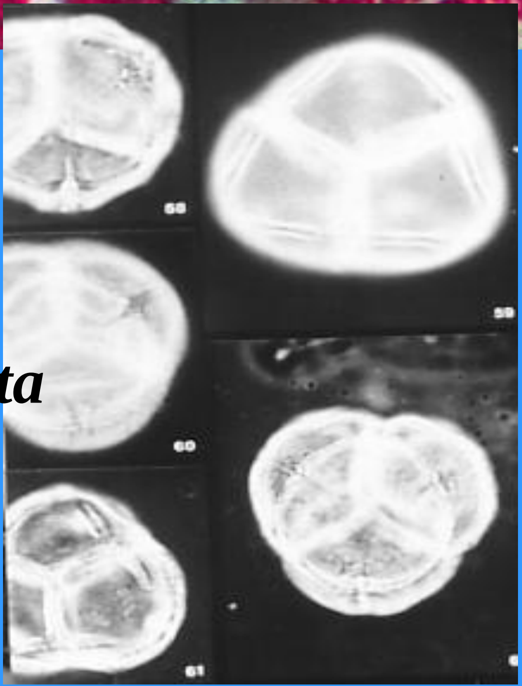
Perry & Morton 1996

Pólen

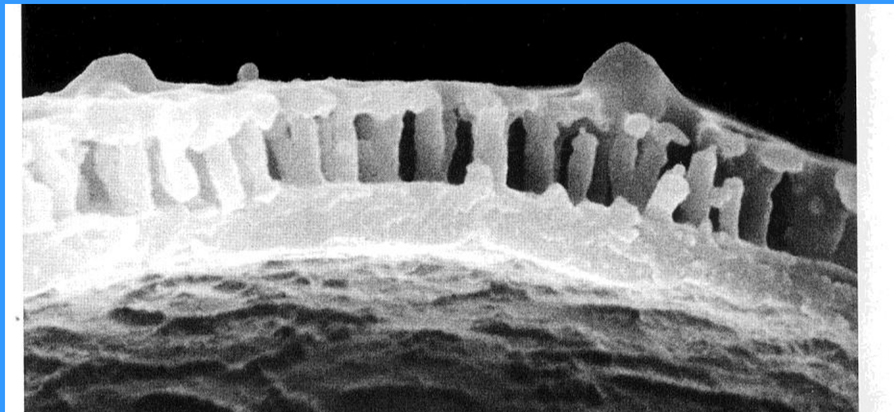


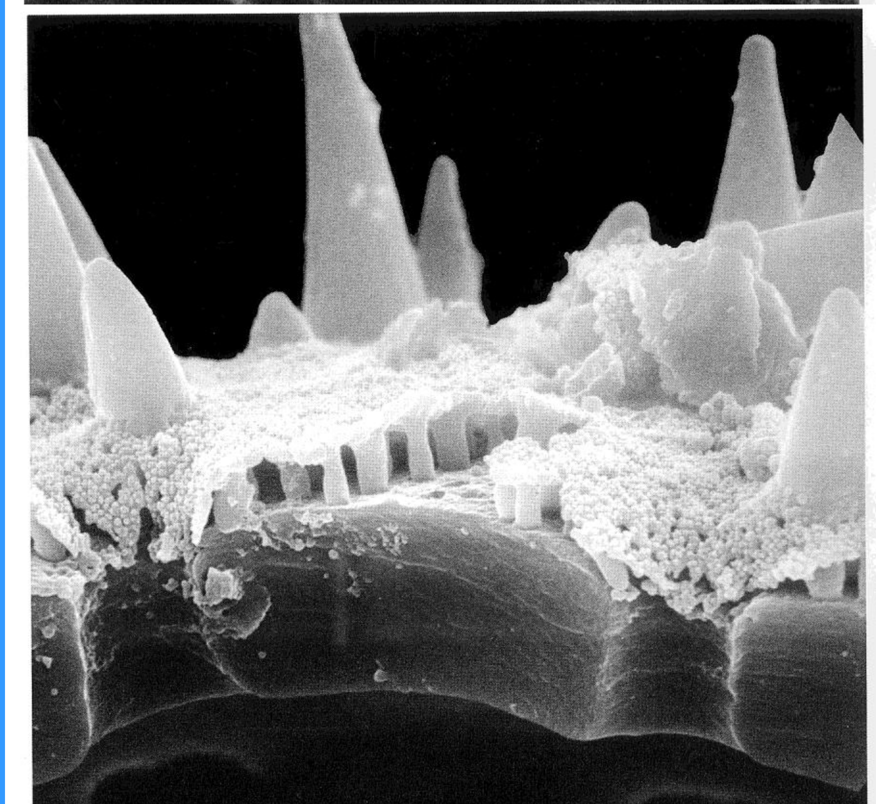


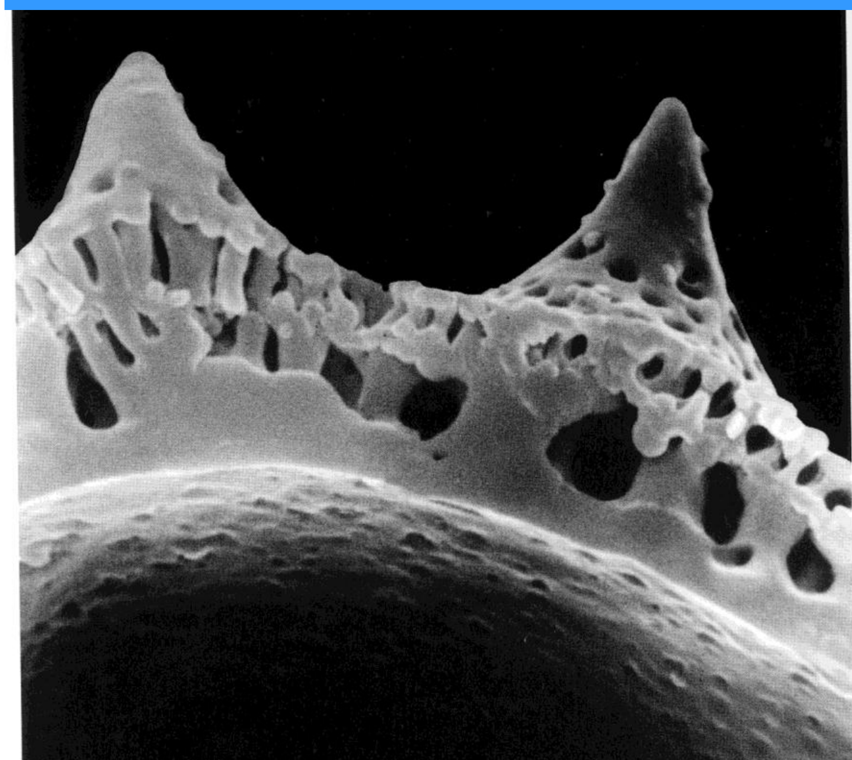




Agarista

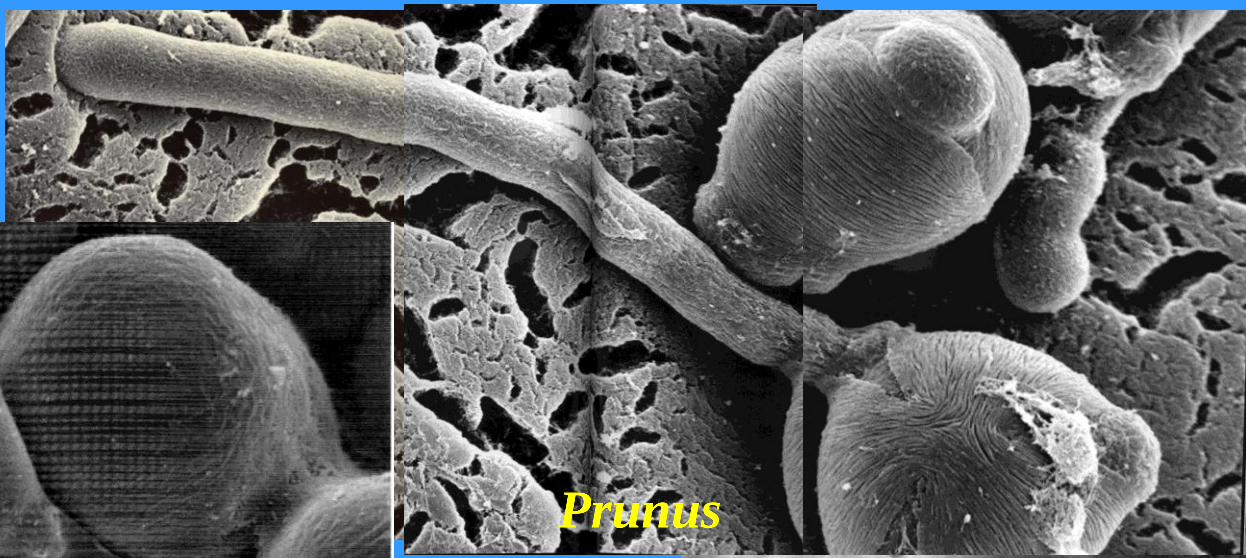




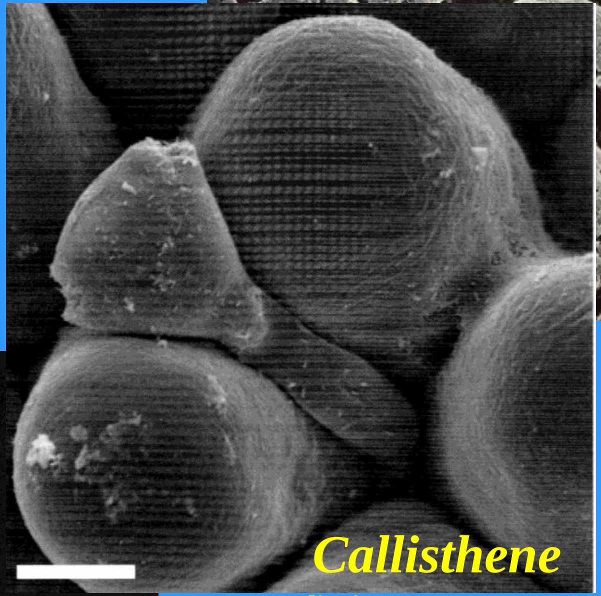


Pólen - exina columelada

Tubo polínico

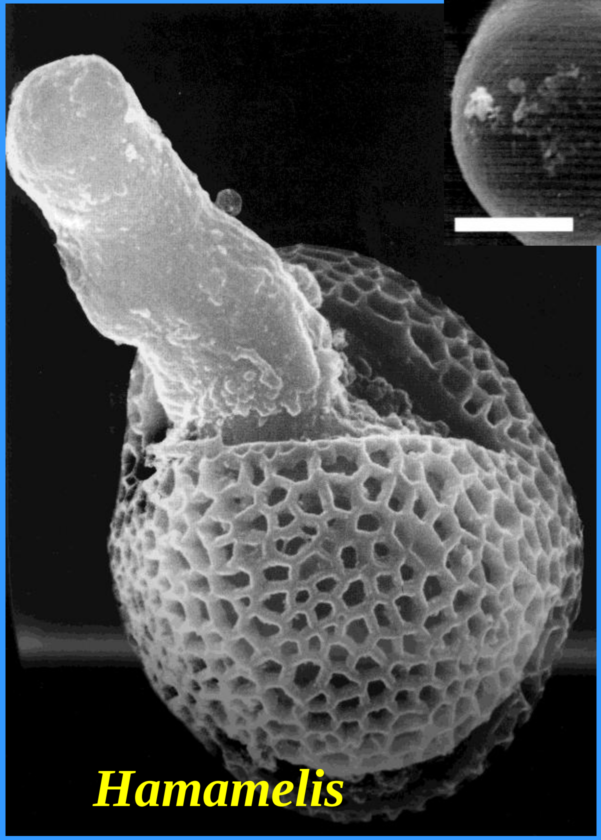


Prunus

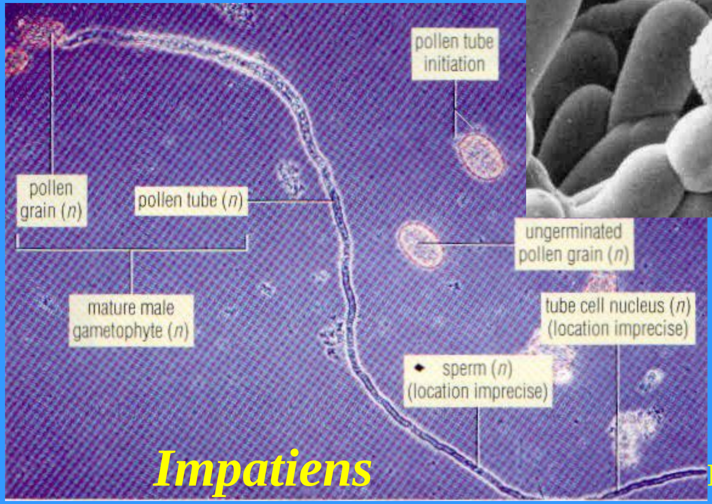


Callisthene

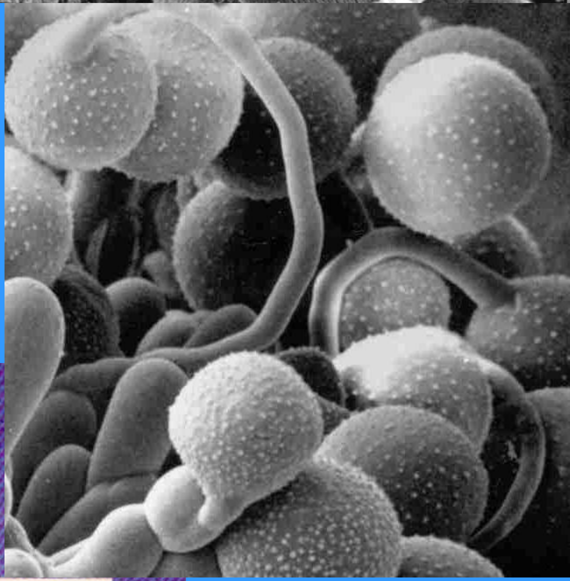
Carmo-Oliveira & Morretes 2009



Hamamelis

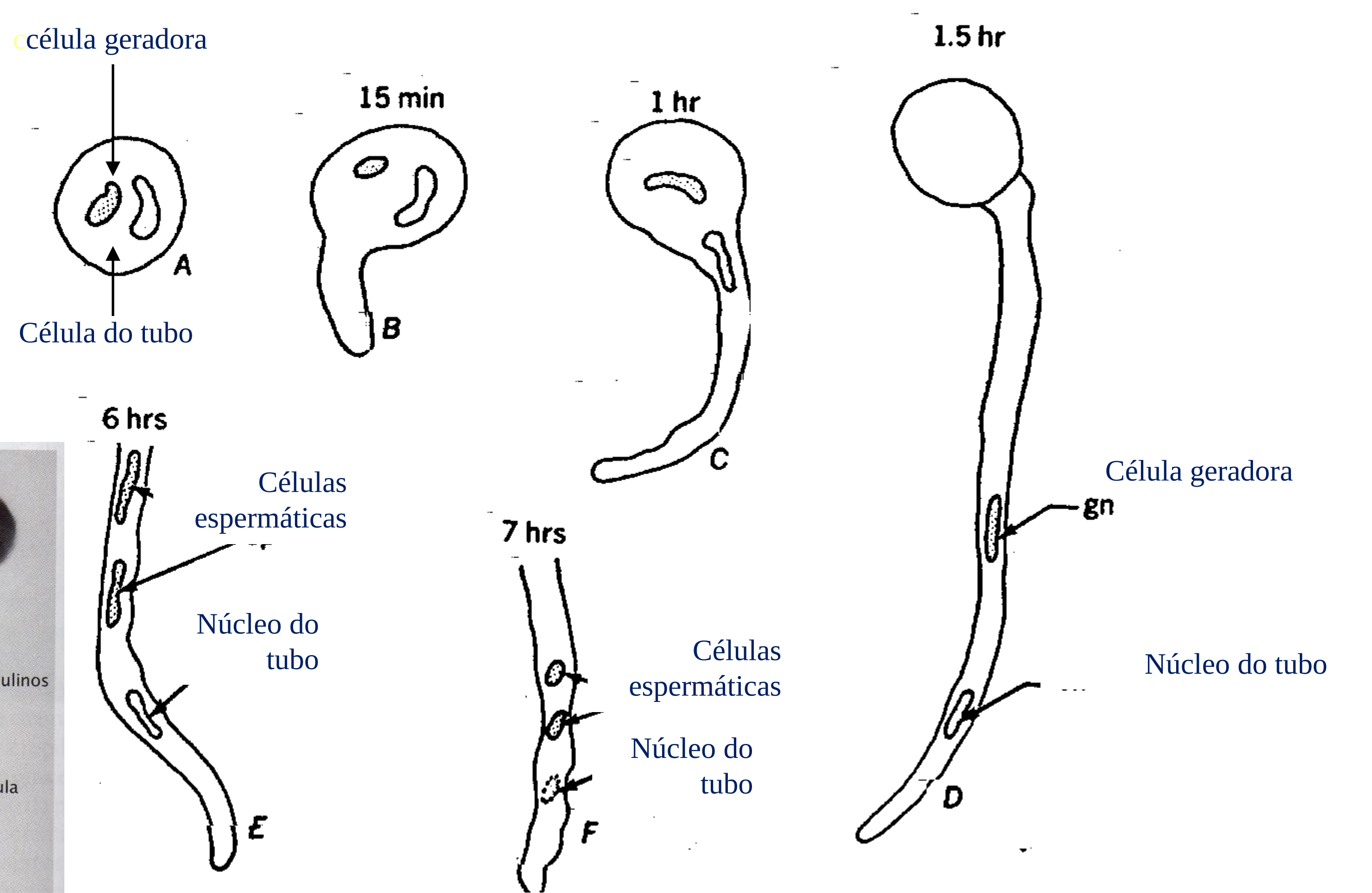


Impatiens



Perry & Morton 1996

Desenvolvimento do tubo polínico



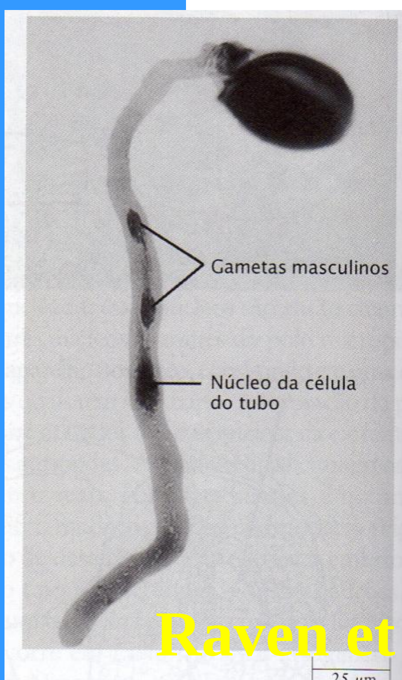
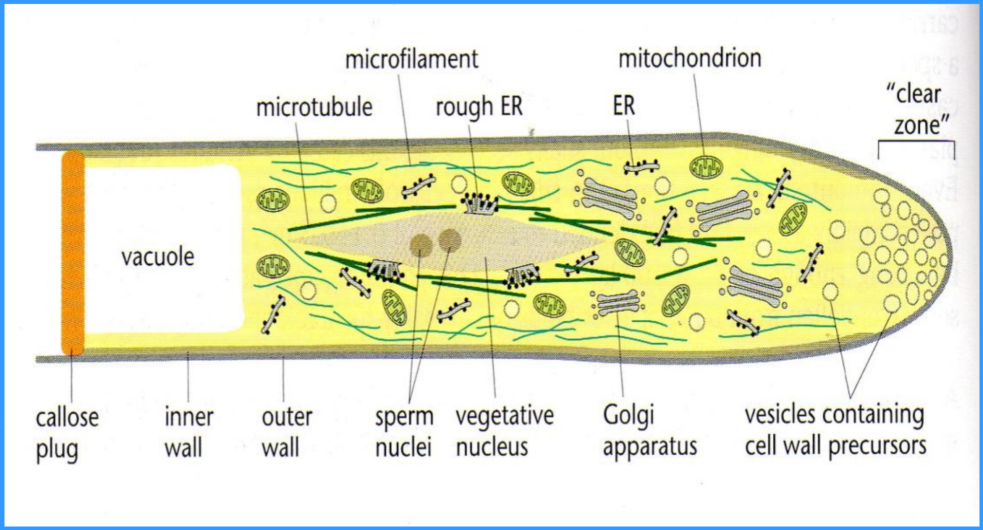


Figure 21.9 Germination of pollen grain of *Scilla* (monocotyledon) in vitro. Medium: 2% agar, 7% cane sugar, traces of sterile yeast. *A*, resting binucleate pollen grain, *B–E*, stages of germination at times after placement on medium indicated above the drawings. Only tips of the pollen tubes in *E* and *F*. The nuclei are compact at end of germination in *F*. Details: *gn*, generative nucleus; *sp*, sperm nucleus; *vn*, vegetative nucleus. (Adapted from R. A. Brink, *Amer. J. Bot.* 11:351–364, 1924.)

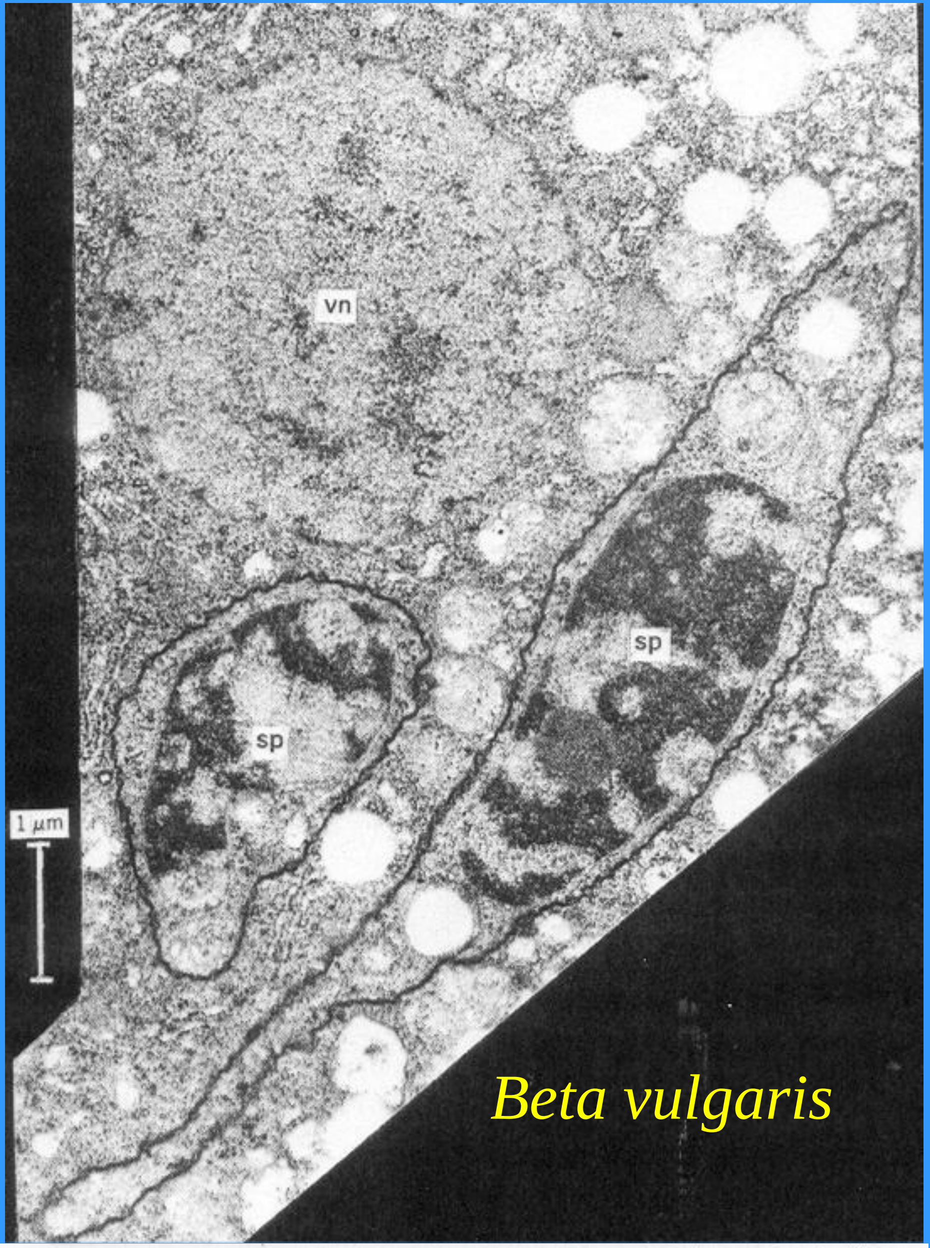
Raven et al. 2007

Gametófito masculino:

Célula do tubo e 2 células espermáticas



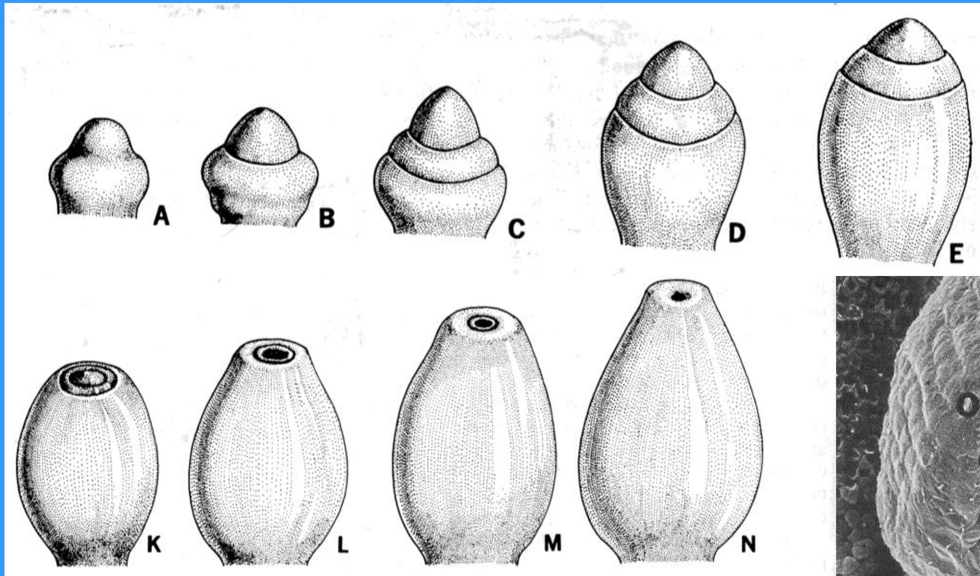
Smith *et al.* 2010



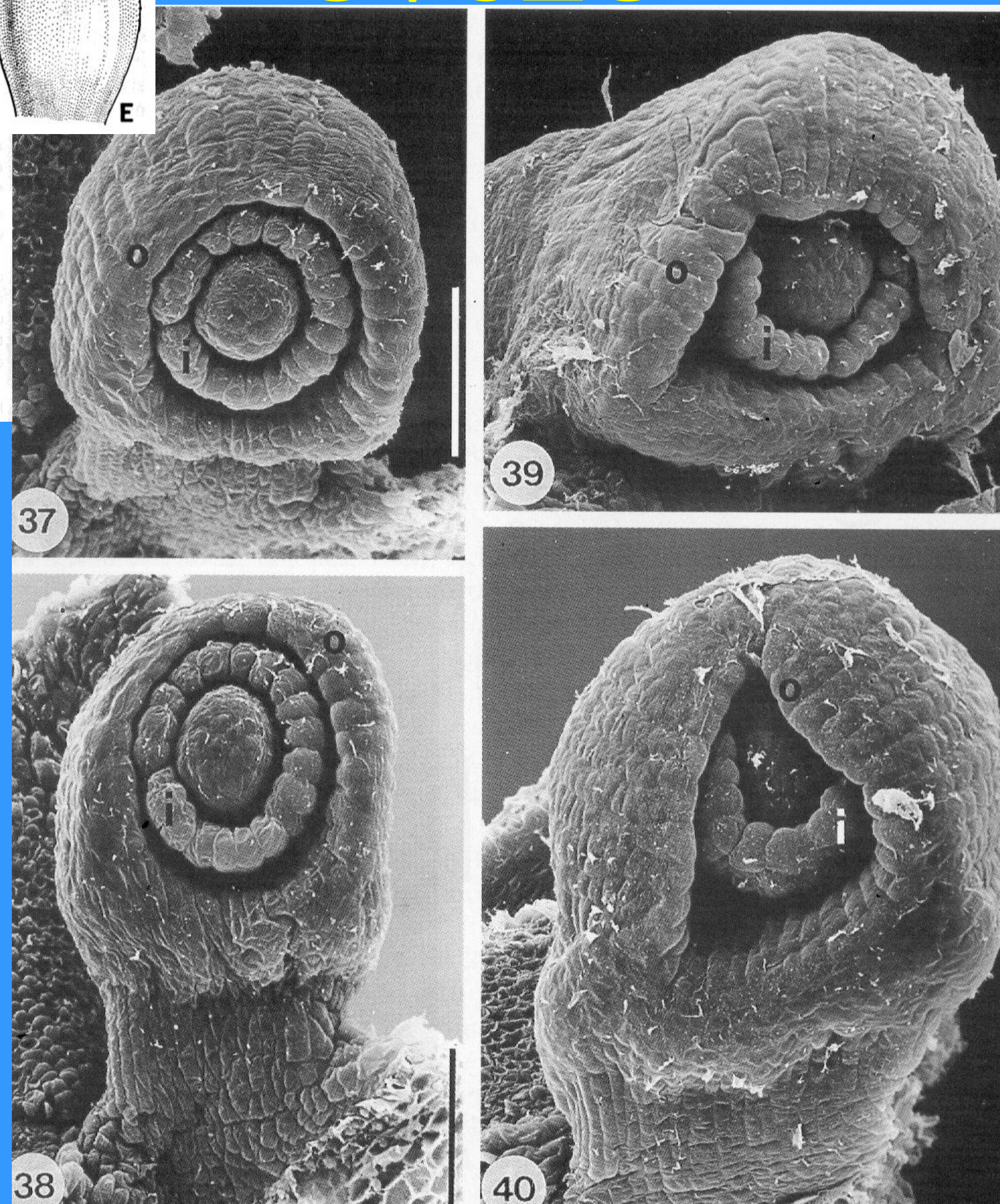
Beta vulgaris

Figure 21.8 Electron micrograph of sperm cells (*sp*) and vegetative nucleus (*vn*) from a three-celled pollen grain of sugar beet (*Beta vulgaris*). The sperms are positioned at righ angles to one another. They are delimited by two membranes interpreted as two plasma lemmas, the outer derived from the vegetative cell, the inner from the sperm cell. (Fron Hoefert.[29])

ÓVULO



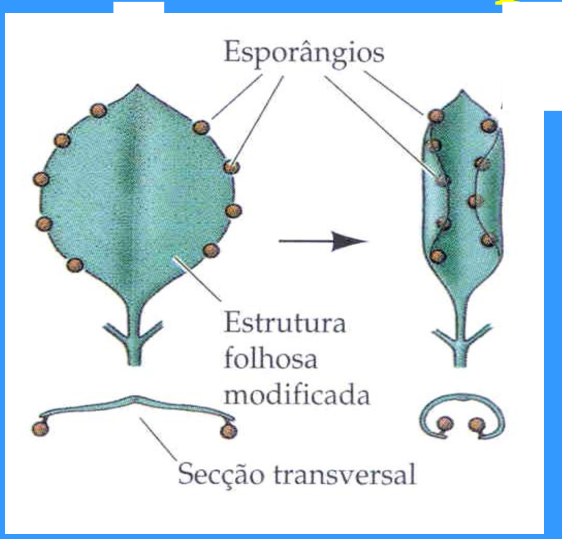
Scagel 1969

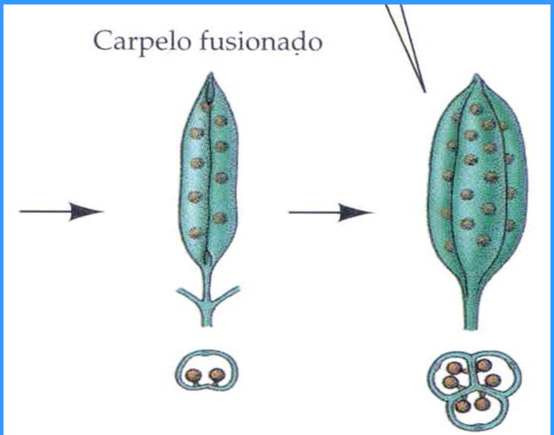


Canella alba
Canellaceae

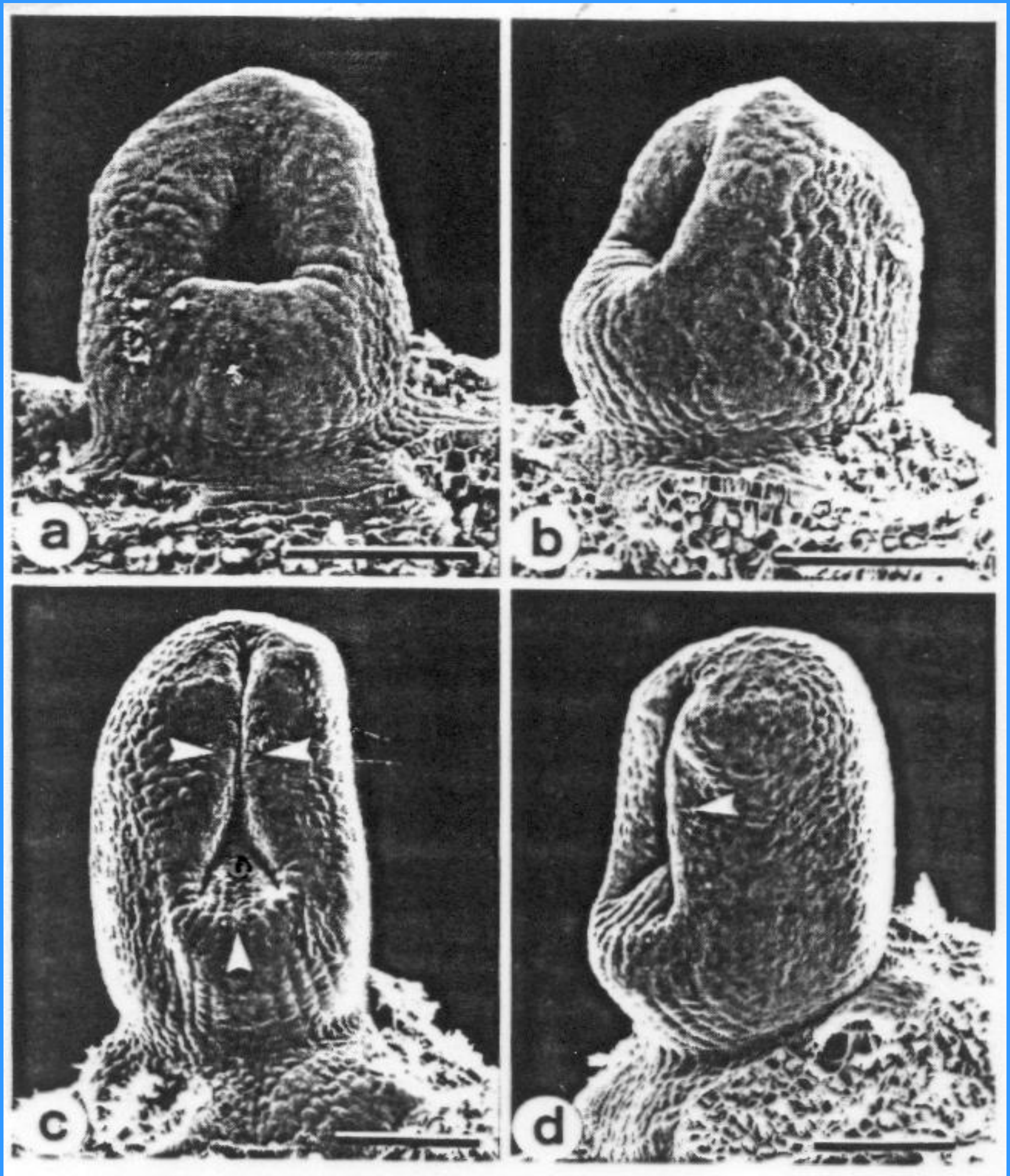
Igersheim & Endress 1997

Carpelo





Mauseth 1995



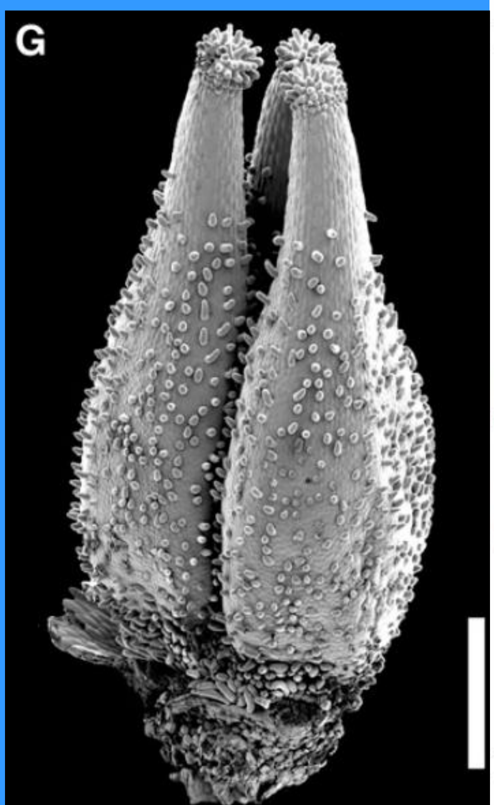
Laurus

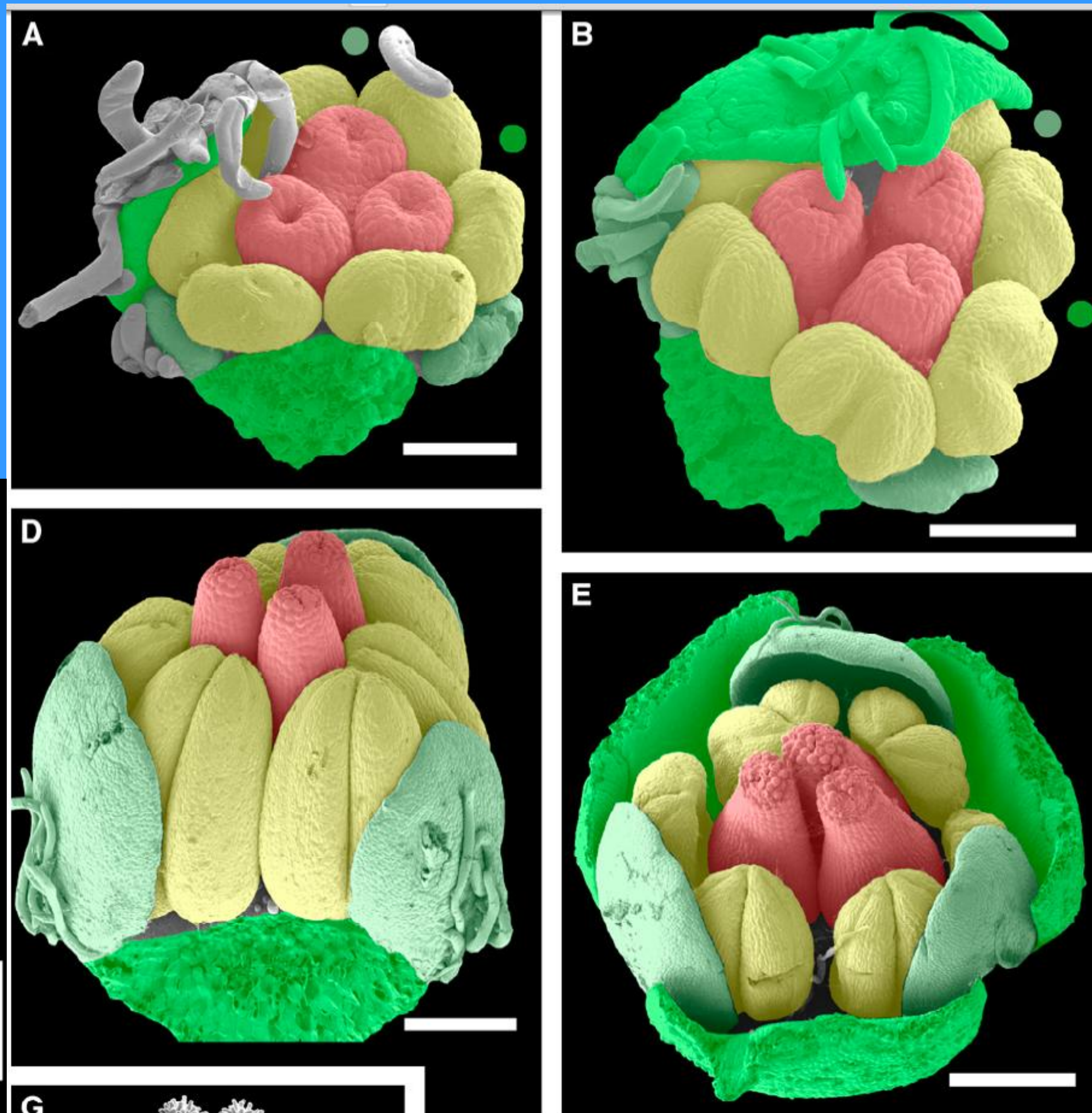
Endress 1997

Carpelos - ontogênese

Cabomba
Cabombaceae

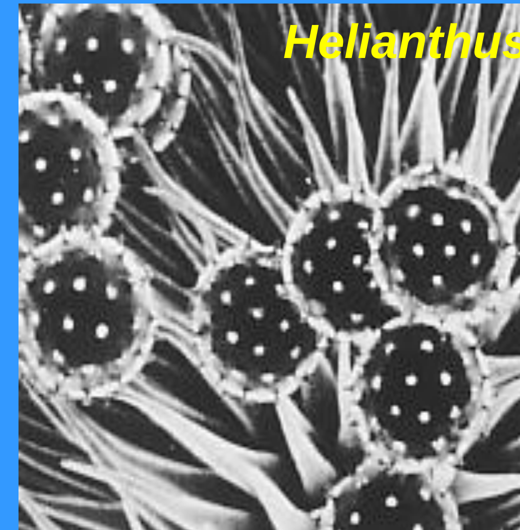
Rudall et al. 2009



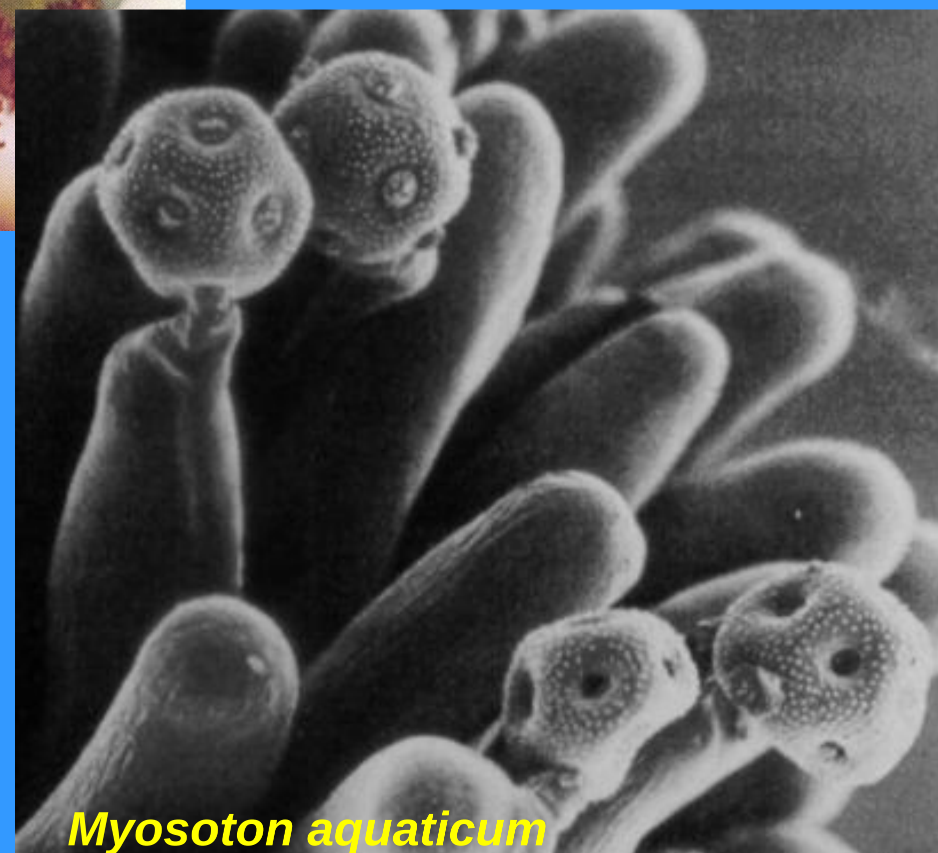


Vinca

Gineceu

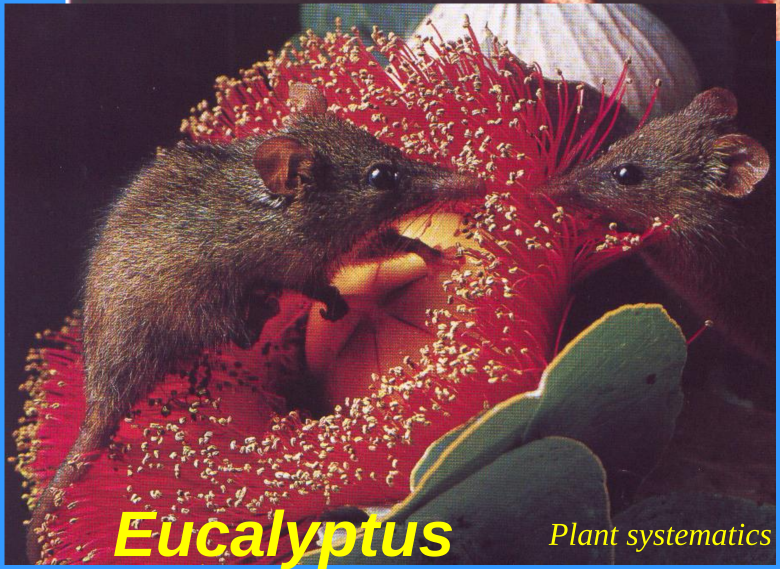


Helianthus



Myosoton aquaticum

POLINIZAÇÃO



Estratégias diversificadas de polinização:

Diversificação em espécies ornitófilas de *Salvia* (Lamiaceae)

Wester & Claßen-Bockhoff 2011

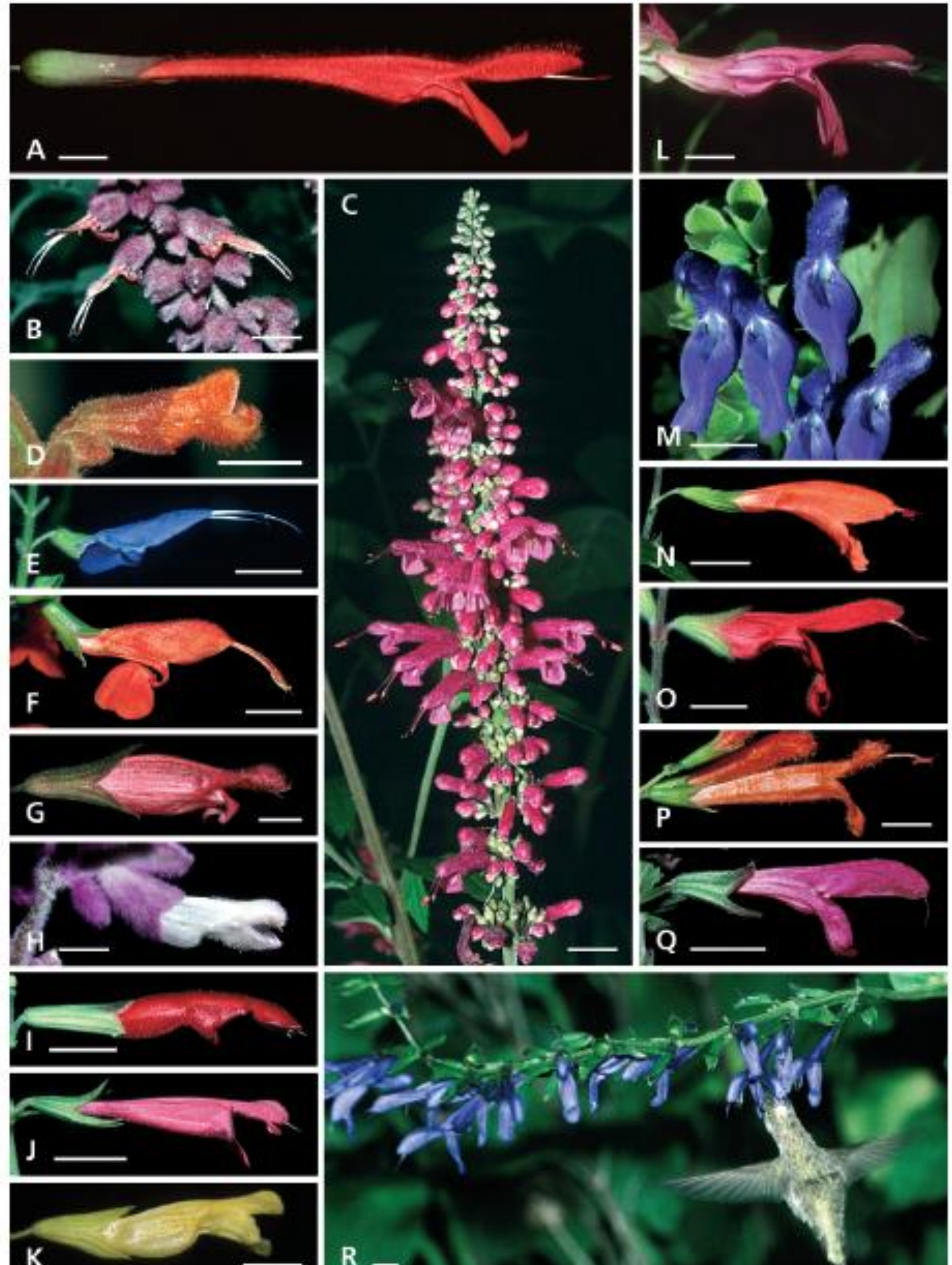
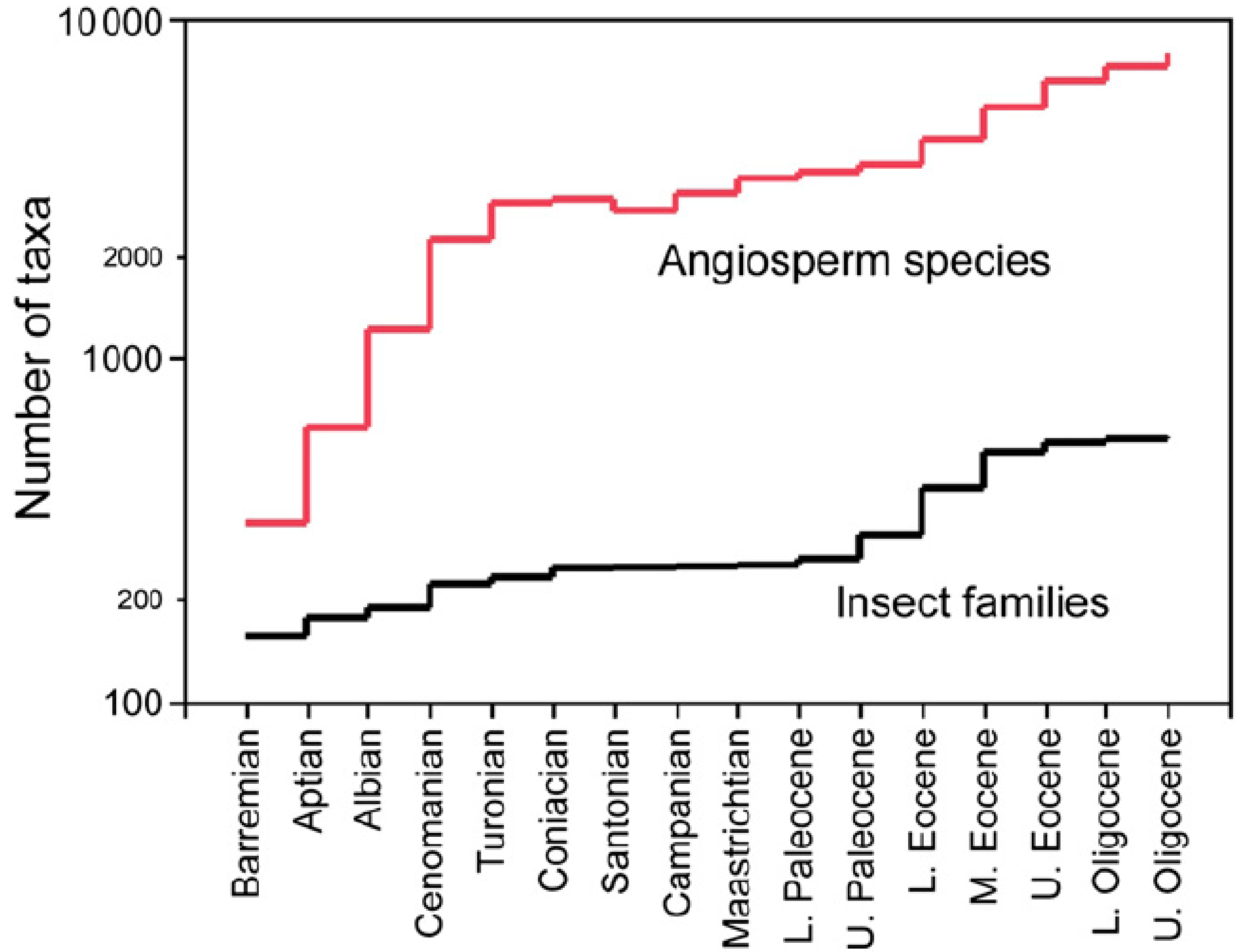
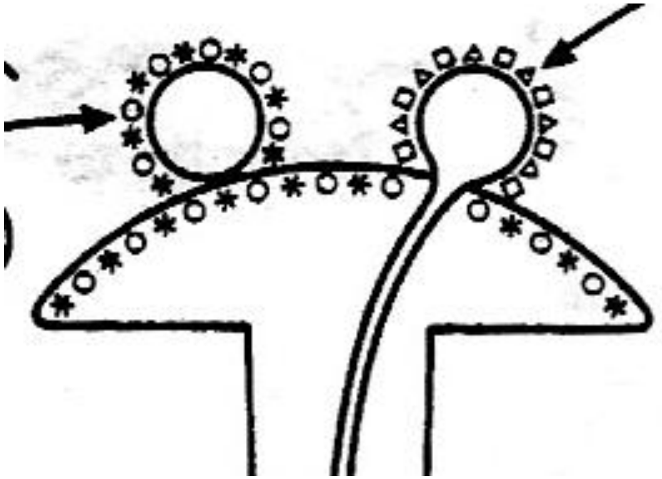


Figure 1. Diversity of ornithophilous *Salvia* flowers. —A. *S. dombeyi* with the largest flower in the genus. —B. *S. lasiantha*, view of inflorescence, with flowers having greatly exserted thecae and reflexed lower lips. —C. *S. iodantha* inflorescence bearing long-tubed flowers with greatly exserted thecae. —D. *S. confertiflora* flower with cup-shaped lower lip. E, F. Flowers with reflexed lower lips and greatly exserted thecae. —E. *S. macrophylla*. —F. *S. pauciserrata*. —G. *S. karwinskii*, elliptic in outline with reflexed lower lip. —H. *S. leucantha* flower with antrorse lower lip lengthening the corolla tube. —I. *S. nervata* flower tubular with very short lower lip. J, K. Relatively long-tubed flowers. —J. *S. henryi*, usually red. —K. *S. madrensis*.

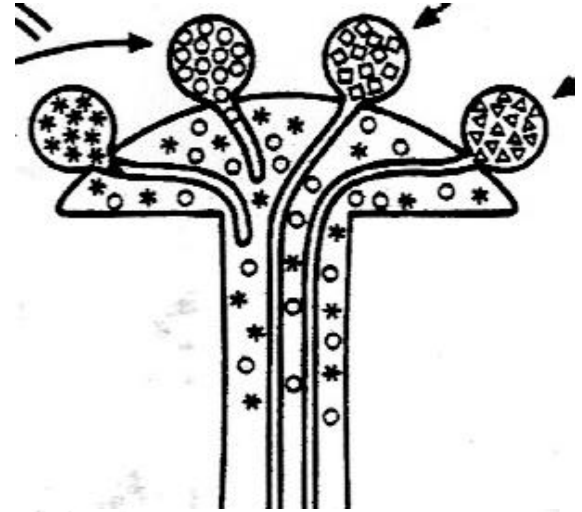


Crepet & Niklas 2009

Fig. 6. Cumulative number of angiosperm species first appearances and cumulative number of new insect families plotted against Cretaceous-Tertiary geological stages. Data taken from Niklas et al. (1980, 1983) and Dmitriev and Ponomarenko (2002).



produtos dos genes



Autoincompatibilidade

Leins & Erbar 2010

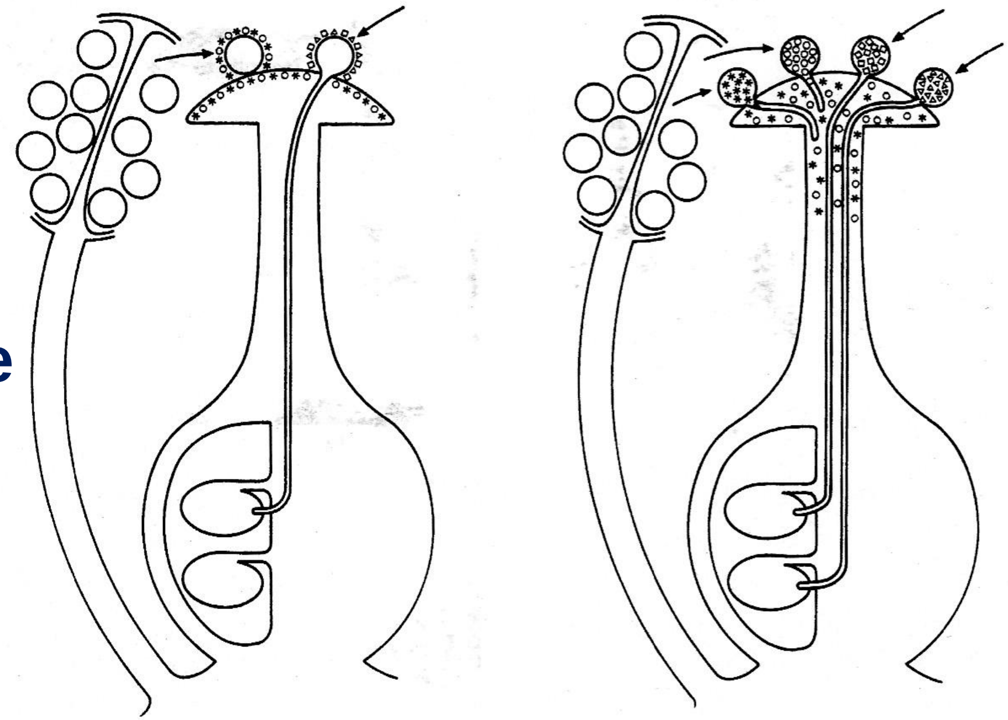
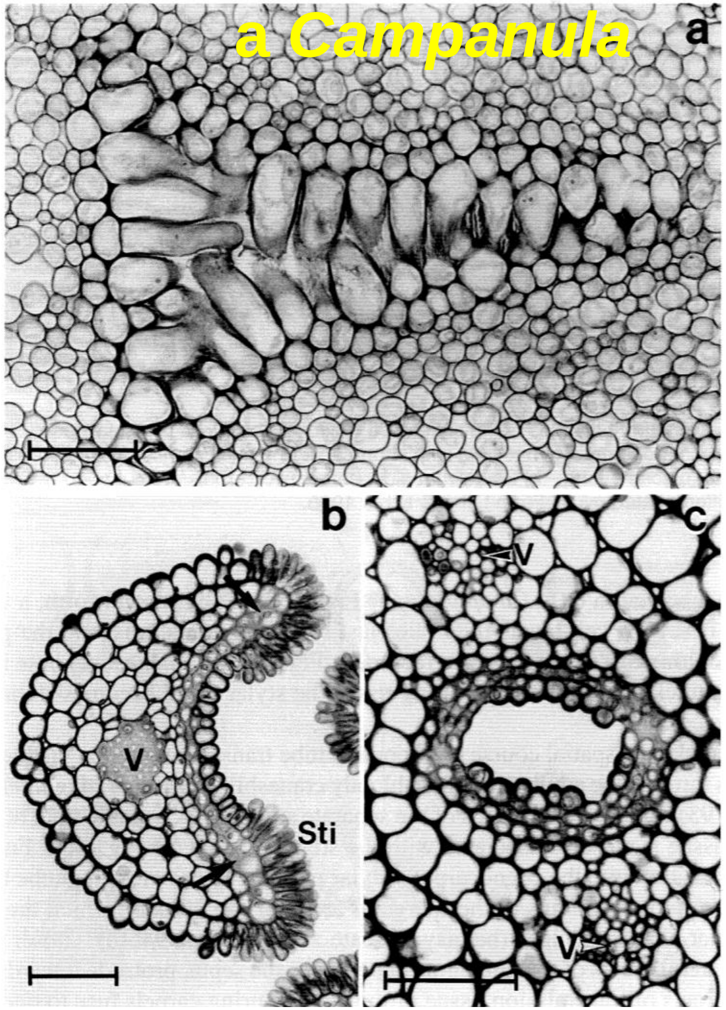


Fig. 138. The principle of self-incompatibility. On the left: diploid (sporophytic) mechanism, on the right: haploid (gametophytic) mechanism. S = self-incompatibility gene; the symbols mark the gene products.

Gineceu – Tecidos de transmissão



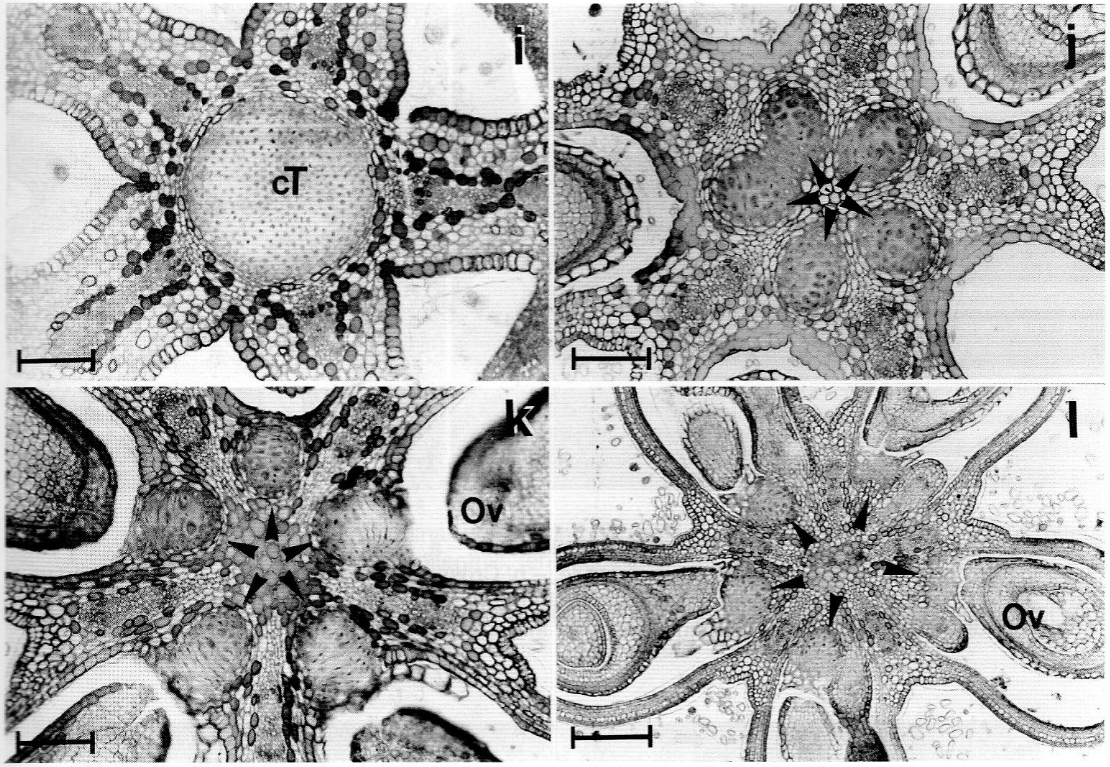
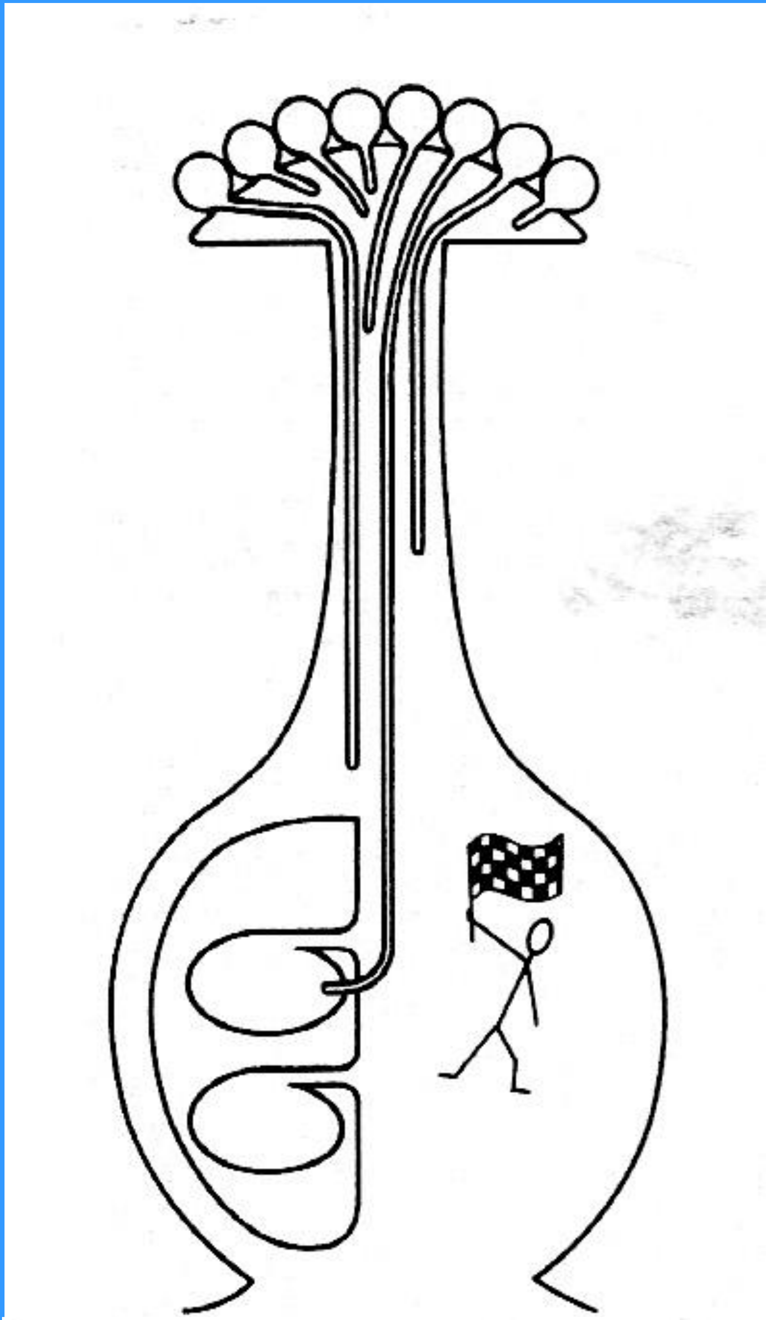


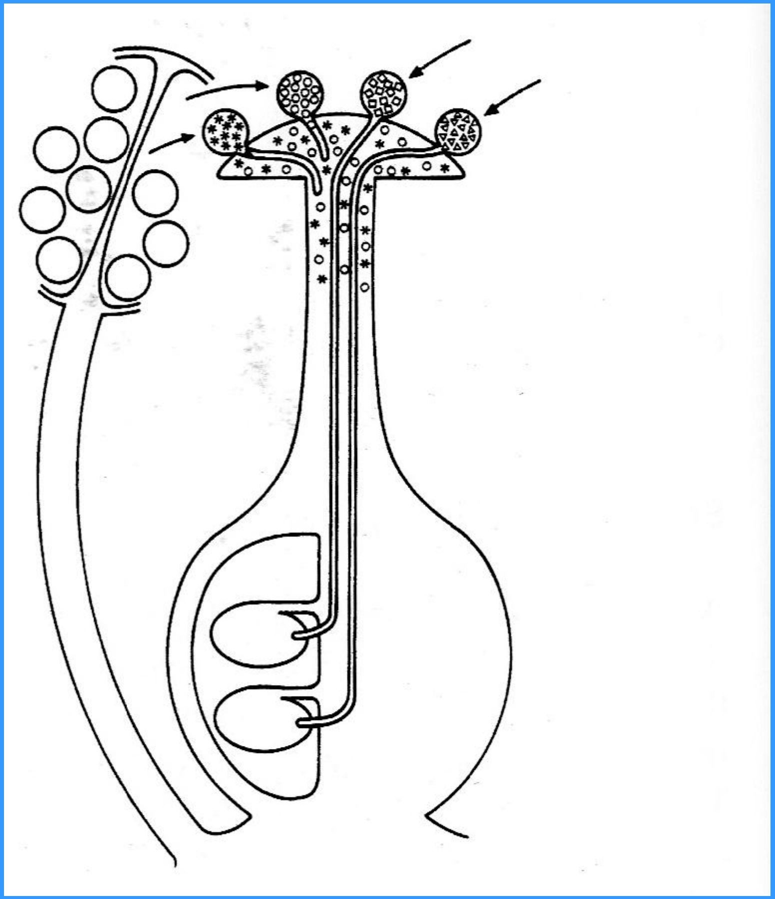
Fig. 94. *Geranium sanguineum*: cross-sections continued. – i, Cross-section through the lower part the sterile septate zone: Central tract of transmitting tissue with strongly swollen cell walls. – j–l, Sections through the fertile ovary part: The central tract separates again, and the five tracts each run into an ovary locule. At the level of the funiculi the pollen tube transmitting tissue extends to the placentae. – cT = central trace of transmitting tissue, Ov = ovule; the magnification bar corresponds to 100 µm in i–k, to 200 µm in l. From Erbar 1998.

b-c *Buphthalmum* **i-l *Geranium***

Fig. 92. Two types of pollen tube transmitting tissue. – a, Stylar canal with secretory epidermis in the bell-flower *Campanula rotundifolia* (Campanulaceae; transverse section). – b, One of two stylar arms (transverse section) of the ox-eye daisy *Buphthalmum salicifolium* (Asteraceae) with a band of pollen tube transmitting tissue beneath the stigmatic tissue (arrows). – c, Pollen tube transmitting tissue of the same object in the common stylar part. The epidermal cells are integrated into the transmitting tissue. – Sti = stigma, V = vascular bundle; magnification bar = 50 µm.

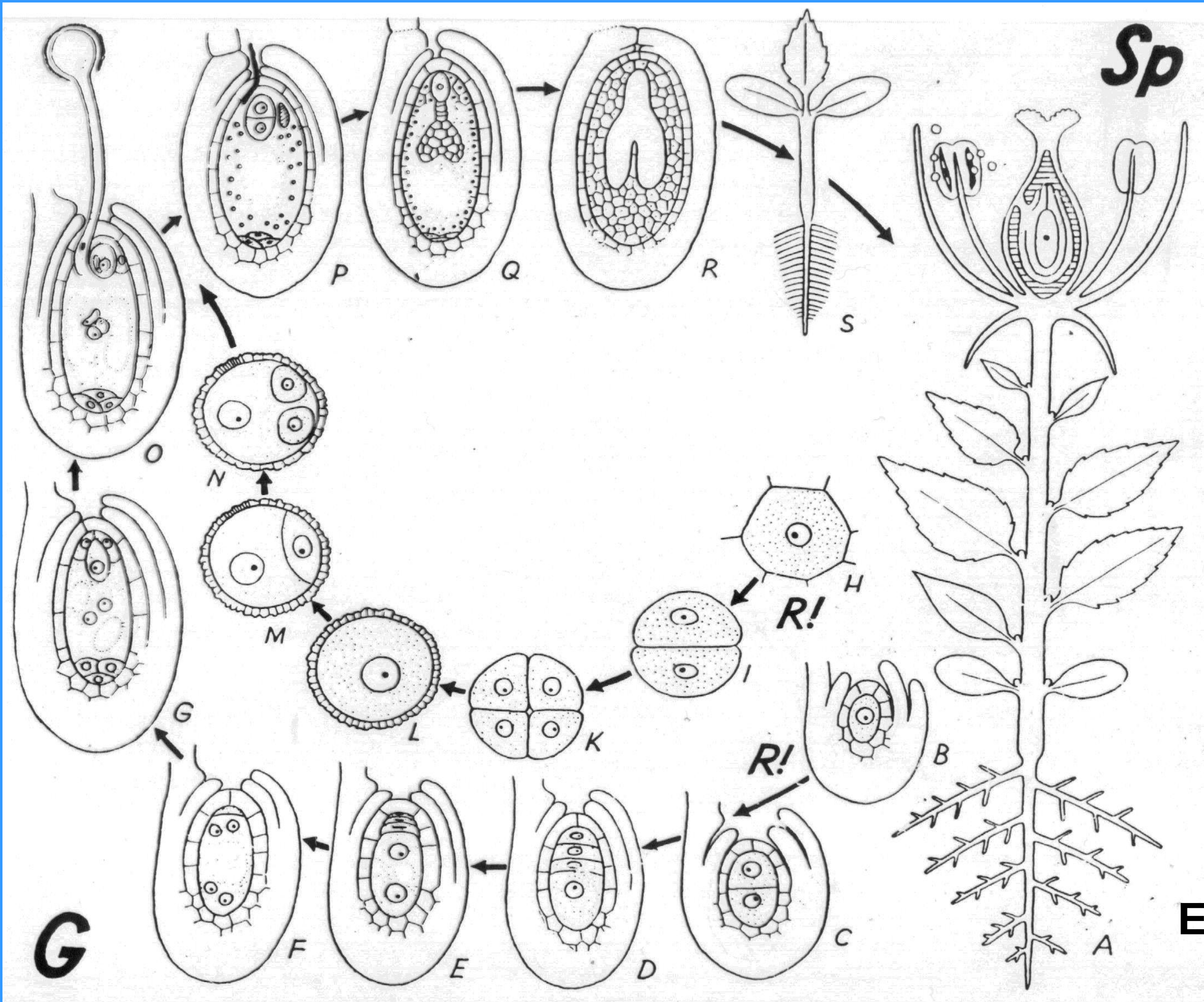
Leins & Erbar 2010



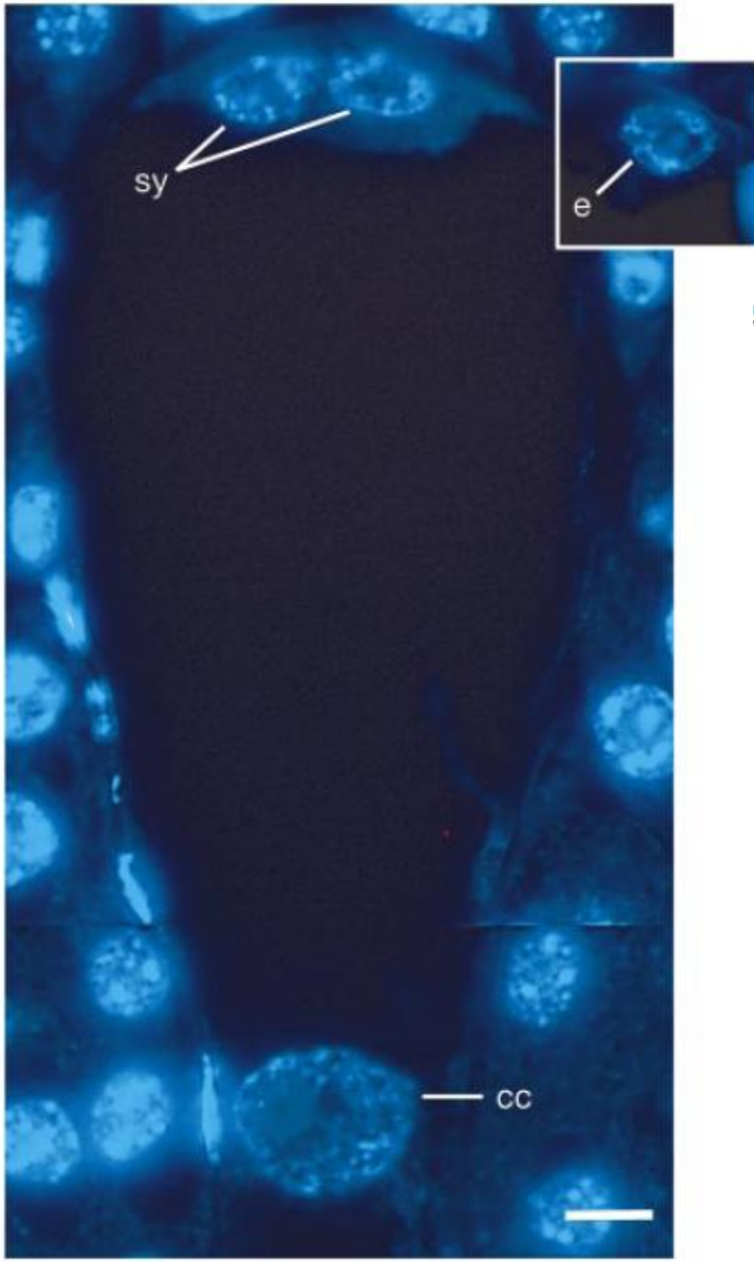


Leins & Erbar 2010

Fig. 161. Pollen tube competition in the pistil: Only the fastest pollen tubes are the “winners”!



Engler
1964



Nuphar
Nymphaeales

efinida

Identification of diploid endosperm in an early angiosperm lineage

Joseph H. Williams*† & William E. Friedman*†

* *Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, Colorado 80309, USA*
† *These authors contributed equally to the work*

In flowering plants, the developmental and genetic basis for the establishment of an embryo-nourishing tissue differs from all other lineages of seed plants. Among extant nonflowering seed plants (conifers, cycads, *Ginkgo*, Gnetales), a maternally derived haploid tissue (female gametophyte) is responsible for the acquisition of nutrients from the maternal diploid plant, and the ultimate provisioning of the embryo. In flowering plants, a second fertilization event, contemporaneous with the fusion of sperm and egg to yield a zygote, initiates a genetically biparental and typically triploid embryo-nourishing tissue called endosperm. For over a century, triploid biparental endosperm has been viewed as the ancestral condition in extant flowering

Williams & Friedman 2004

Figure 1 Four-celled/four-nucleate *Nuphar* female gametophyte. Two synergids (sy) and an egg (e) are located at the micropylar end of the female gametophyte. The egg cell

Williams & Friedman 2004

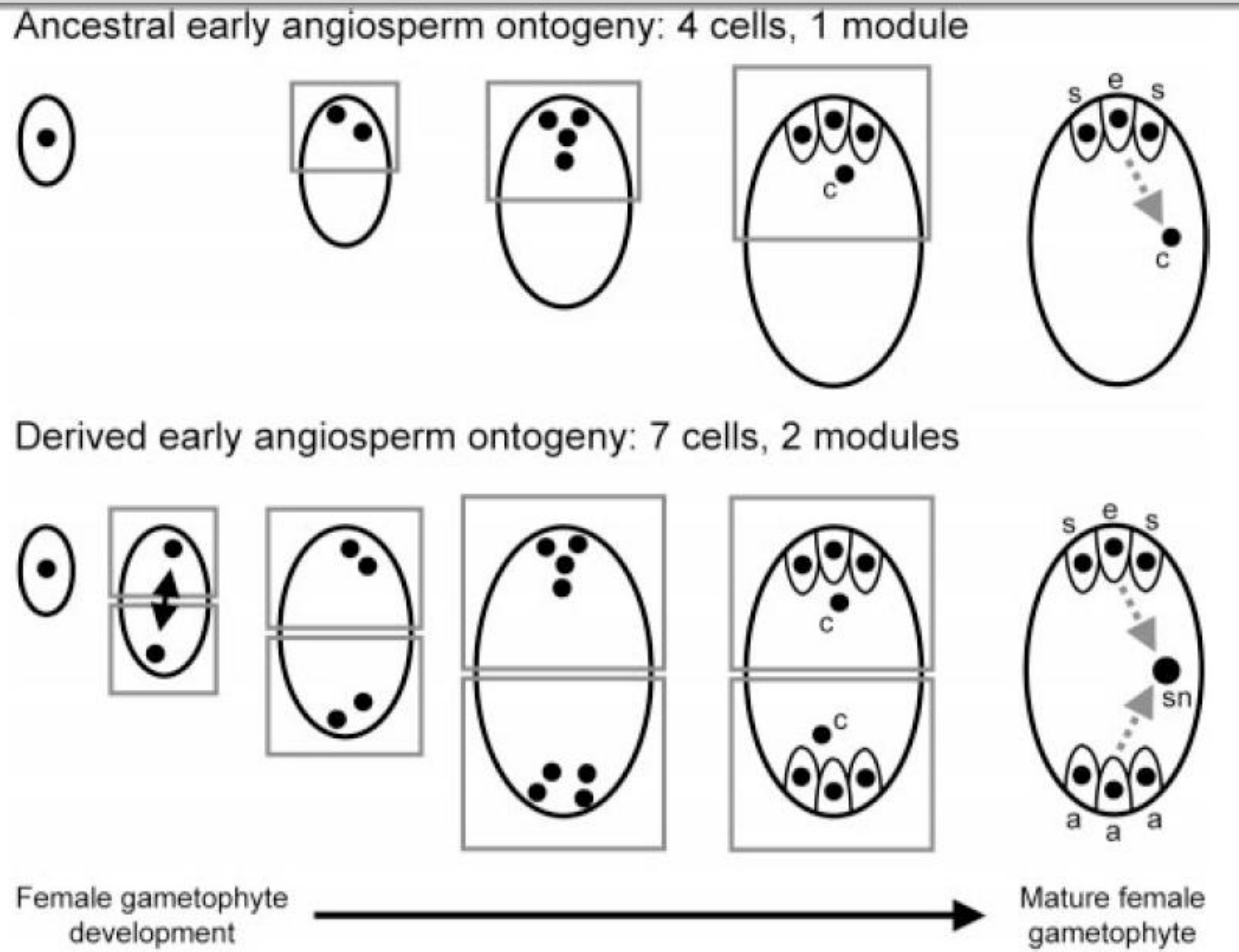
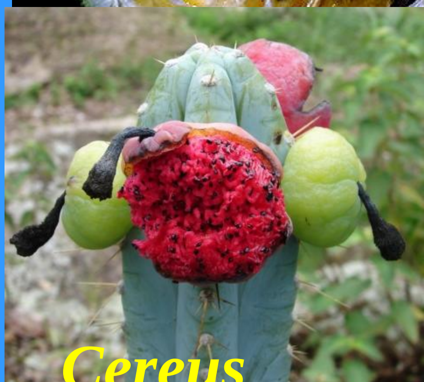


Fig. 6. Comparative development of female gametophytes of early angiosperms. The *Illicium*-like four-celled/four-nucleate female gametophyte of Austrobaileyales is at the top, and the reconstructed seven-celled/eight-nucleate female gametophyte of the common ancestor of the clade that includes monocots, eumagnoliids, and eudicots is below. Female gametophytes of an-

DISPERSÃO

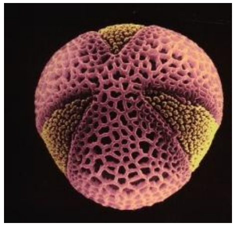



Sorbus

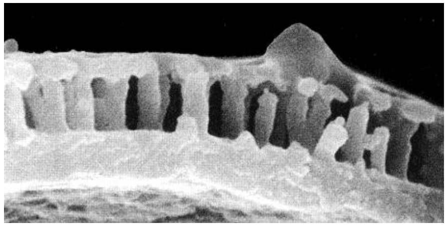
Origem das angiospermas

ca. 120 m.a. – Barremiano-Aptiano - flores de angiospermas com pólen *in situ*/ sementes/frutos/ carpelos com pólen no estigma

ca. 125 m.a. - Barremiano Superior - primeiros grãos triaperturados



ca. 136 m.a. - Valanginiano-Hauteriviano - pólen monossulcado com exina semitectada columelada



ca. 144 m.a. - limite Jurássico/Cretáceo - sem evidências de angiospermas


Baixo Eoceno
50 m.a.

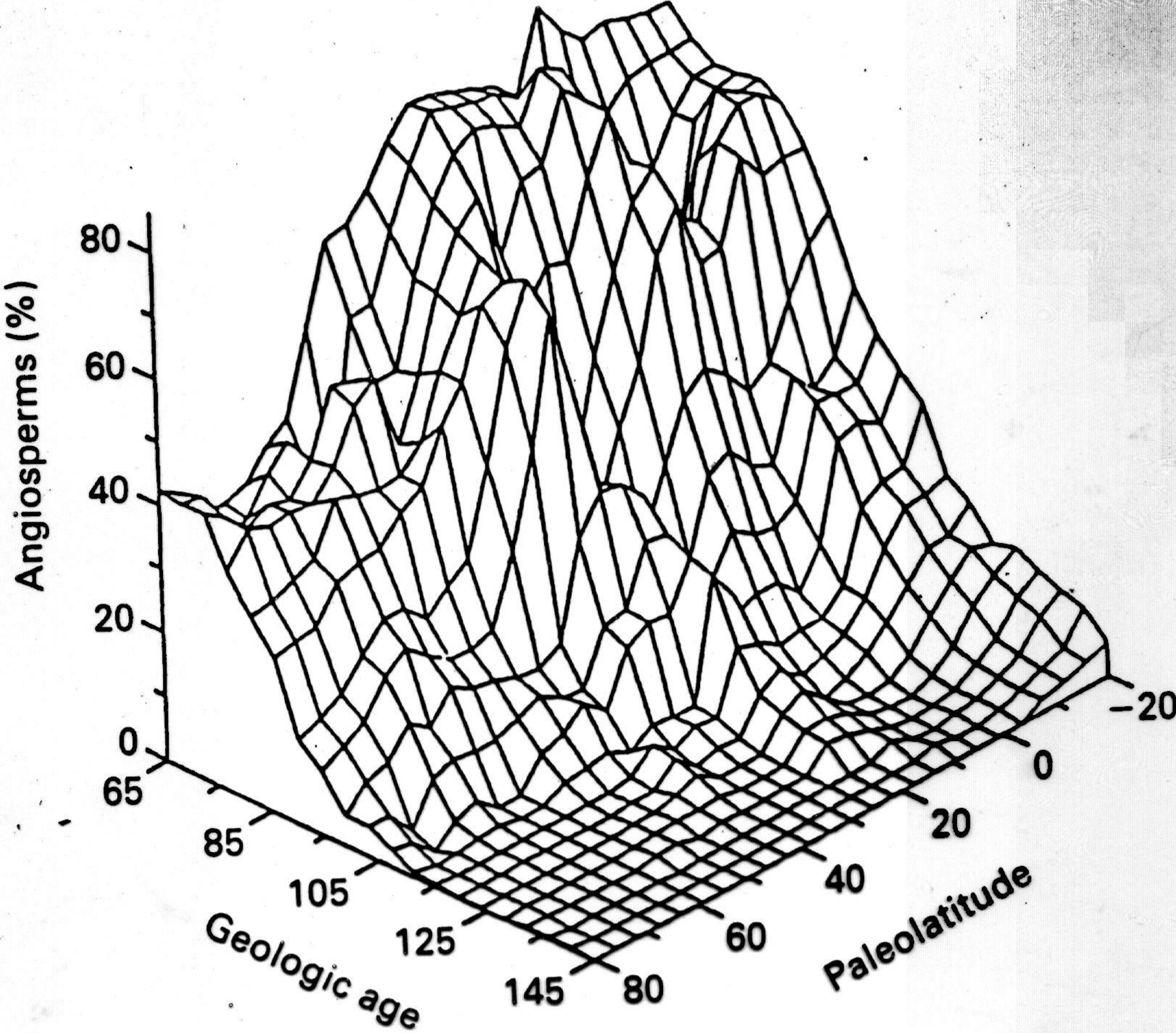
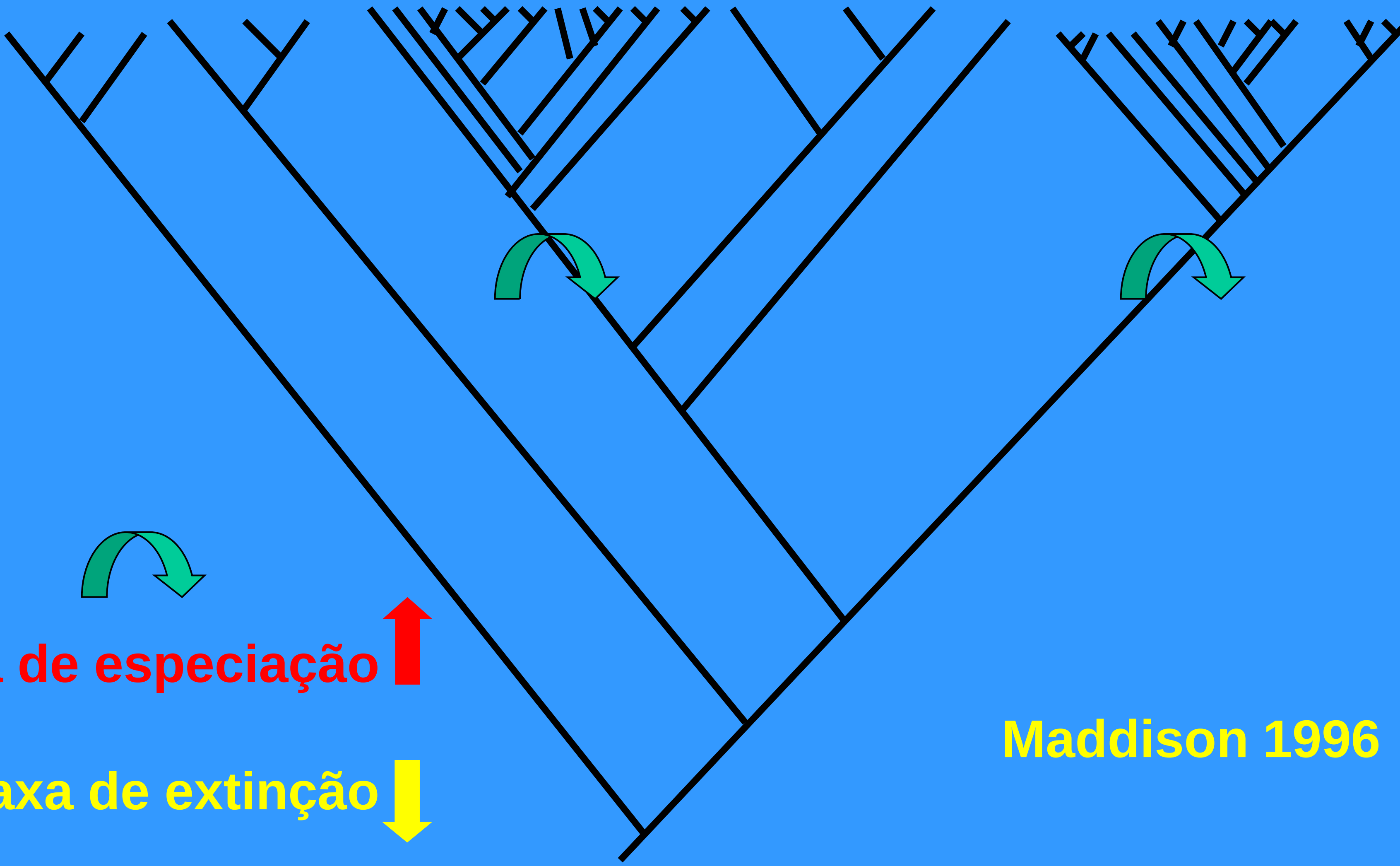


Fig. 2.11 Estimated percentage representation of flowering plants (angiosperms) at different times in geological history and at different latitudes. Angiosperms have always been most abundant in the low-latitude (tropical) regions, suggesting that they originated in this part of the earth. From Crane and Lidgard [11].

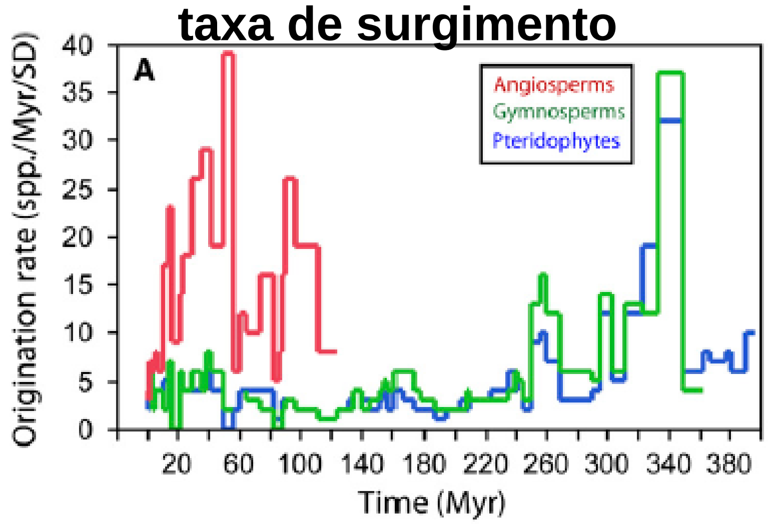
Inovações-chave

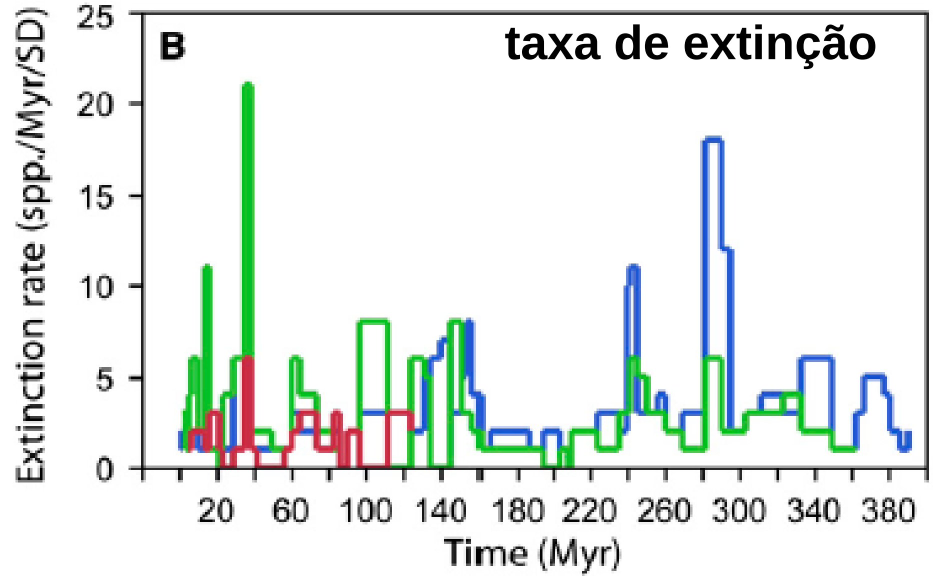


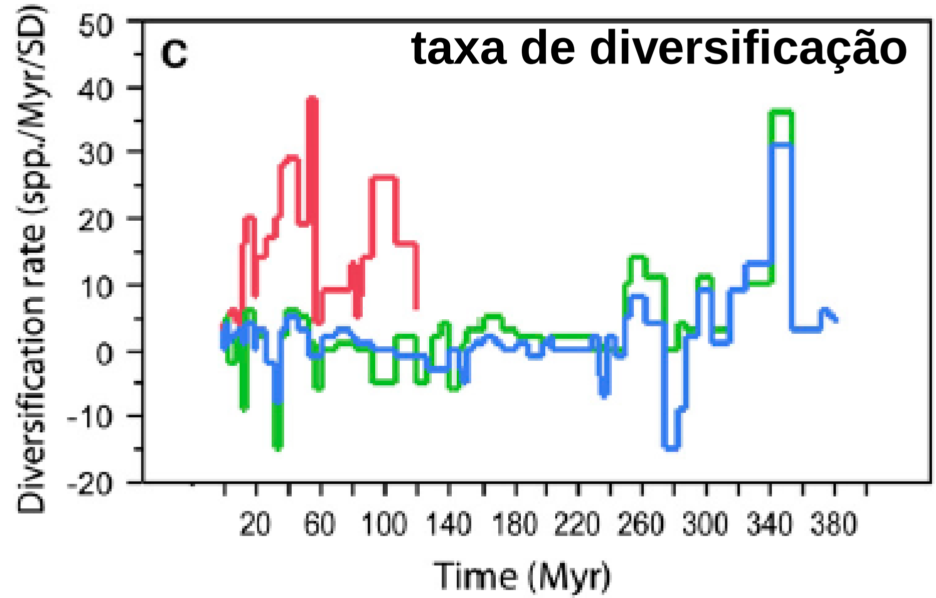
taxa de especiação ↑

taxa de extinção ↓

Maddison 1996







Crepet & Niklas 2009

Fig. 2. Rates of (A) origination, (B) extinction, and (C) diversification for angiosperms, gymnosperms, and pteridophytes plotted against time. SD = standing species diversity. Data from Niklas et al. (1980, 1983) and Niklas (1997).

Diversidade relativa dos grandes grupos de traqueófitas ao longo do tempo geológico

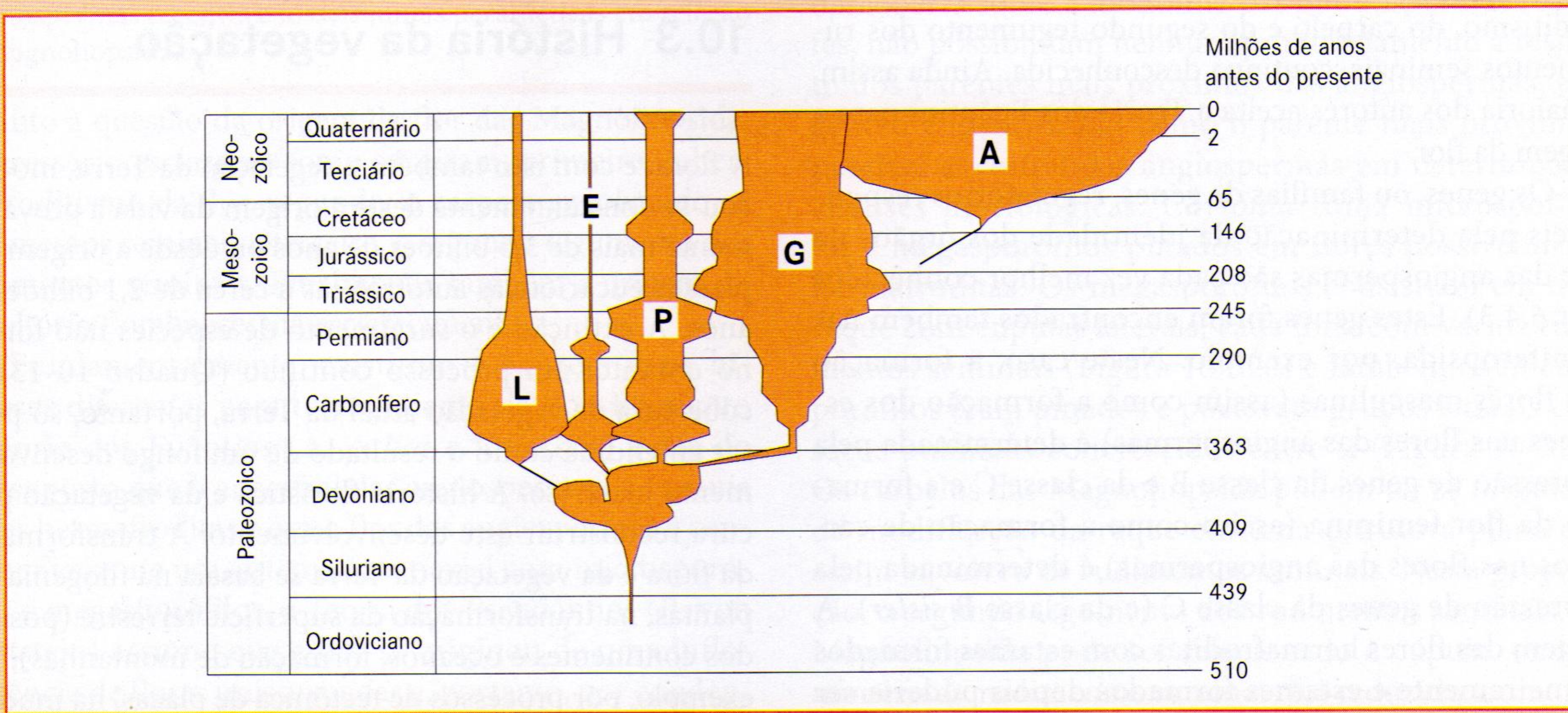
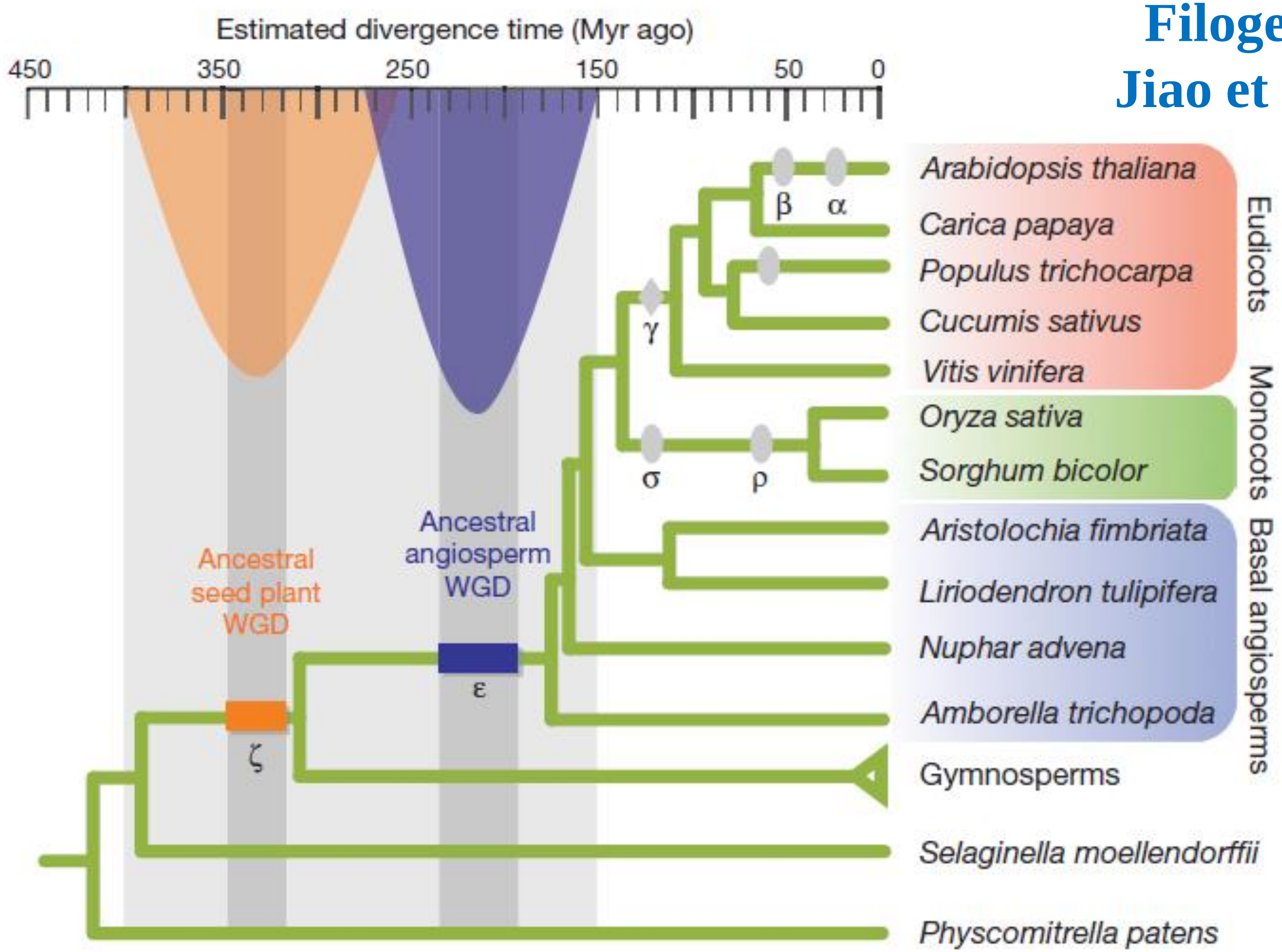


Figura Diversidade relativa de espécies dos principais grupos de plantas terrestres desde o início do Ordoviciano. **A** Angiospermas, **E** Equisetophytina, **G** Gimnospermas, **L** Lycopodiophytina, **P** Marattiophytina e Filicophytina. (Segundo Niklas, 1997.)

Bresinsky *et al.* 2012

Filogenômica
Jiao et al. 2011



12.6 milhões de sequências de linhagens-pivôs: 2 grupos de WGDs (whole-genome duplication) antigos: 319 m.a. e 192 m.a. (poliploidização seguida de perda de genes e diploidização)

Figure 3 | Ancestral polyploidy events in seed plants and angiosperms. Two ancestral duplications identified by integration of phylogenomic evidence and molecular time clock for land plant evolution. Ovals indicate the generally accepted genome duplications identified in sequenced genomes (see text). The diamond refers to the triplication event probably shared by all core eudicots. Horizontal bars denote confidence regions for ancestral seed plant WGD and ancestral angiosperm WGD, and are drawn to reflect upper and lower bounds of mean estimates from Fig. 2 (more orthogroups) and Supplementary Fig. 5 (more taxa). The photographs provide examples of the reproductive diversity of

Irradiação das angiospermas após evolução de maior capacidade fotossintética

Crisp & Cook 2012

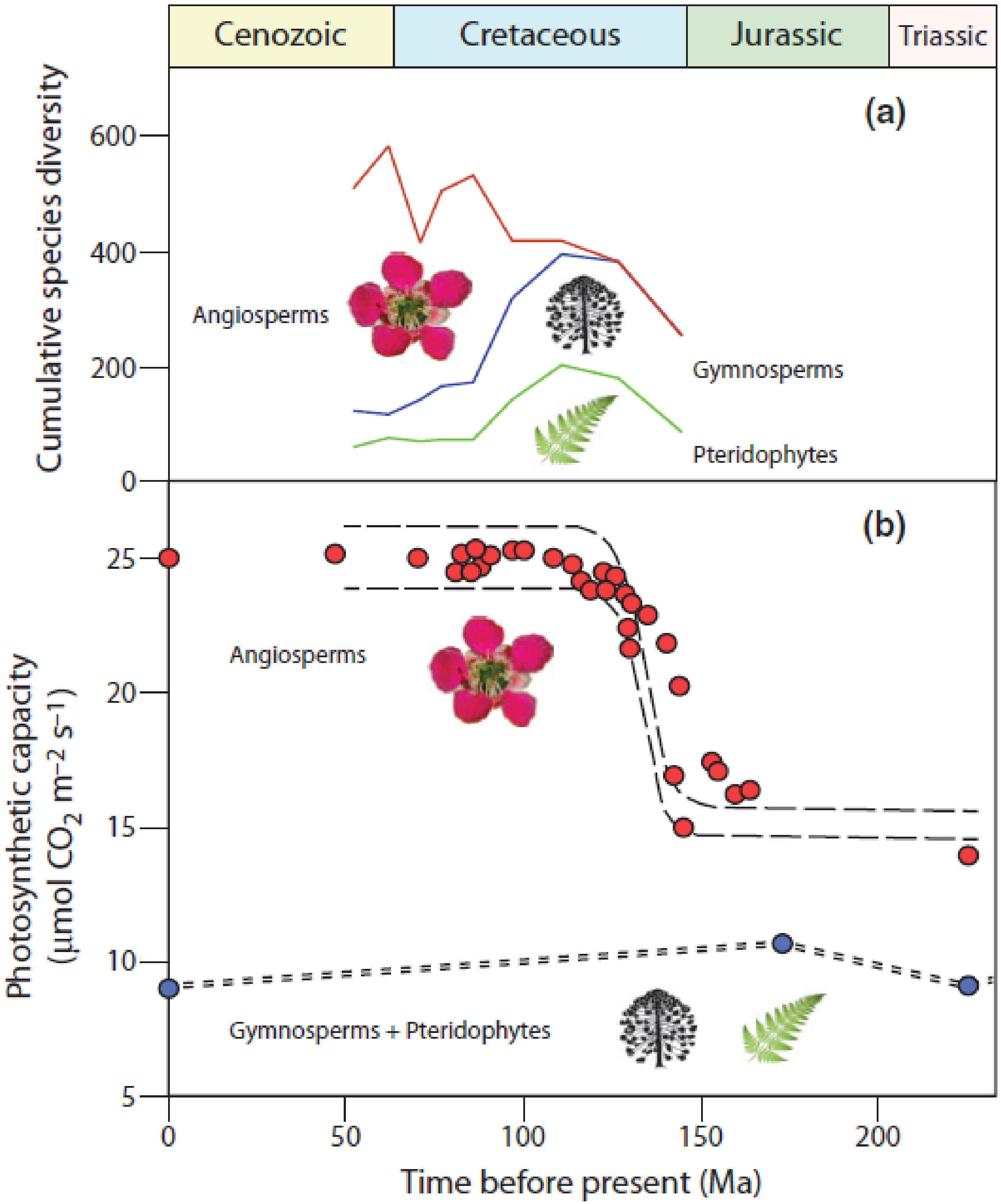
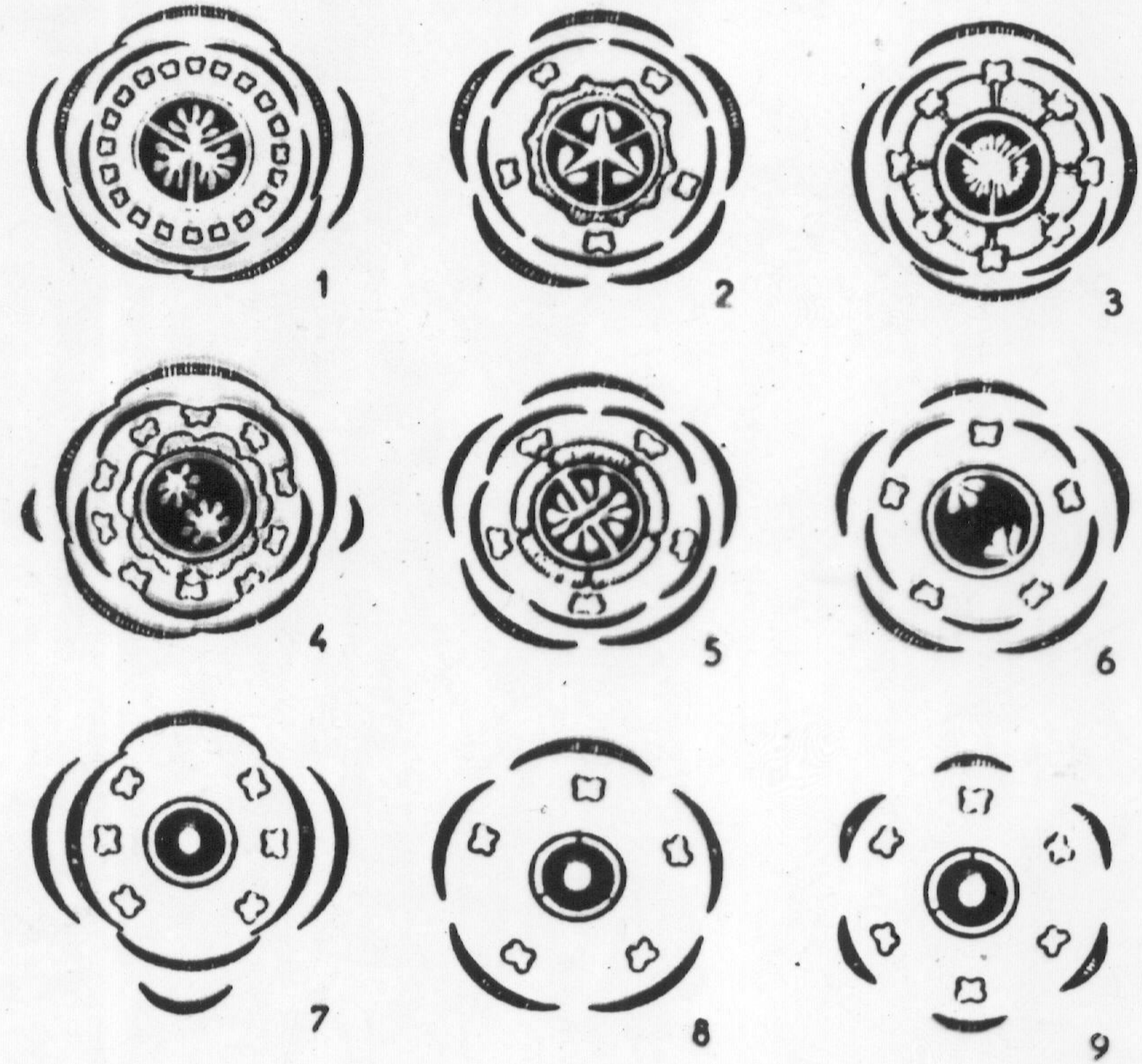


Fig. 5 The dramatic mid-Cretaceous radiation of angiosperms followed release from conserved slow photosynthesis rates, which remained conserved in other vascular plants until the present. (a) Trend through the Cretaceous in species diversity of angiosperms, gymnosperms and pteridophytes (free-sporing plants) using data from Friis *et al.* (2011). (b) An abrupt surge in maximum angiosperm photosynthesis capacity (P_c) is evident in the mid Cretaceous, rising from levels close to the non-angiosperm maximum, to levels far beyond those of other clades. Relatively high P_c in angiosperms is thought to have contributed significantly to their success over competing clades. Plots of reconstructed leaf P_c in C_3 angiosperms (red dots, long-dash lines) and non-angiosperm vascular plants (blue dots, short-dash line) are redrawn from Brodribb and Feild (2010, fig. 3). Photosynthetic capacities are reconstructed values from leaf vein density and a coupled hydraulic photosynthetic model (for details, see Brodribb & Feild, 2010).

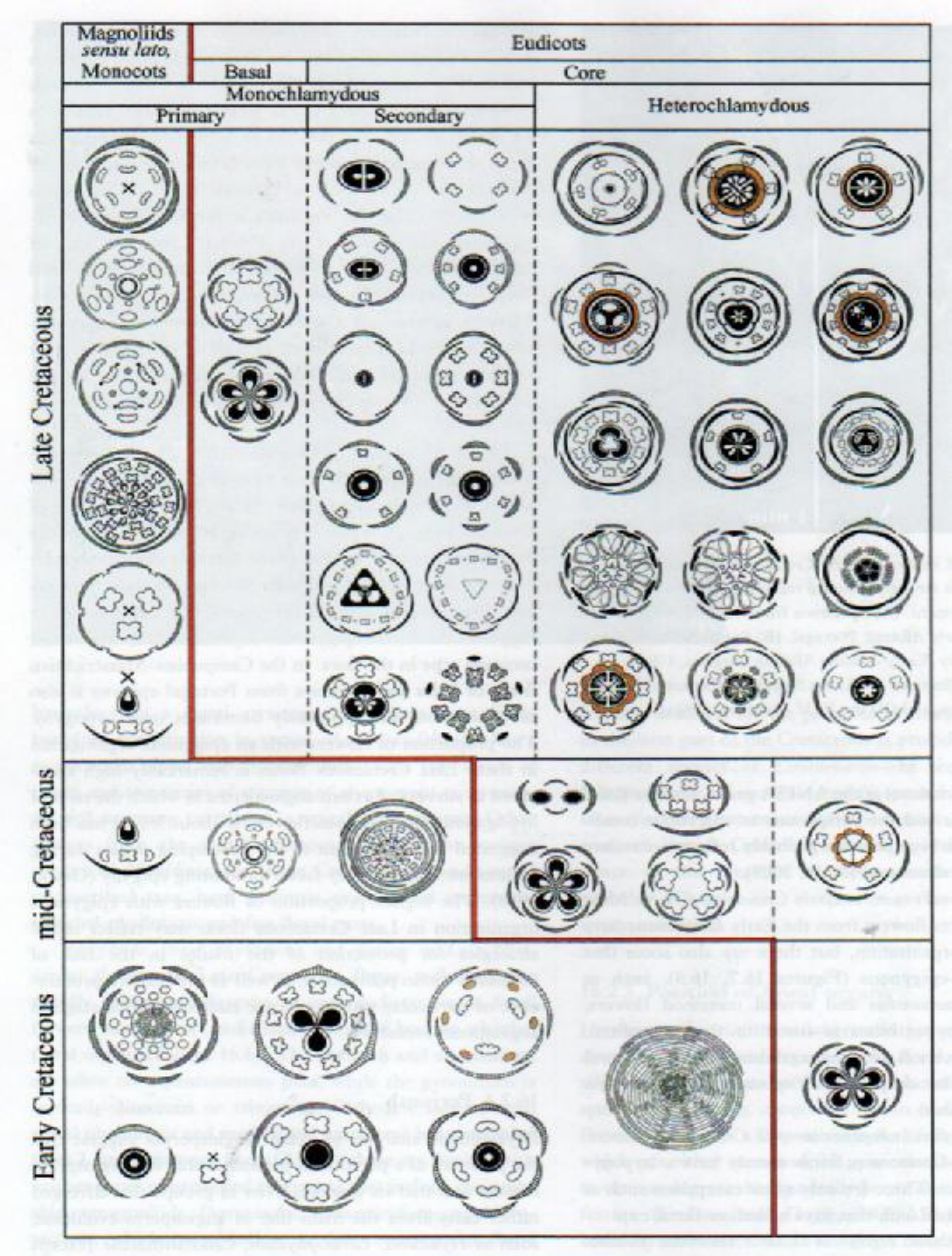
Diagramas florais - Cretáceo superior (80 m.a.)



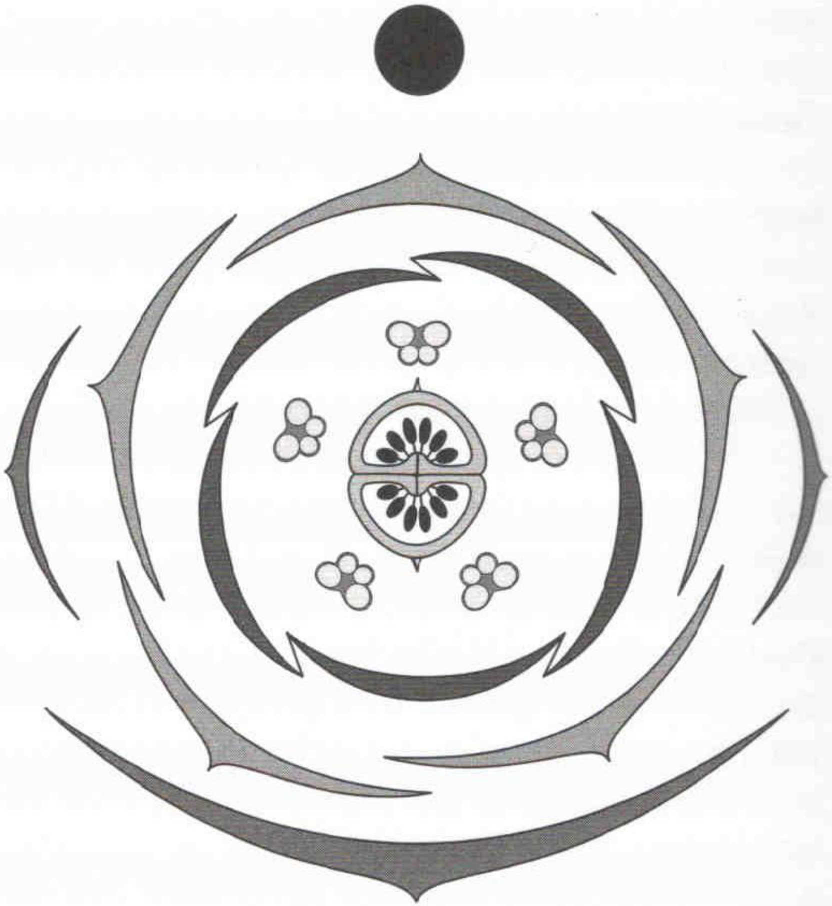
FIGURES 1–9. Floral diagrams of the basic floral types found among the Upper Cretaceous fossils from Åsen, Sweden.—1–2. Heterochlamydous, hypogynous flowers.—3–6. Heterochlamydous, epigynous flowers.—7–9. Monochlamydous, epigynous flowers.

Dilcher & Crane 1988

Diagramas florais - do Cretáceo Inferior (130 m.a.) ao Superior (70 m.a.)



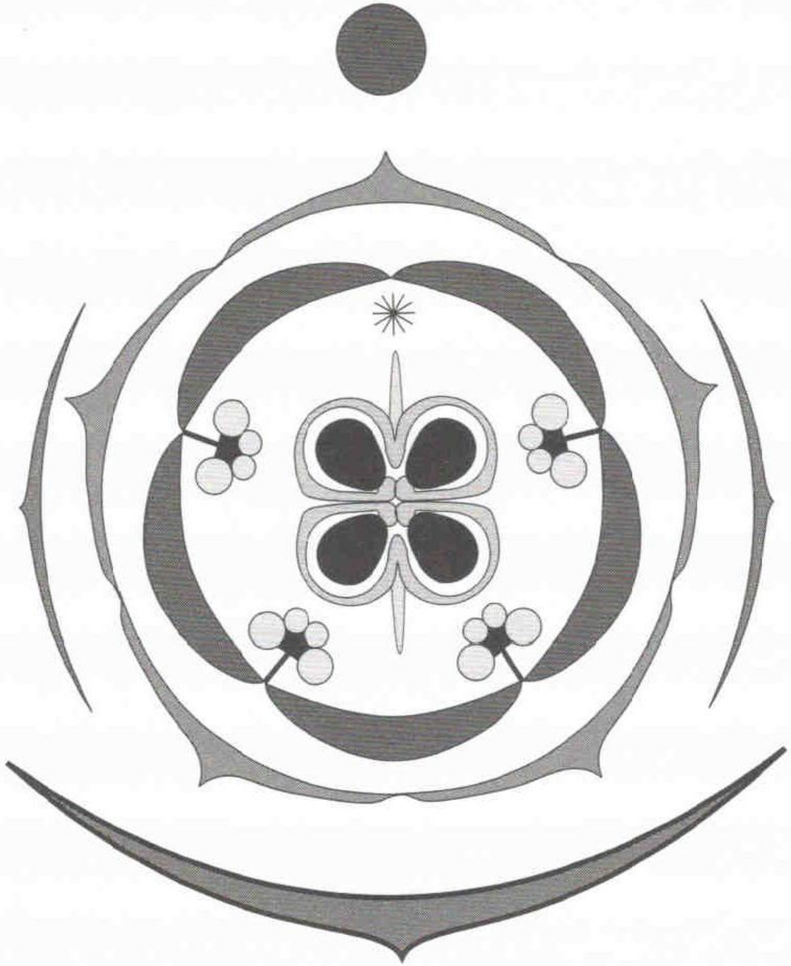
Friis et al. 2011



Scrophulariaceae (*Verbascum*)

✳ K5 C(5) A5 G(2)

Abb. 37: Blütendiagramm der Scrophulariaceae.



Lamiaceae (*Lamium*)

↓K(5) [C(5) A4] G(2)

Abb. 40: Blütendiagramm der Lamiaceae (*Lamium*).

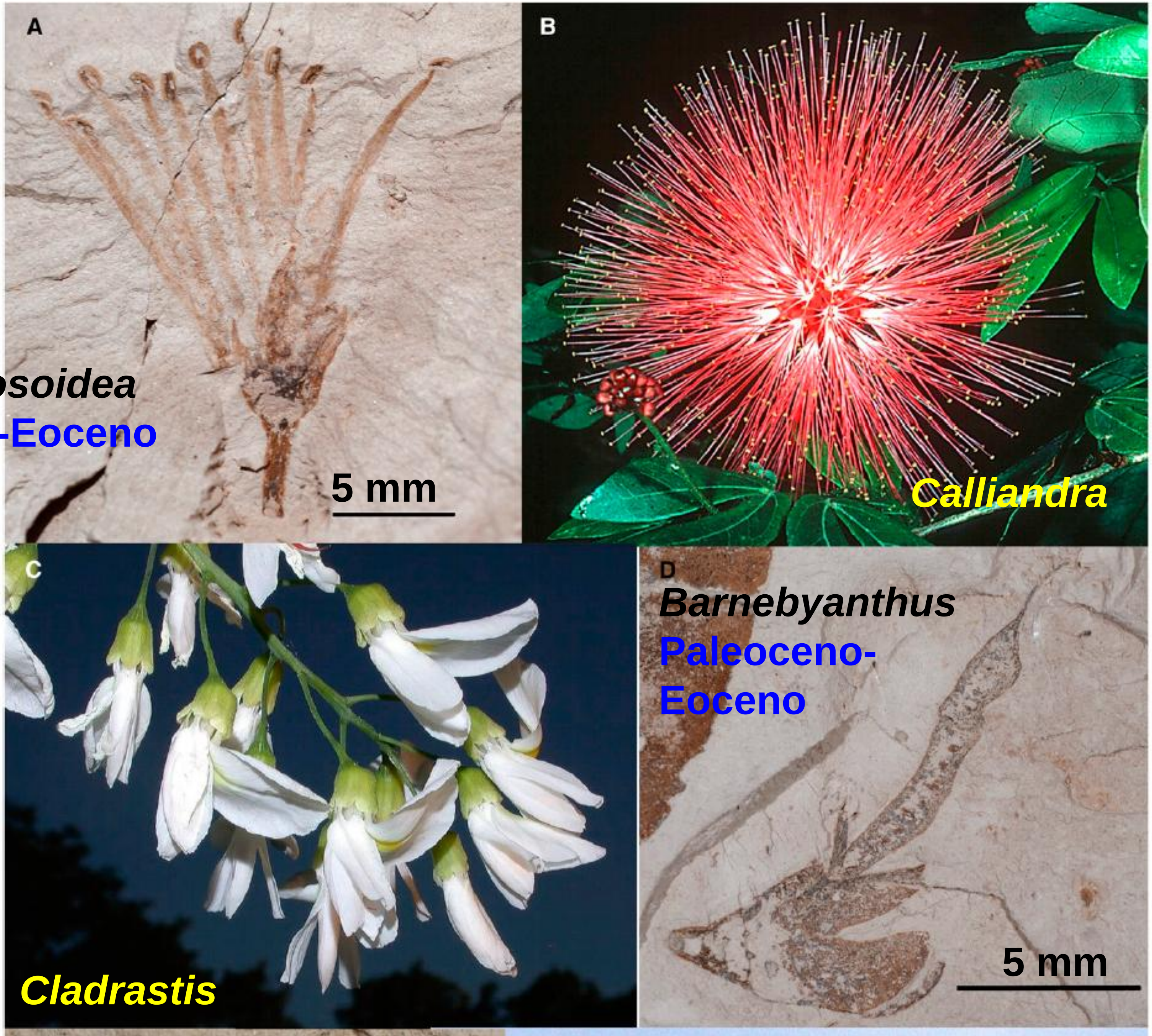
Diagrama e fórmula floral

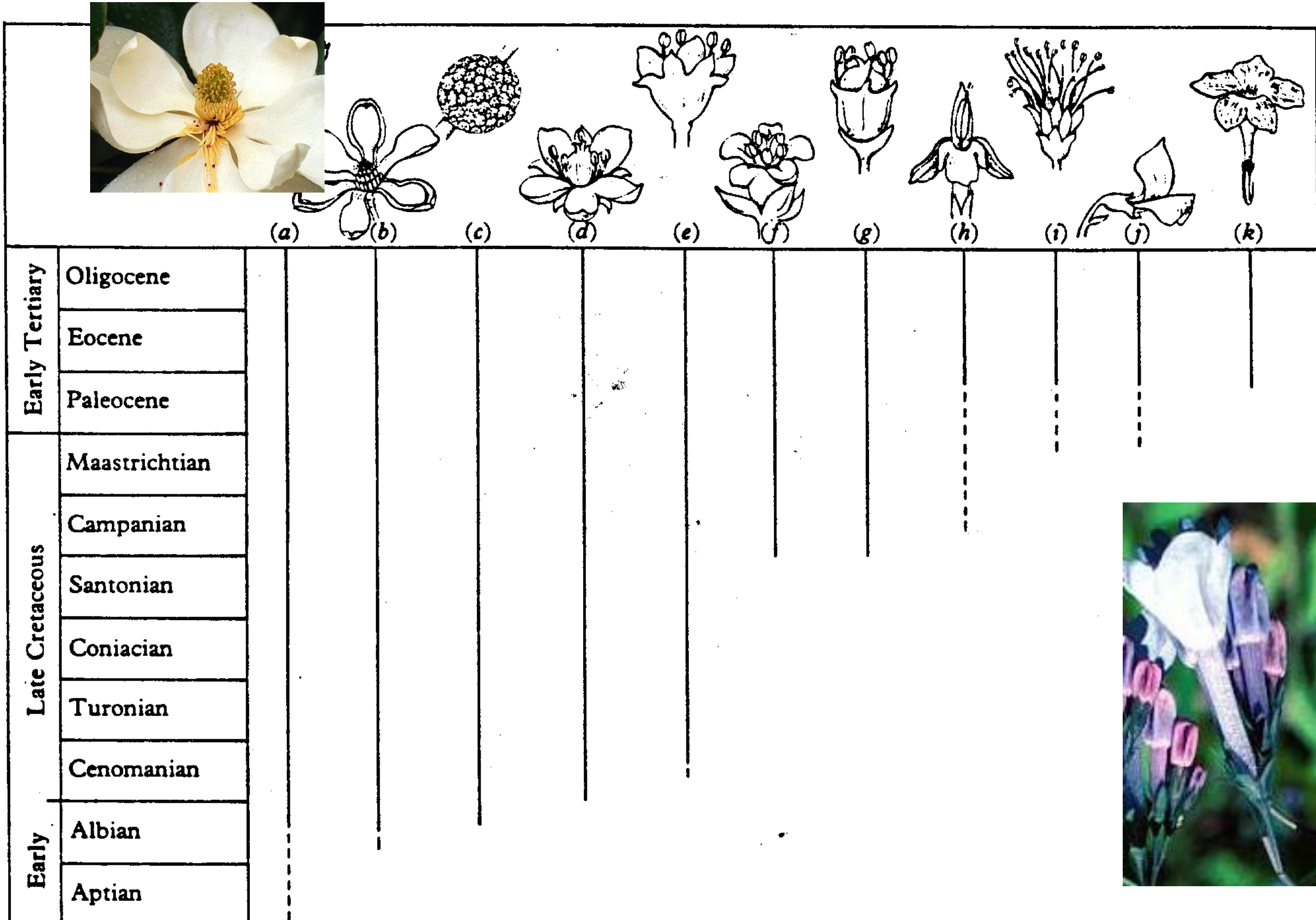
Stützel 2006

Crepet & Niklas 2009

Protomimosoidea

Paleoceno-Eoceno

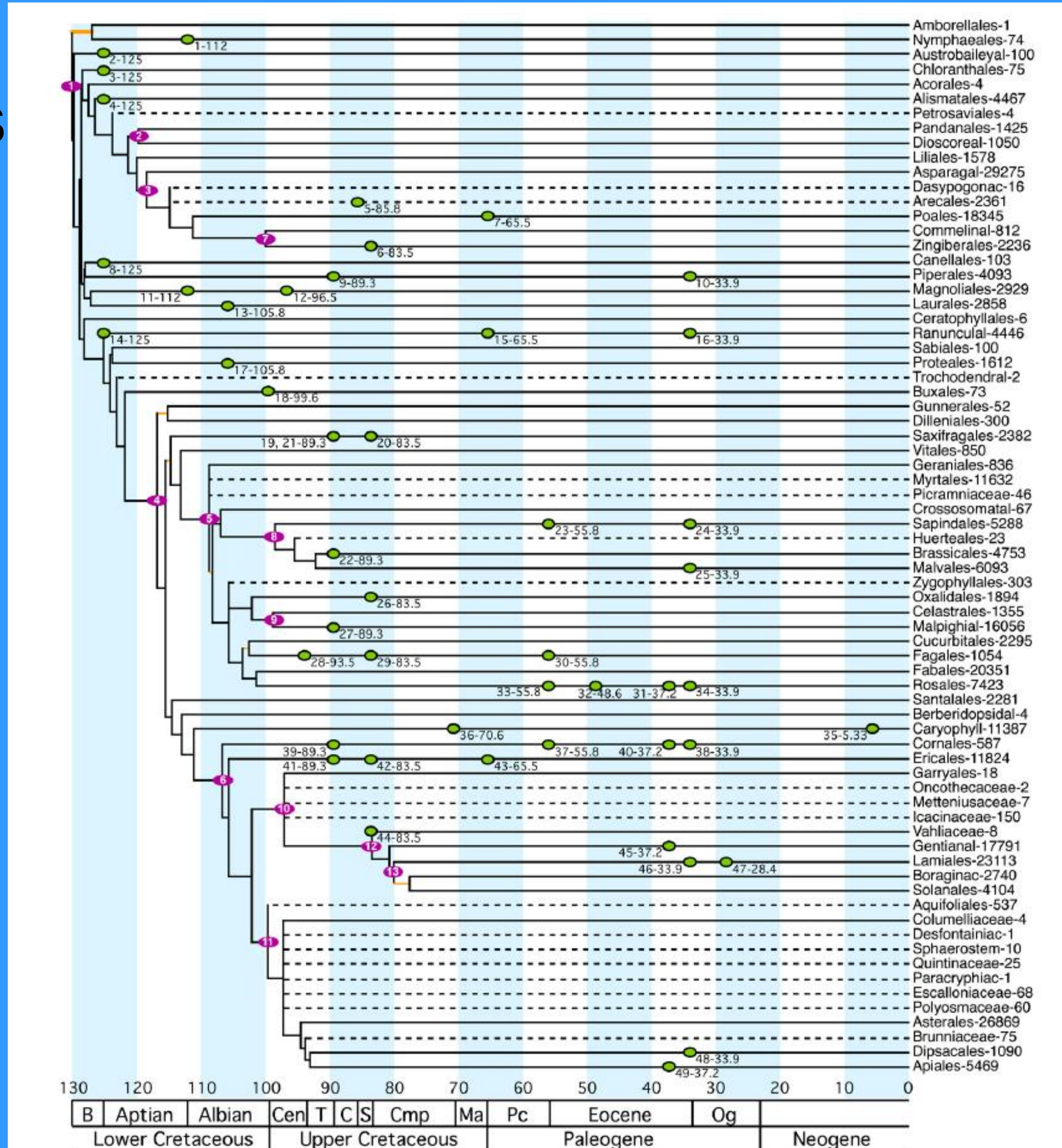




Friis & Endress 1990

ANGIOSPERMAS

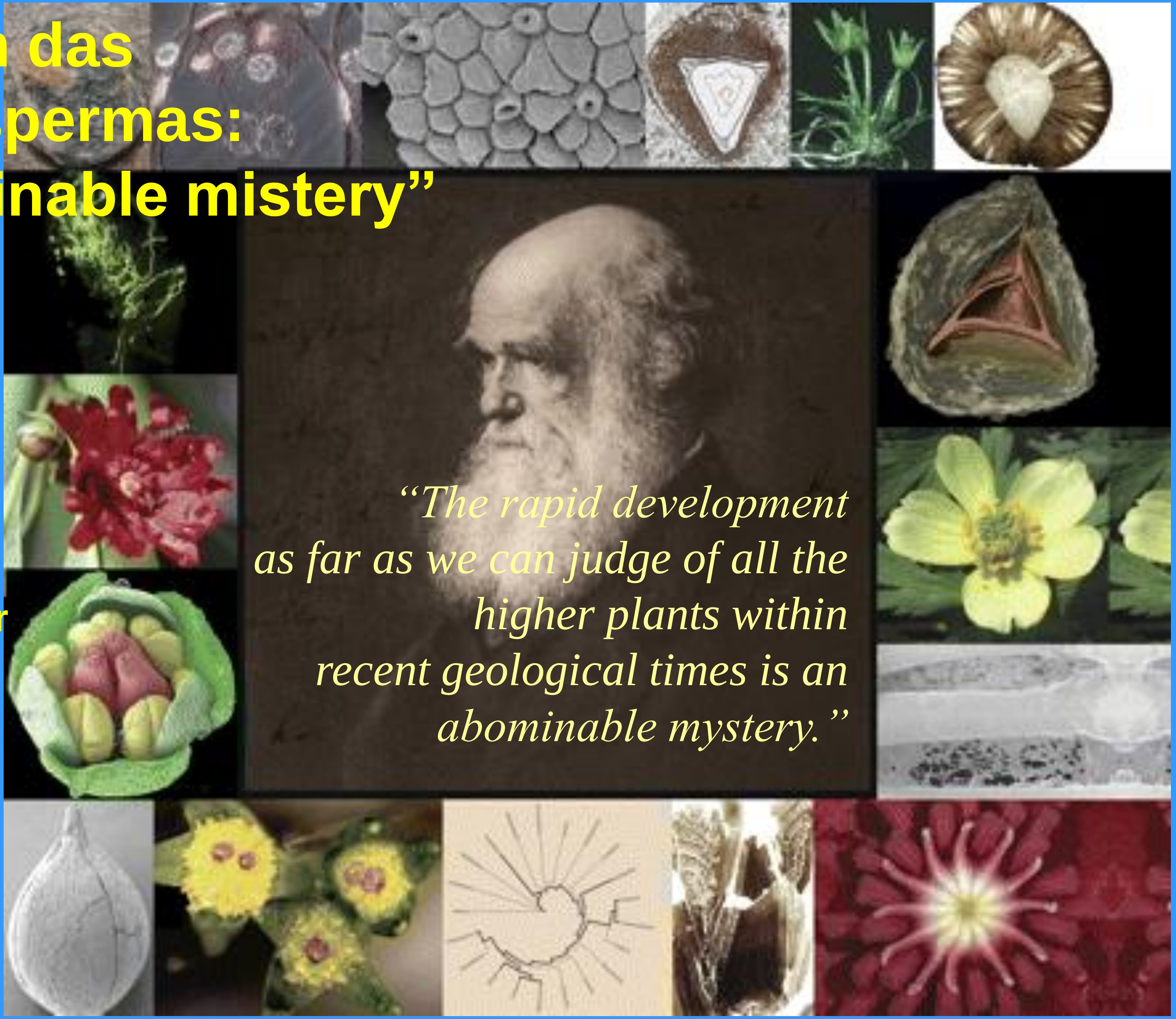
Árvore filogenética das ordens **com datação molecular de clados**



Magallón & Castillo 2009

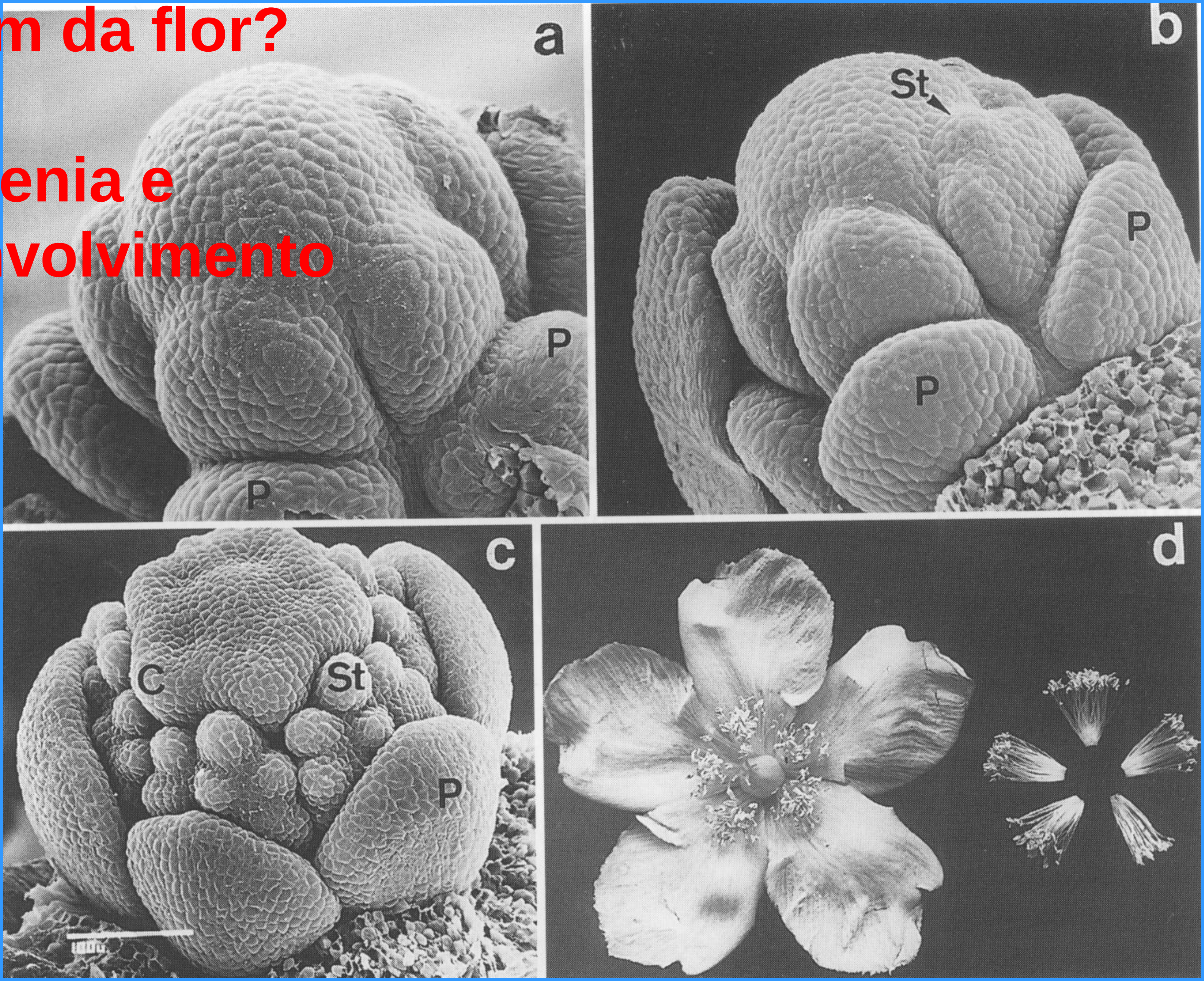
Origem das Angiospermas: “abominable mistery”

C. Darwin em carta para J.D. Hooker 1879



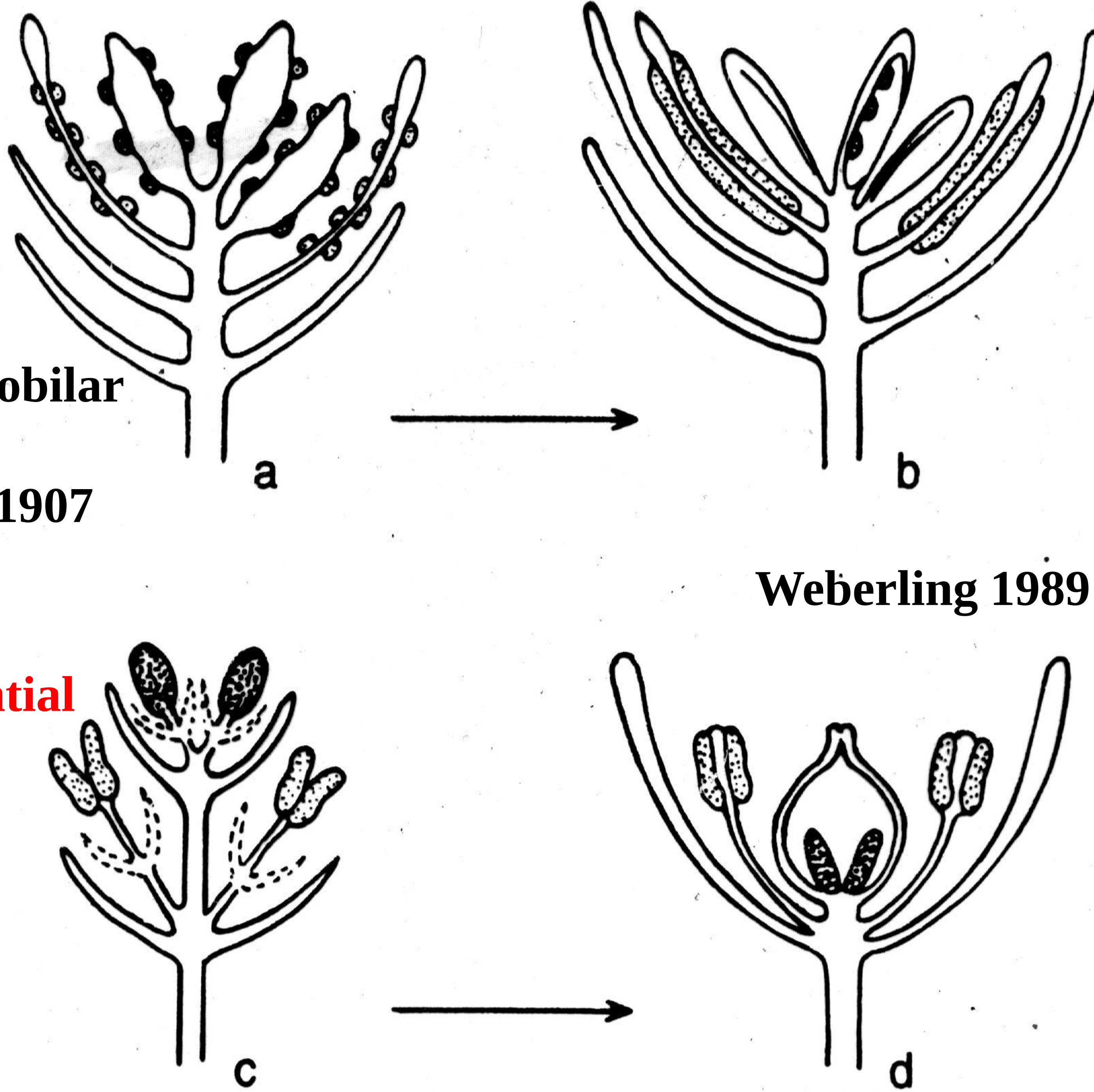
Origem da flor?

ontogenia e desenvolvimento floral



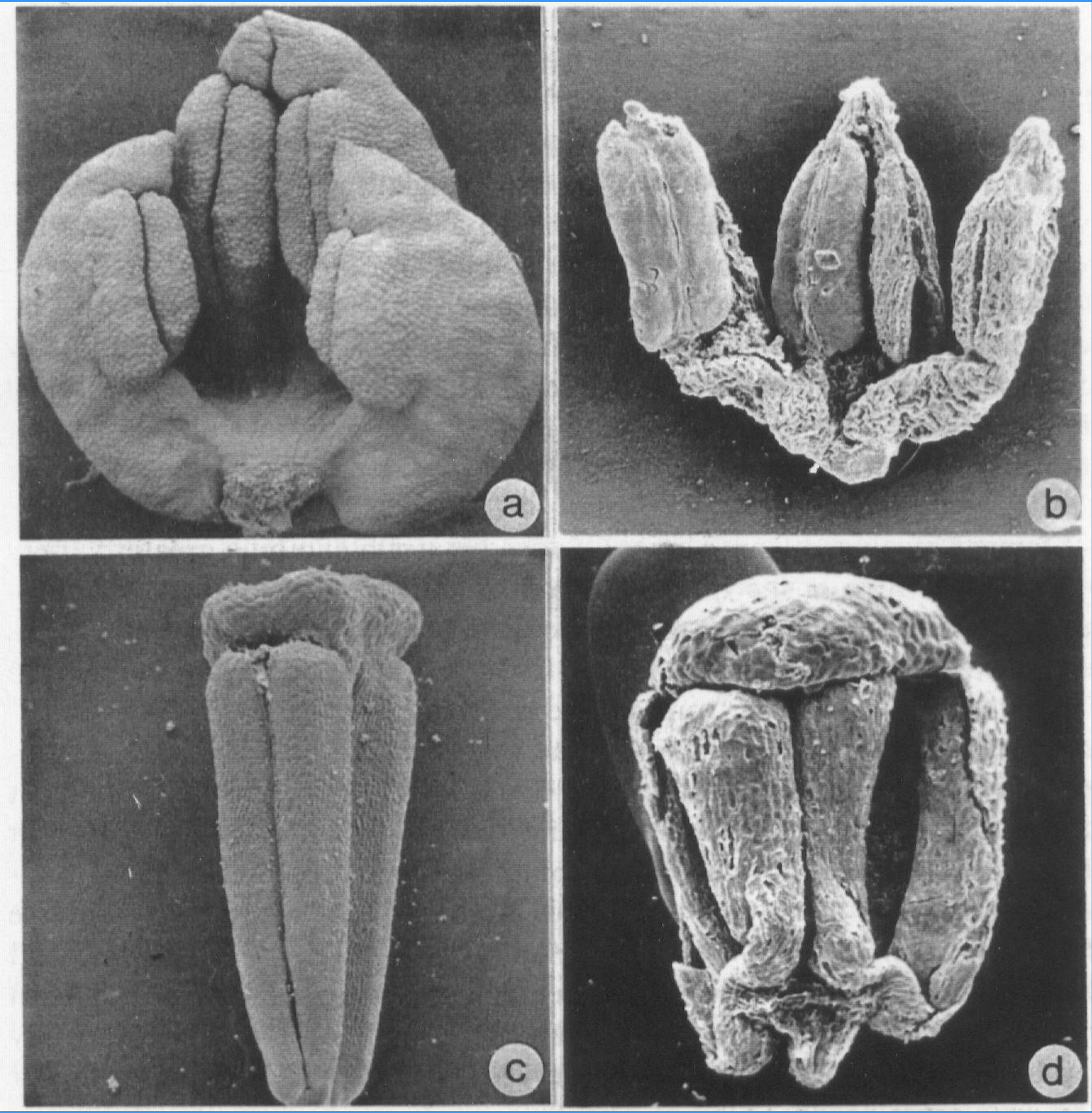
Hypericum hookerianum, Guttiferae Leins 2000

Hipótese Antostrobilar
ou Euantial
Arber & Parkin 1907



Weberling 1989

Hipótese Pseudantial
Wettstein 1907

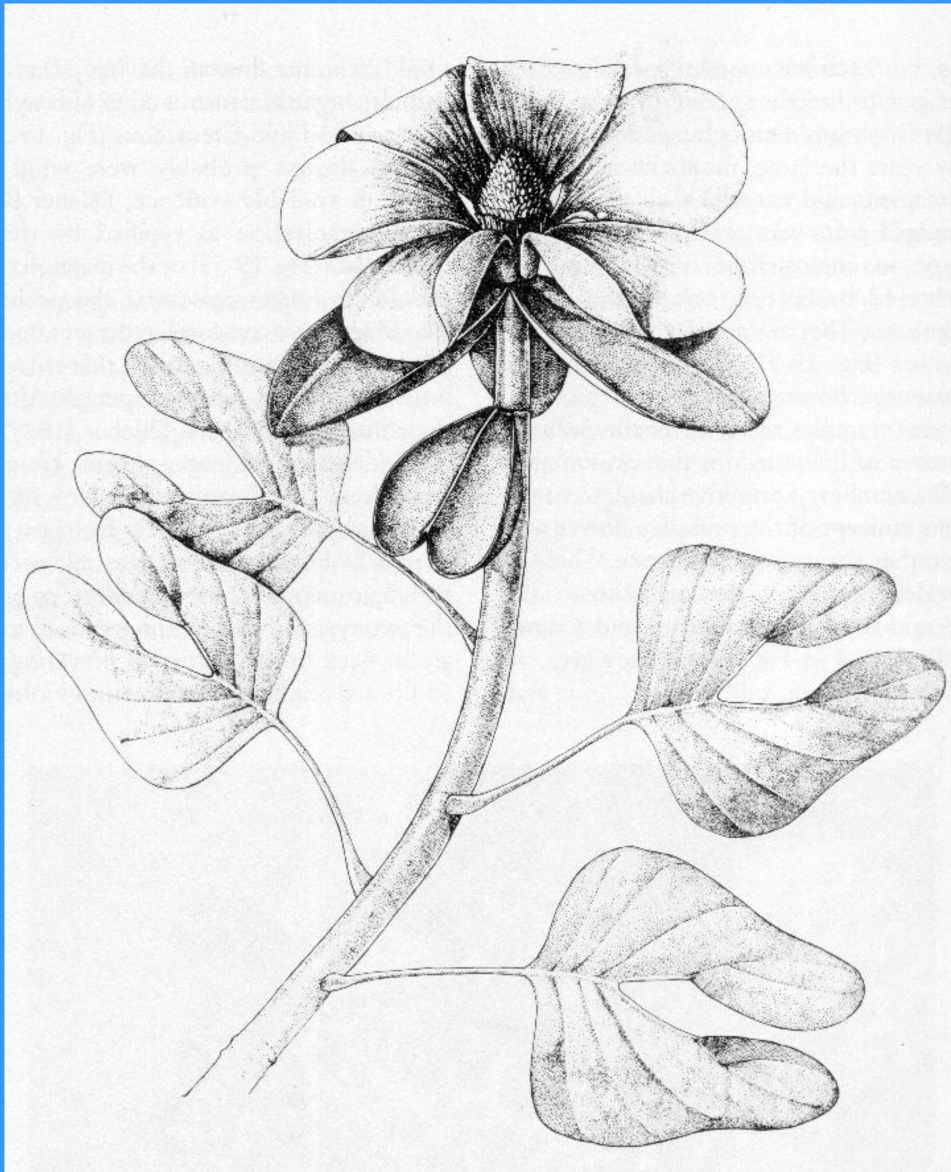


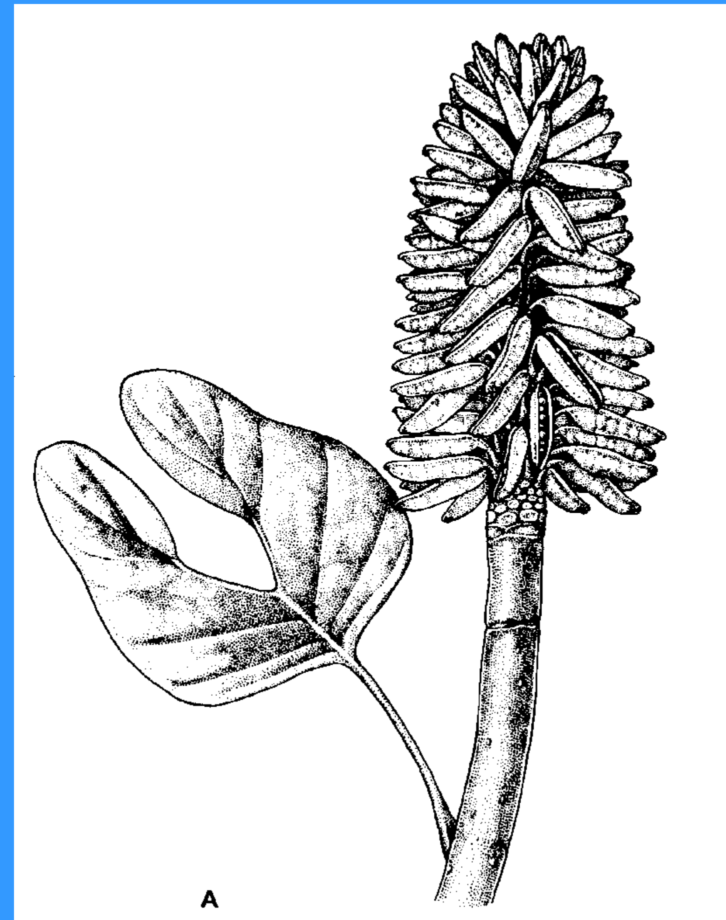
Chloranthaceae

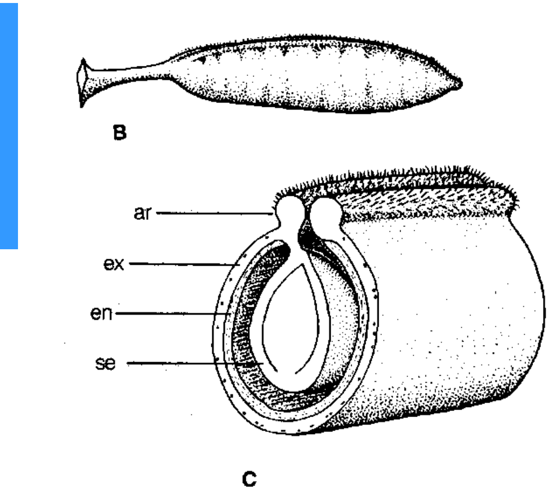
Platanaceae

Viventes

Cretáceo



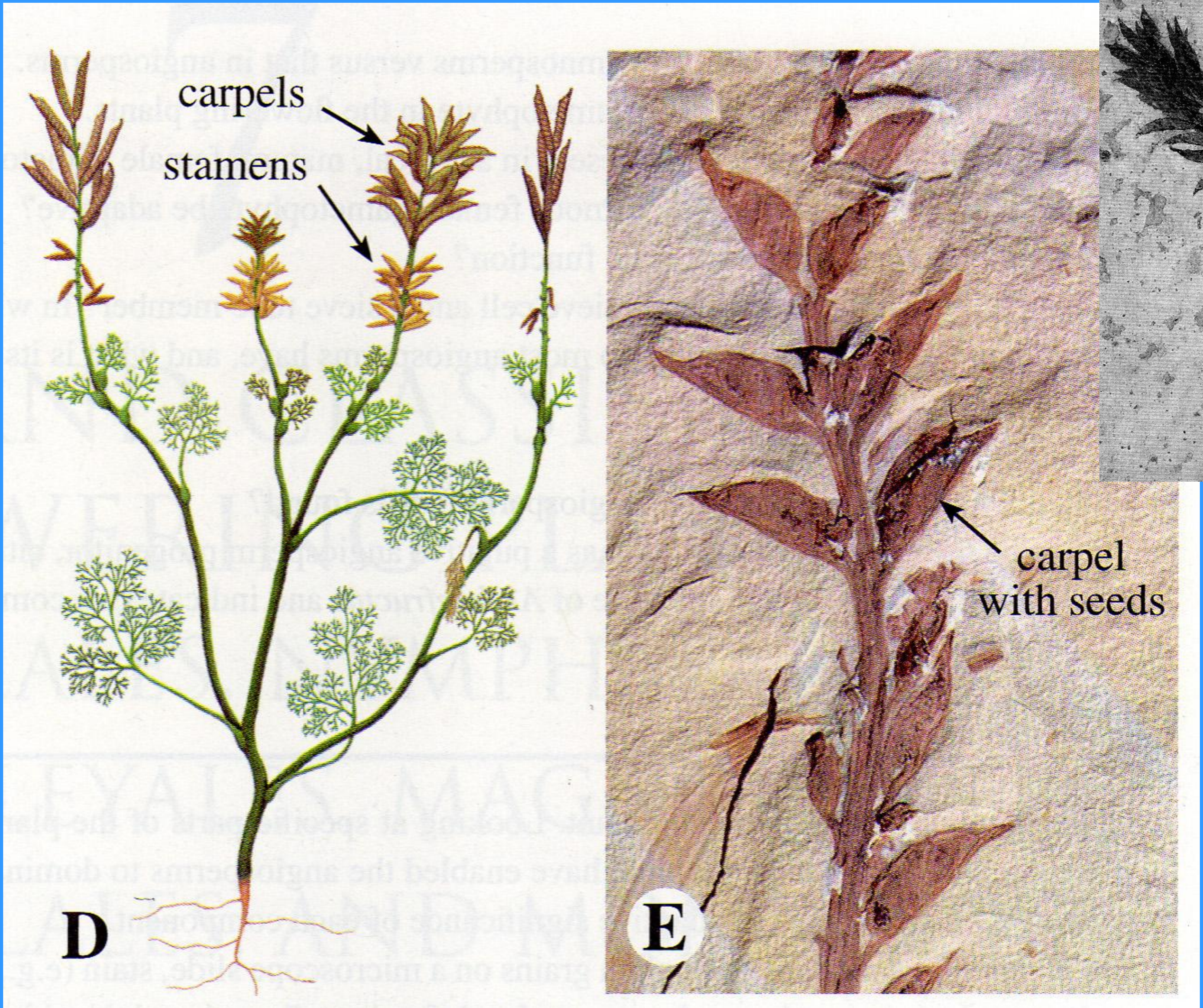




Archaeanthus linnenbergeri

Dilcher & Crane 1985

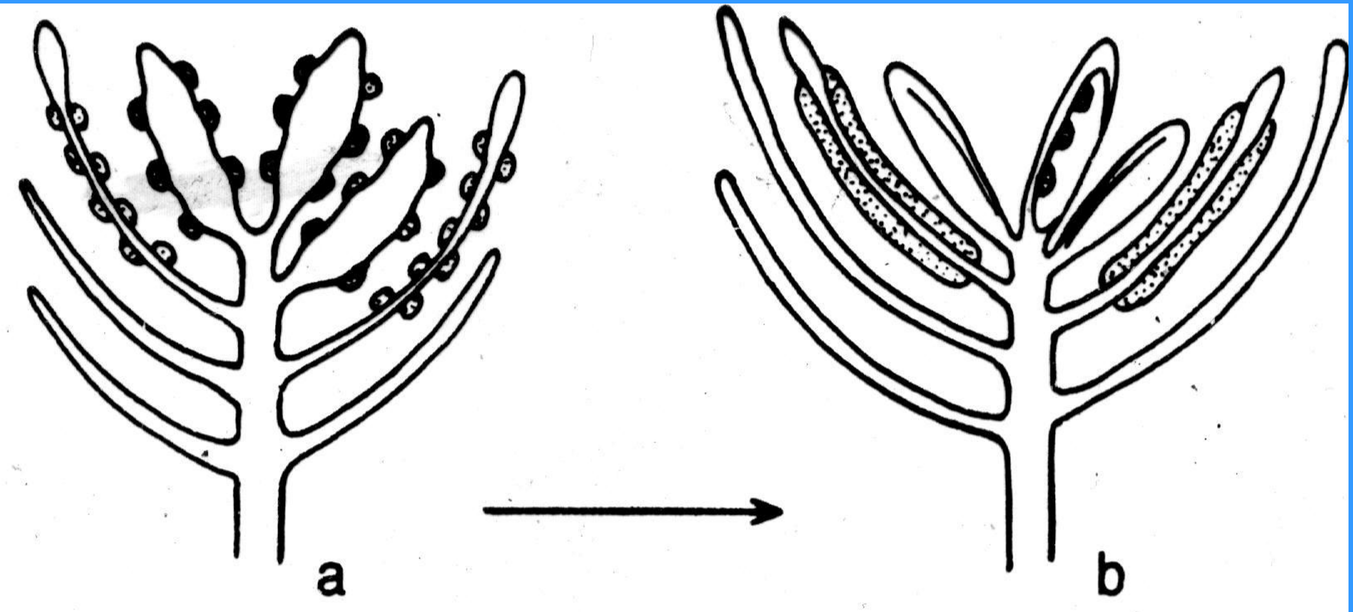
Cretáceo médio



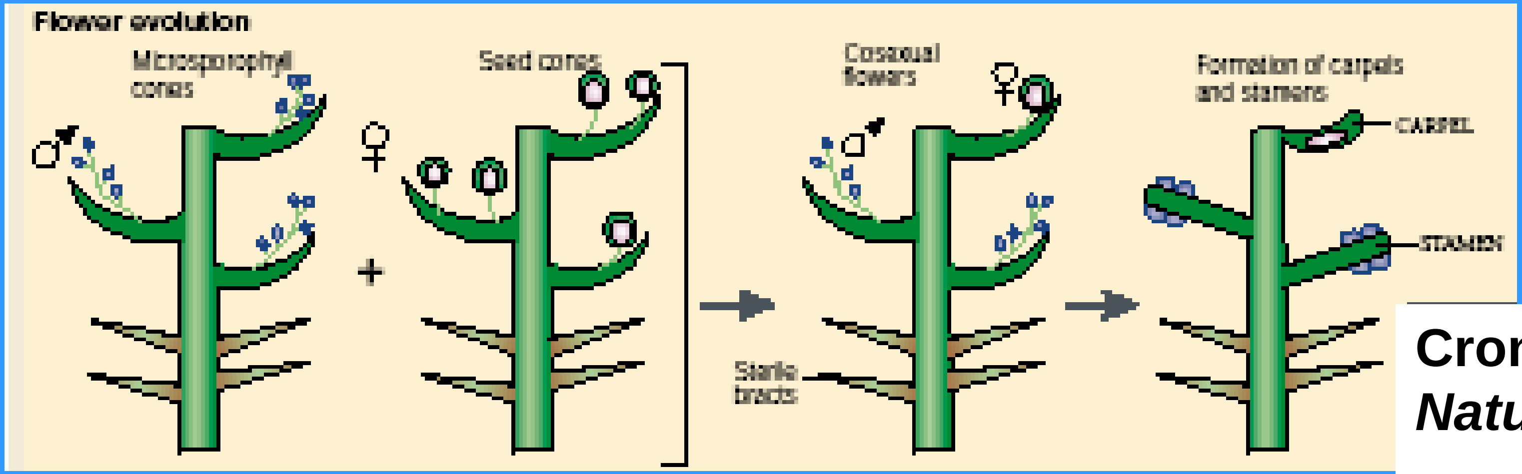
Archaefructus sinensis **130 m.a.** **Simpson 2006**

Origem da flor:

Hipóteses ?

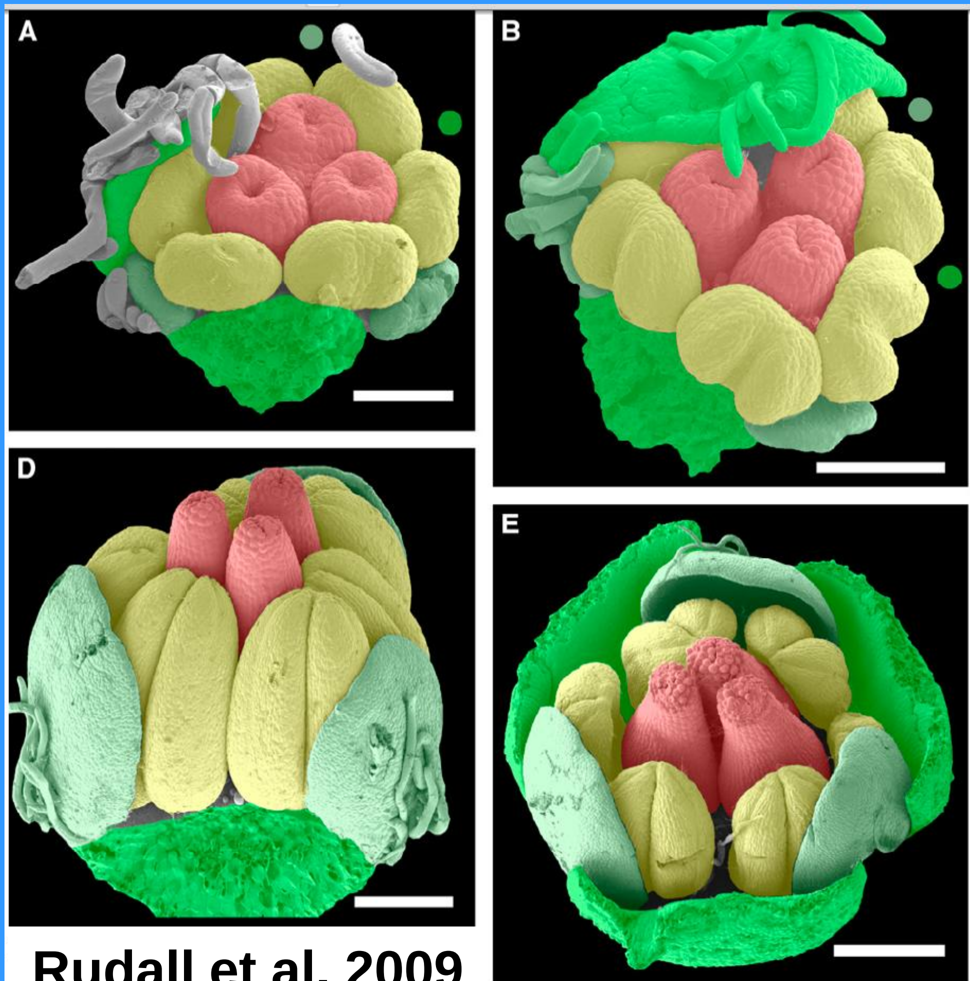


Weberling 1989



Cronk 2001
Nature

Origem da flor?



Rudall et al. 2009

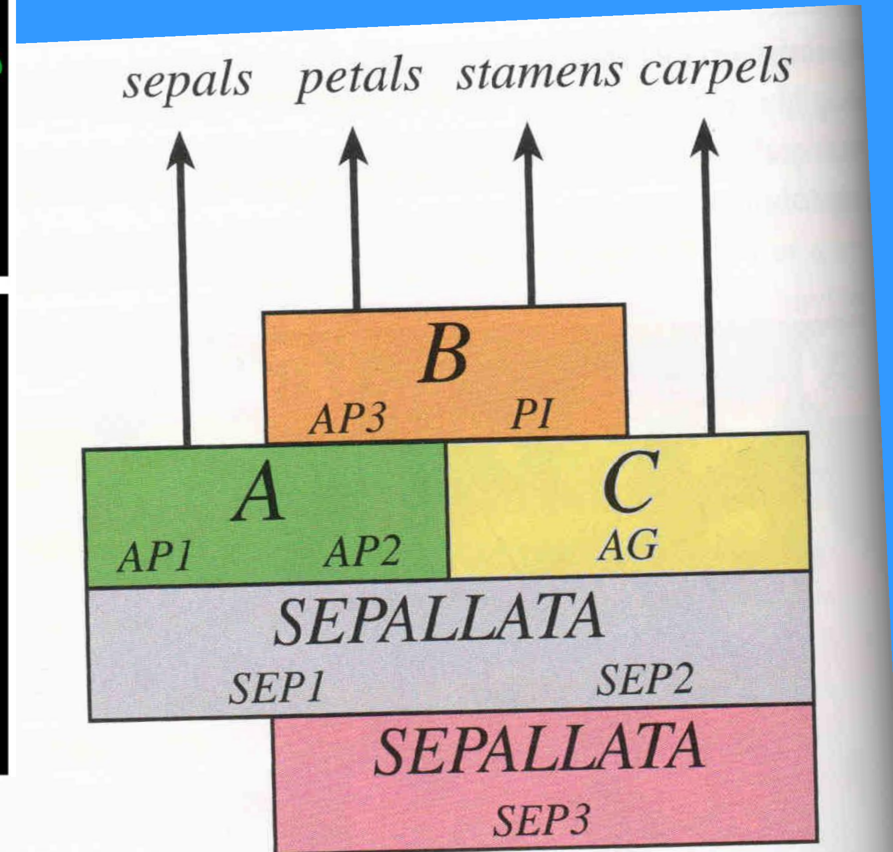


FIGURE 6.5 The "ABC" model of floral development. With[illegible] each gene class are specific genes (*AP1, AP2, AP3, AG, PI, SEP*[illegible] *SEP2, SEP3*), identified in mutant forms in *Arabidopsis thallia*[illegible] (Diagram after Jack, 2001.)

Simpson 2006

Evodevótica
Modelo ABC

Grandes grupos de Angiospermas

Engler – Syllabus: 1892 (1964 - ed. 12, póstuma)

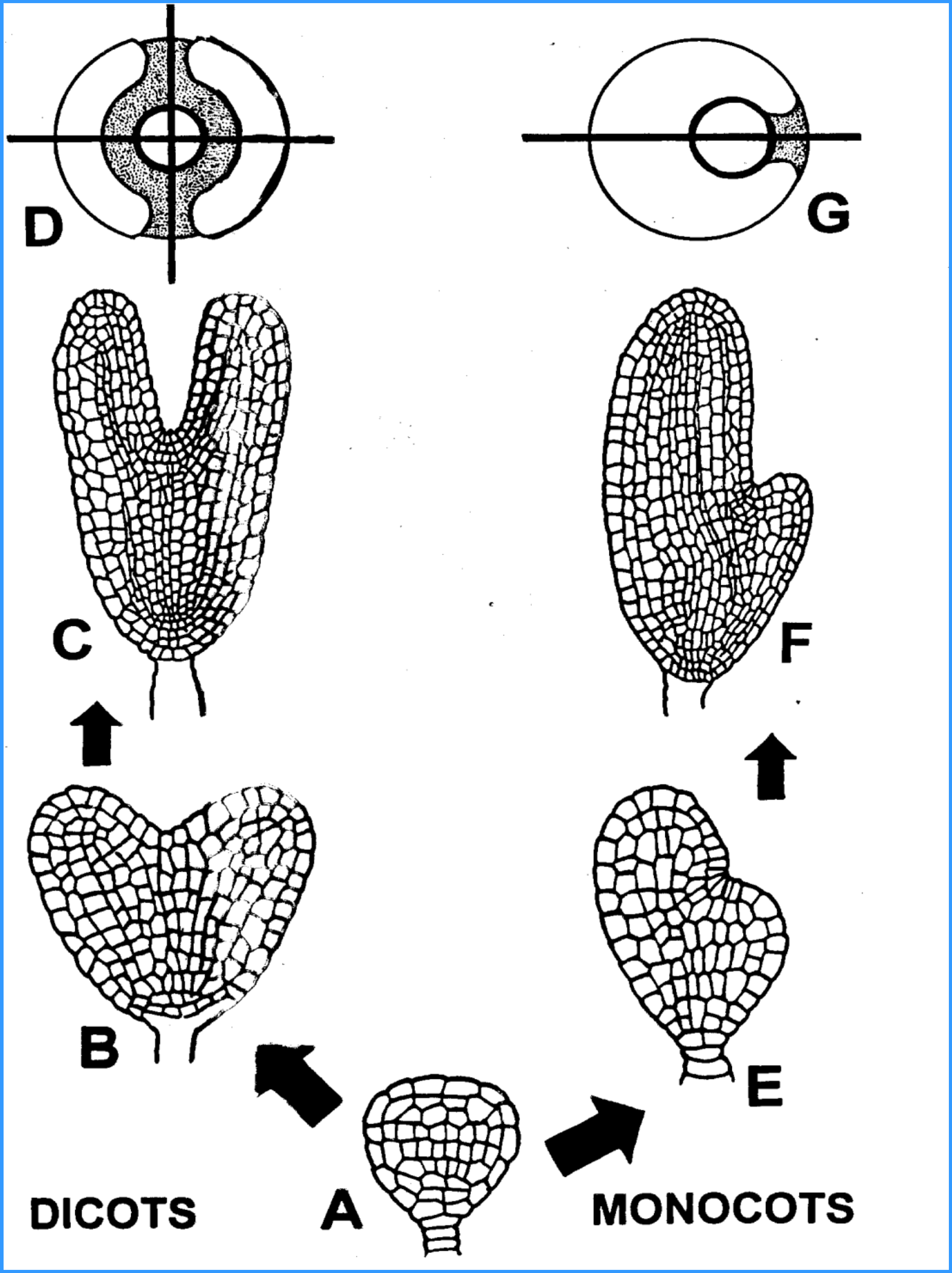
Divisão Angiospermae ou Anthophyta:

FIGURE 11.11 Adolf Engler (1844–1930), who, with his associate Karl Prantl, became famous for completing the only detailed classification of plants from algae to flowering plants.

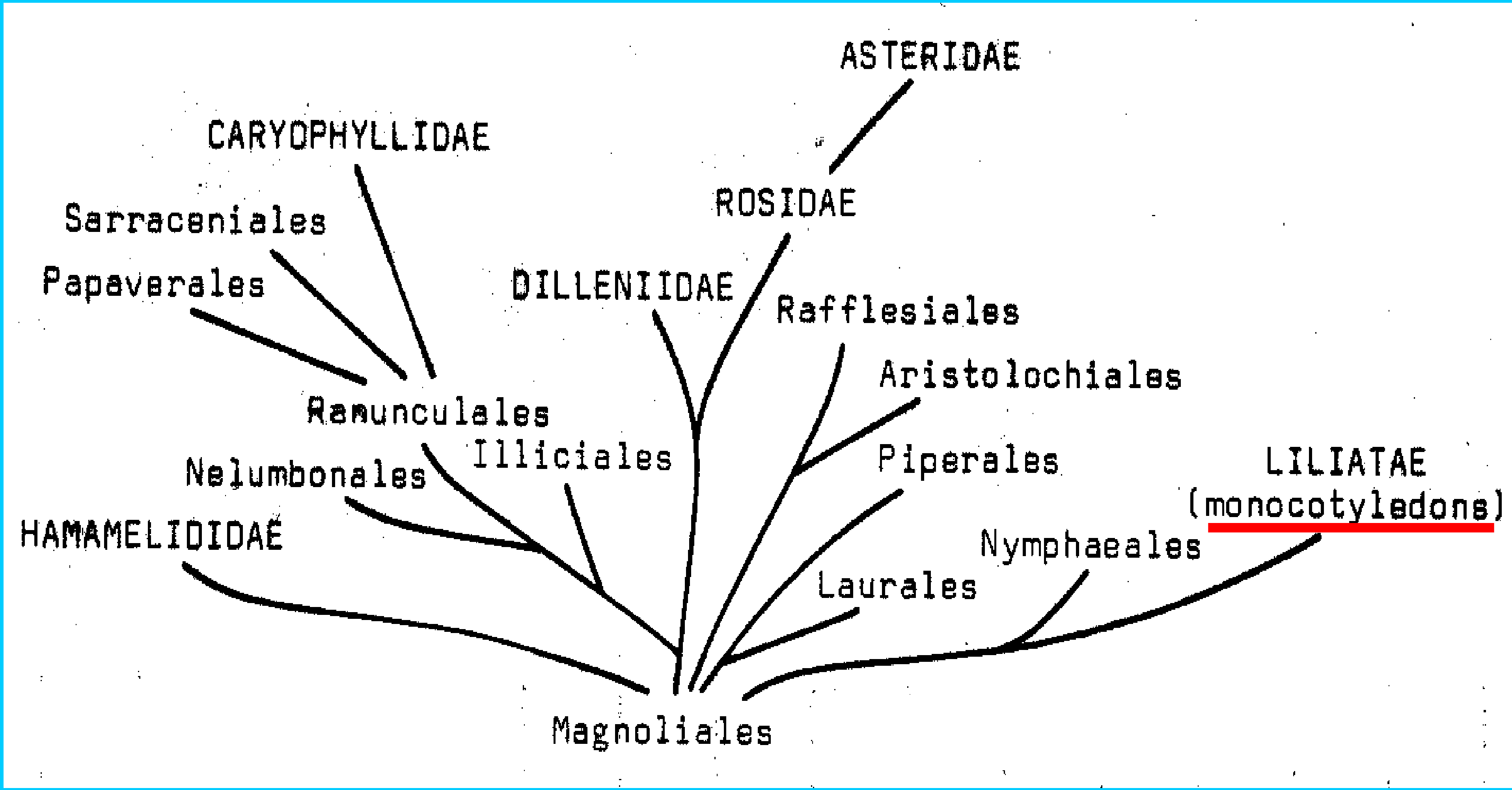
SOURCE: Photo courtesy of the Royal Botanic Gardens, Kew.

Classe Monocotyledoneae
Classe Dicotyledoneae

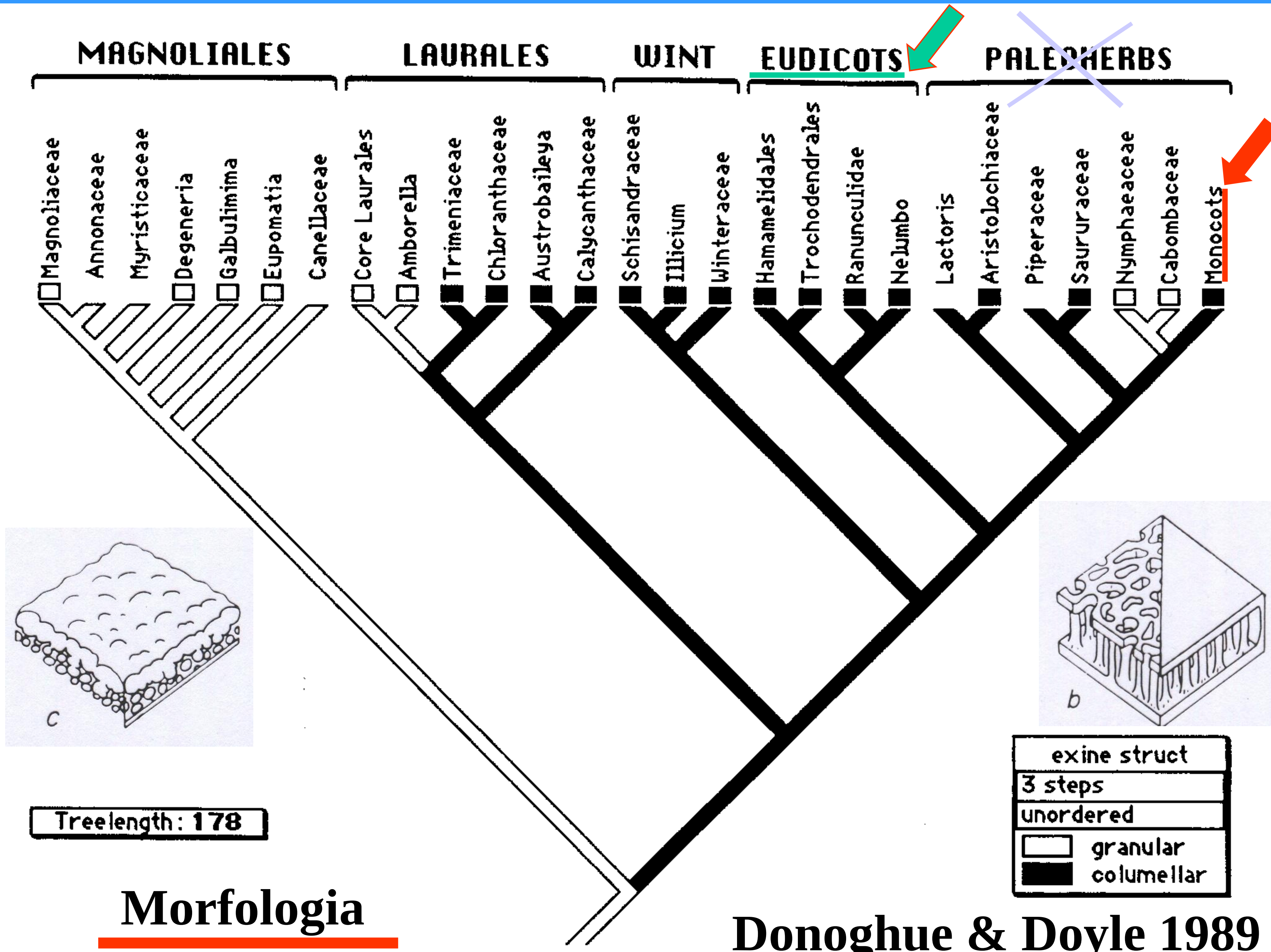
Embrião nas espermatófitas



Gifford & Foster 1988, Yamashita 1976

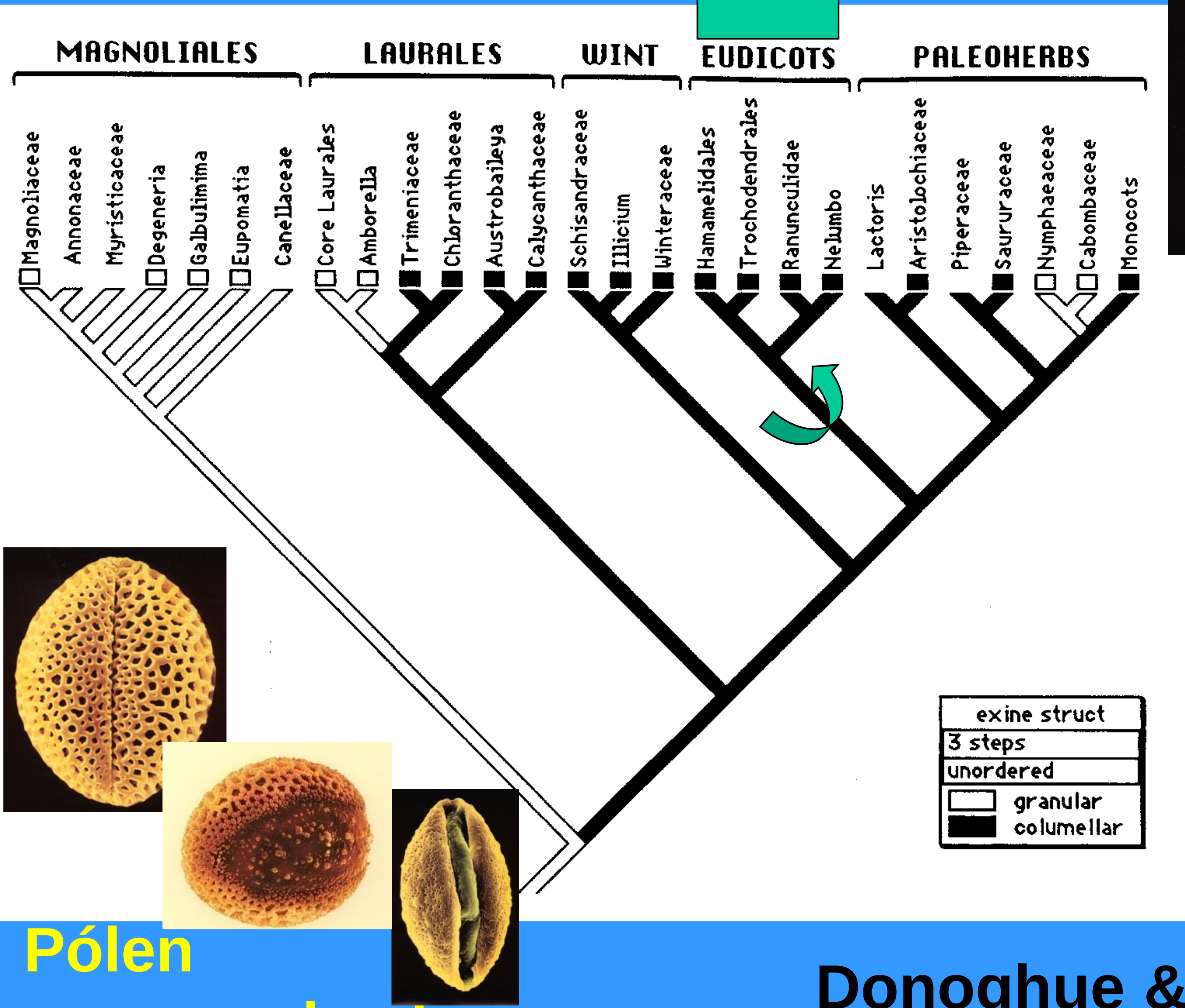


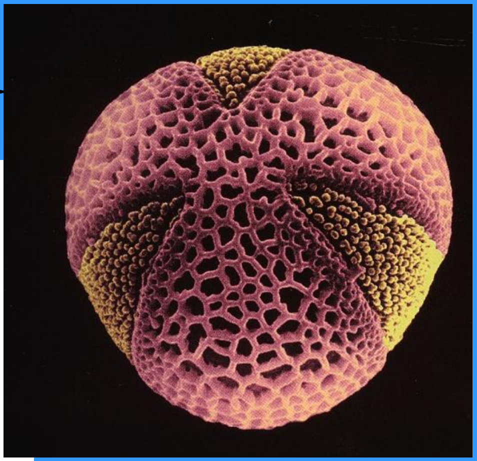
Takhtajan 1969



Morfologia

Donoghue & Doyle 1989

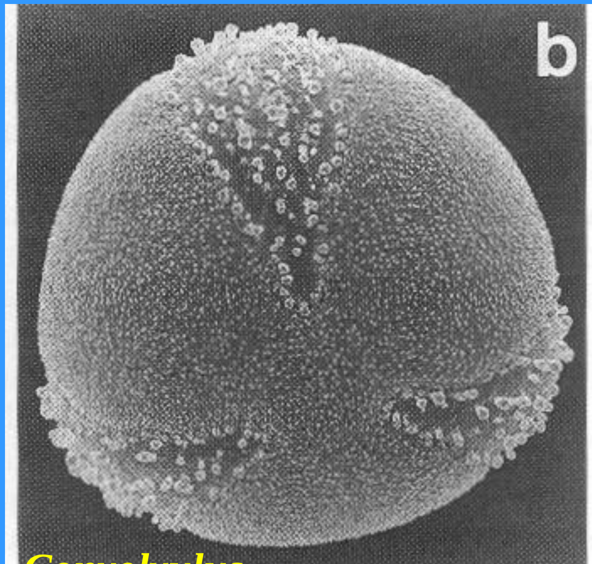




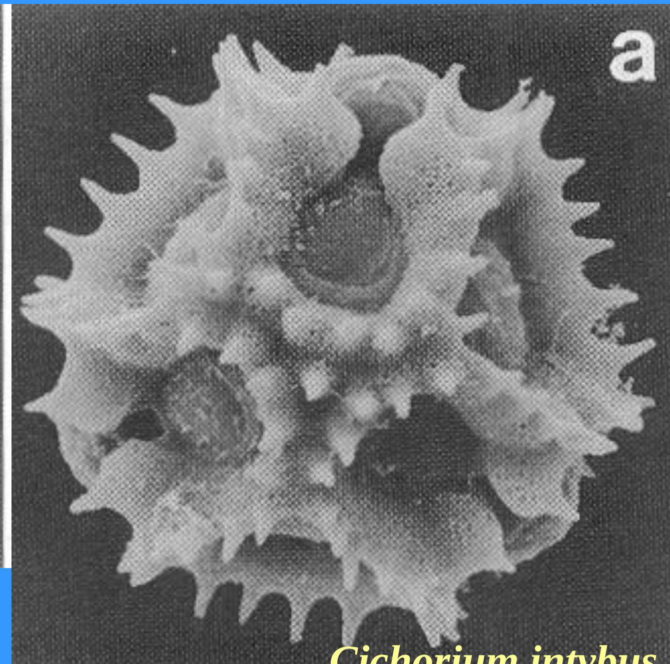
Pólen tricolpado

Pólen monossulcado

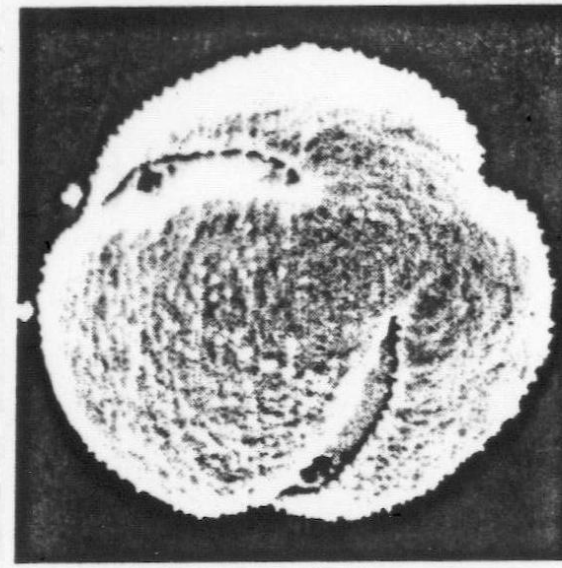
Donoghue & Doyle 1989



Convolvulus
Convolvulaceae

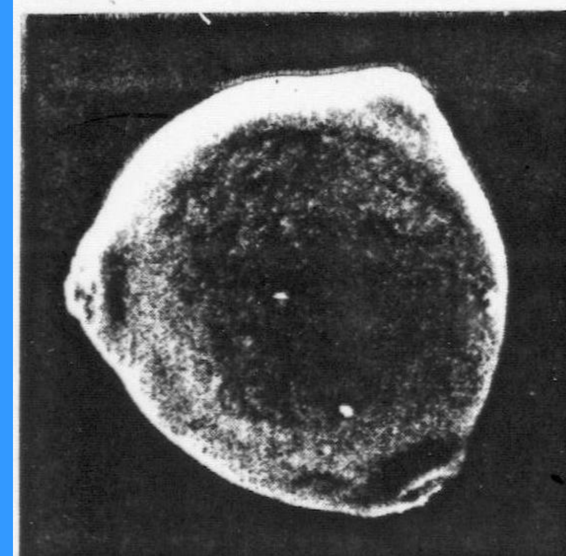


Cichorium intybus
Asteraceae

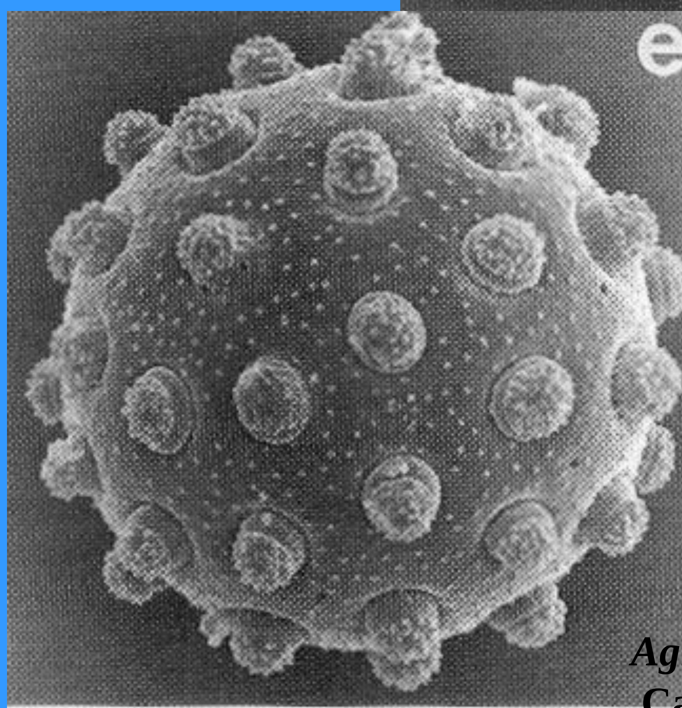


Scaevola glabra (Goodeniaceae)
Tricolporate (× 1050)

(D)

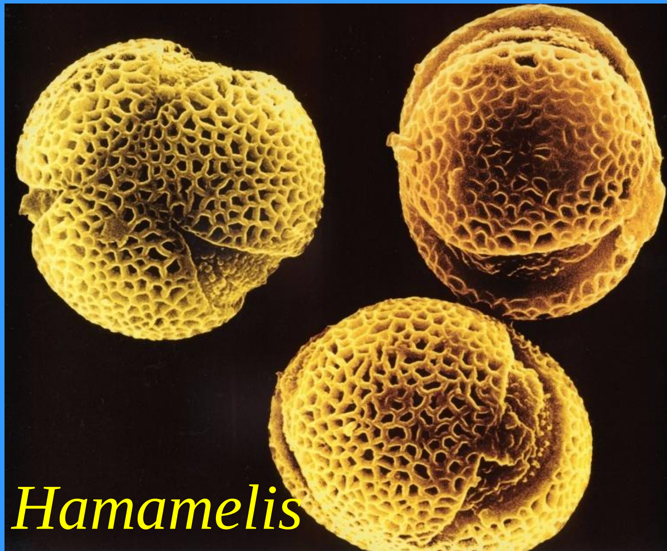


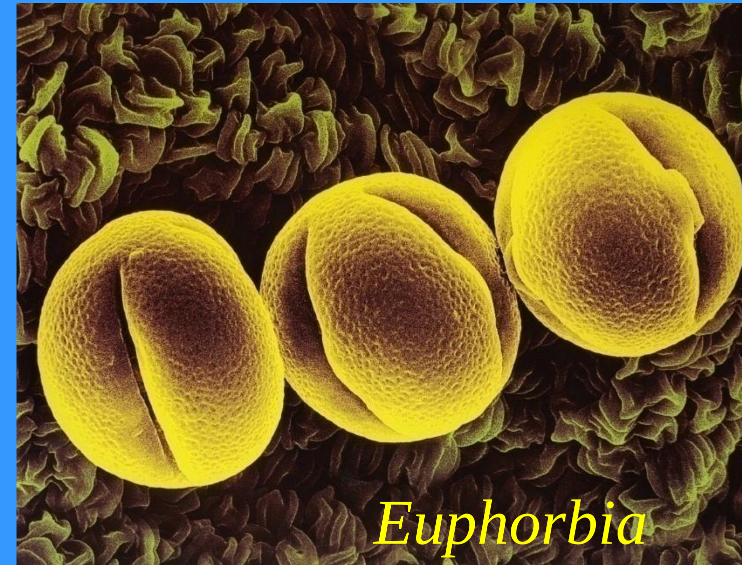
Cucumis sativus (Cucurbitaceae)
Triporate (× 700)



Agrostemma
Caryophyllaceae

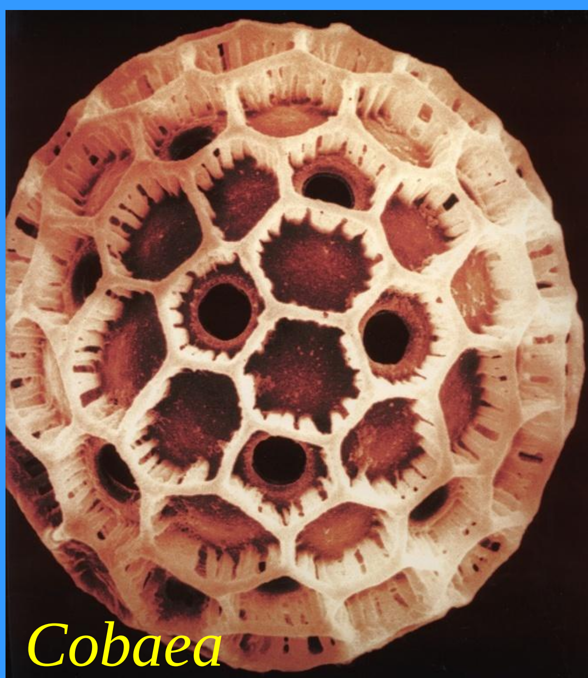
pólen tricolpado





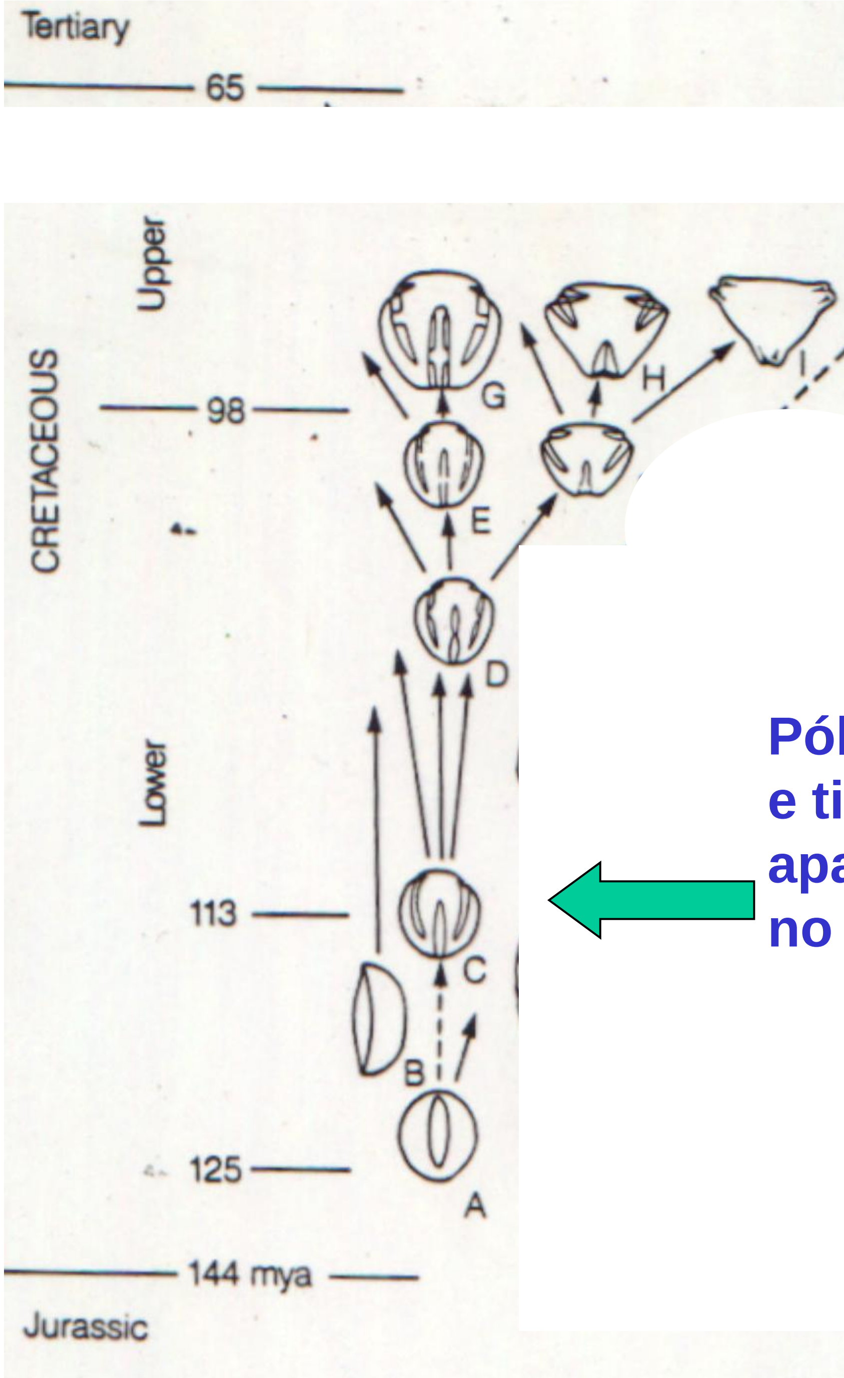
pólen tricolporado

Aesculus



pólen porado

Pólen de angiospermas no tempo geológico

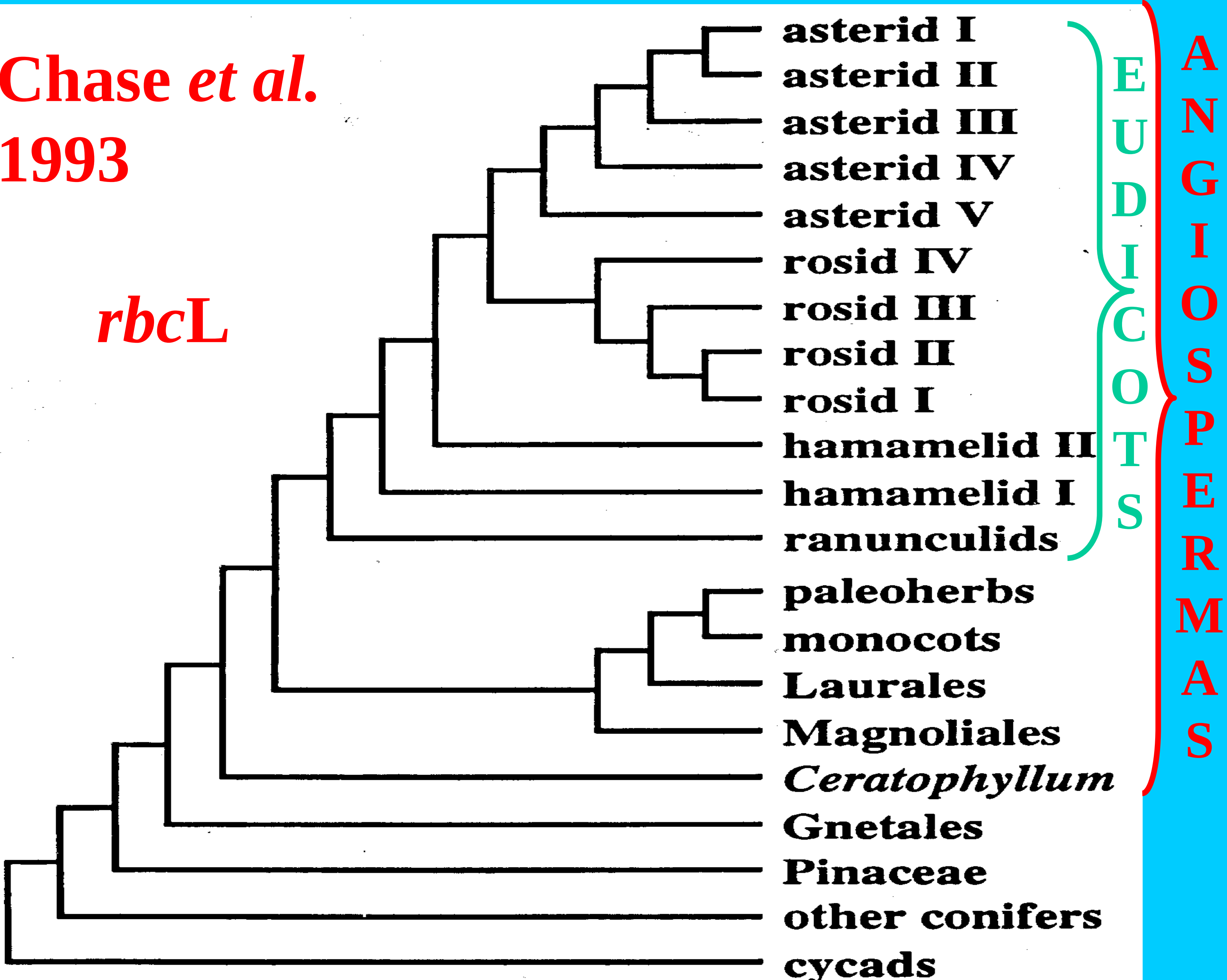


Pólens triaperturados
e tipos derivados
aparecem bem mais tarde
no registro fóssil

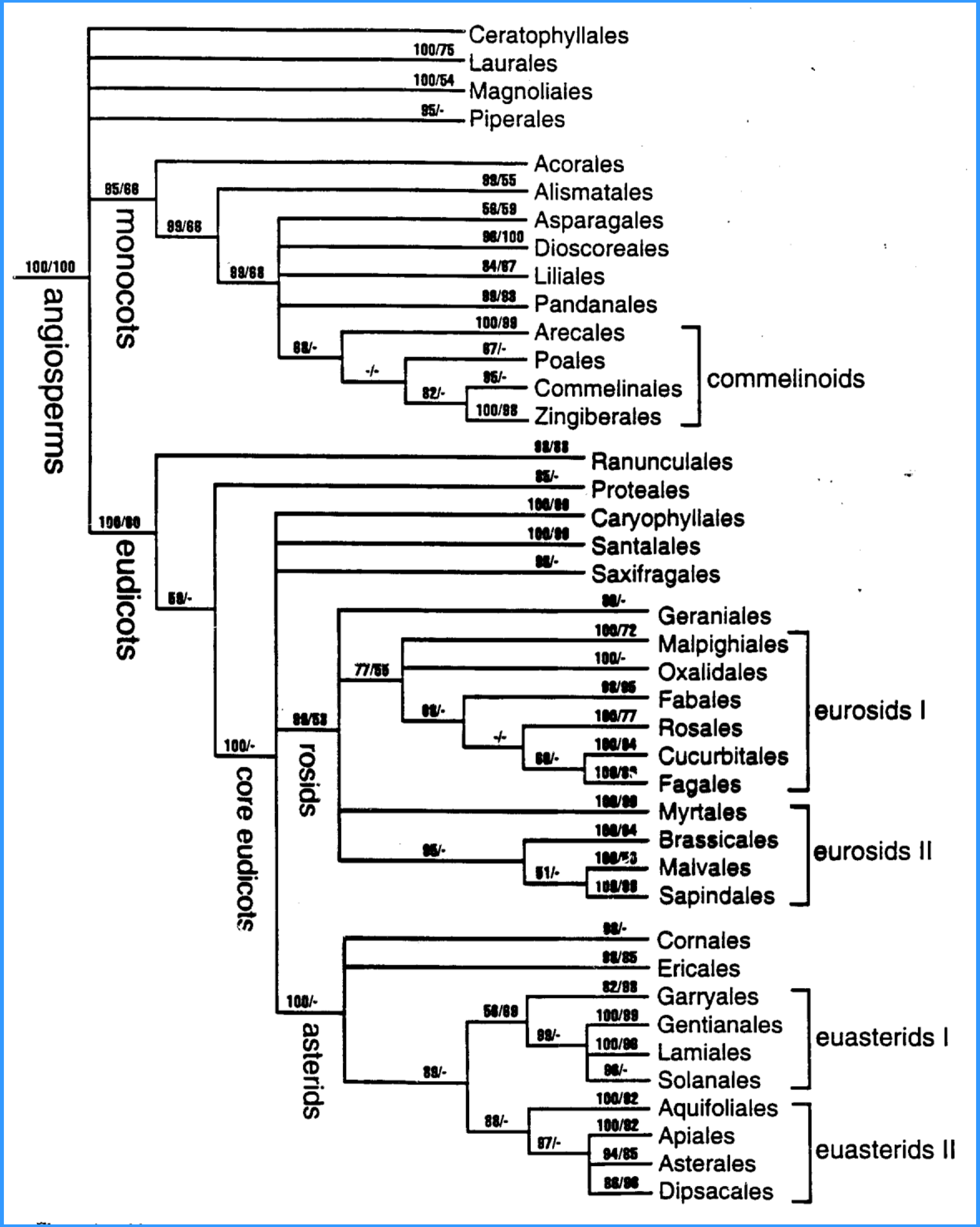
Hickey & Doyle 1977

Chase *et al.* 1993

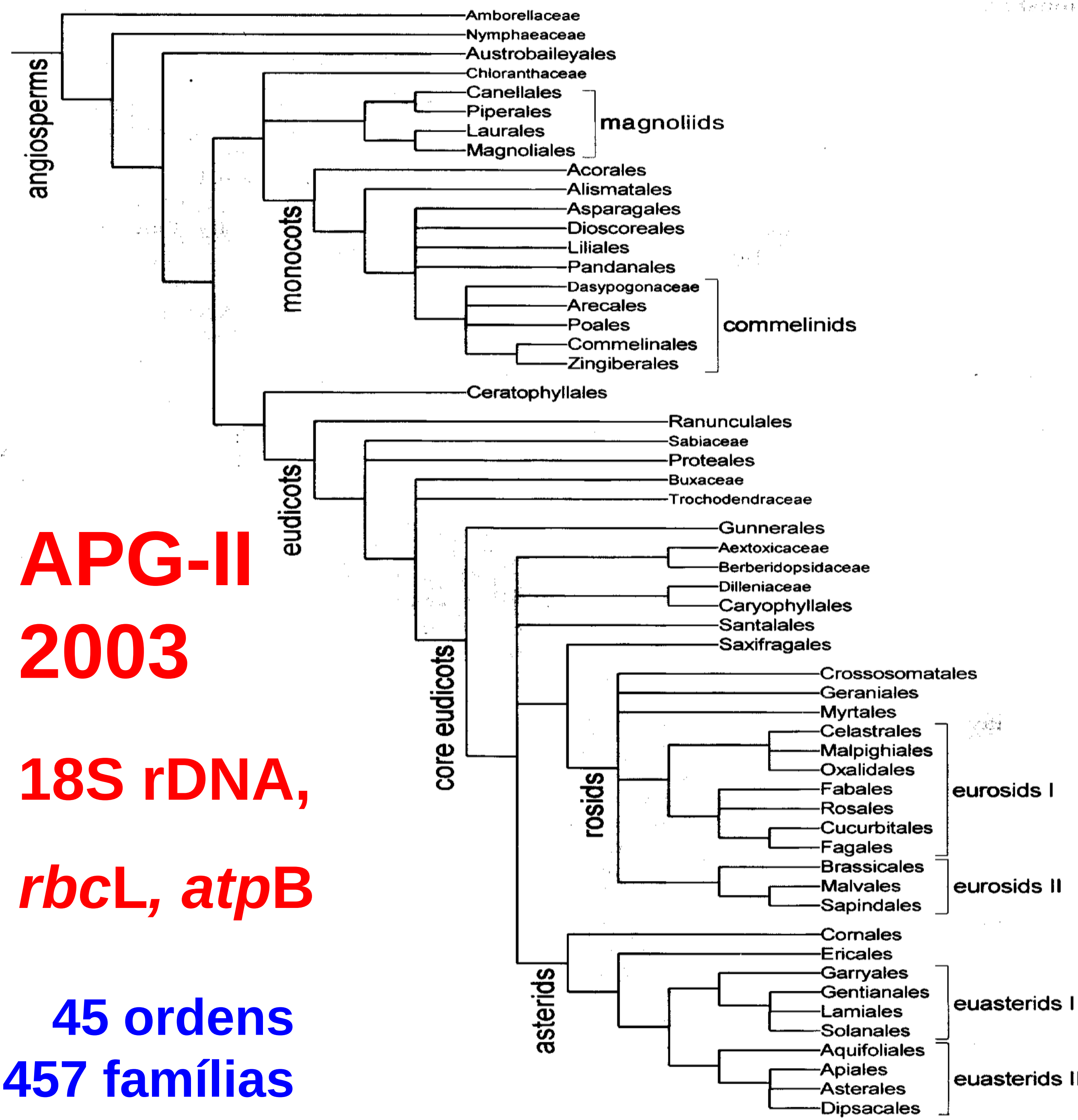
*rbc*L



Angiosperm Phylogeny Group (APG) 1998



***rbc*L, *atp*B**
18S rDNA



APG-II 2003

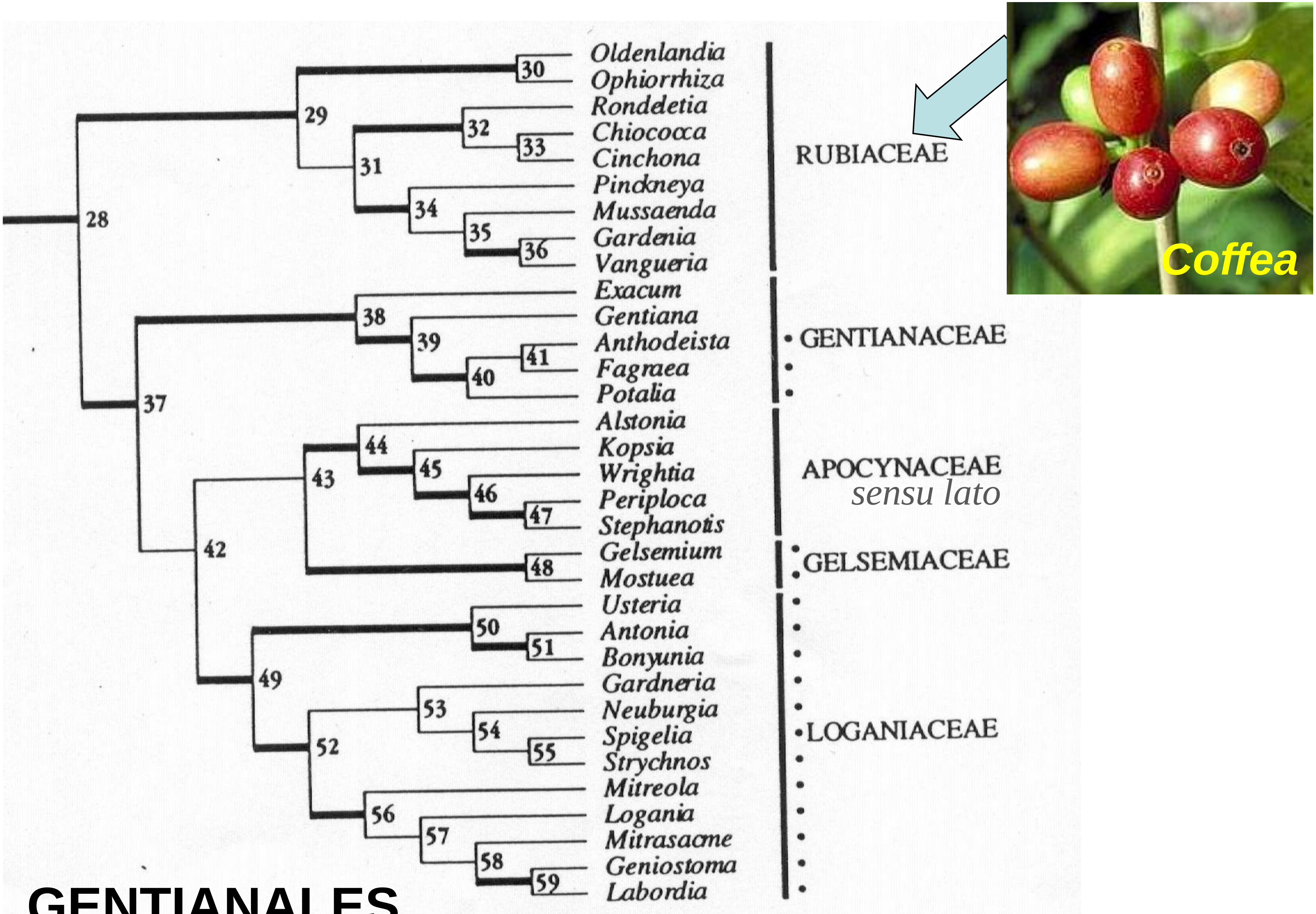
18S rDNA, *rbc*L, *atp*B

45 ordens
457 famílias

Sistema APG II (2003) e APG-III (2009):
- sistema de classificação em ordens
- são nomeados somente os grupos que satisfazem a condição primordial de monofiletismo
- evitam-se ordens com uma só família (informatividade).

Classificações:
são necessariamente menos informativas que filogenias, pois nem todos os clados são nomeados.

Embora não comparáveis, táxons monofiléticos fornecem certeza de ancestralidade comum de seus grupos menos inclusivos.

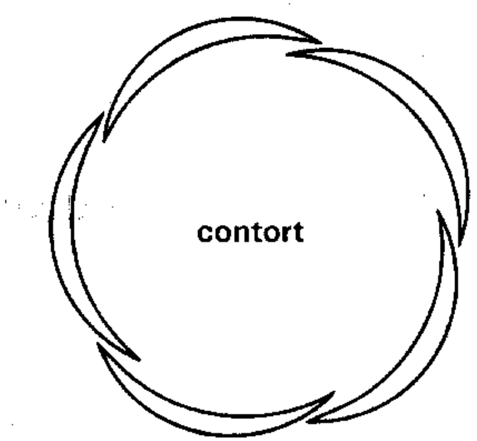


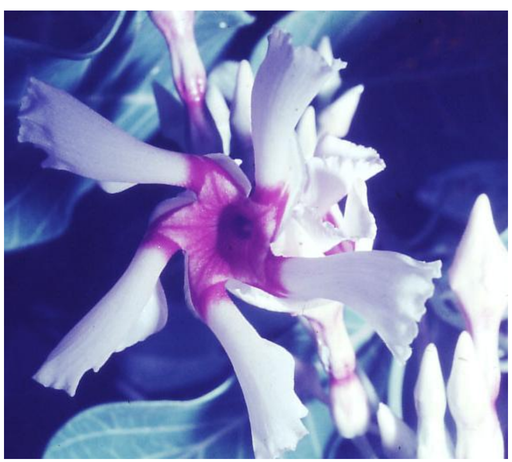
GENTIANALES

Ordem GENTIANALES
5 famílias 14.200 spp.

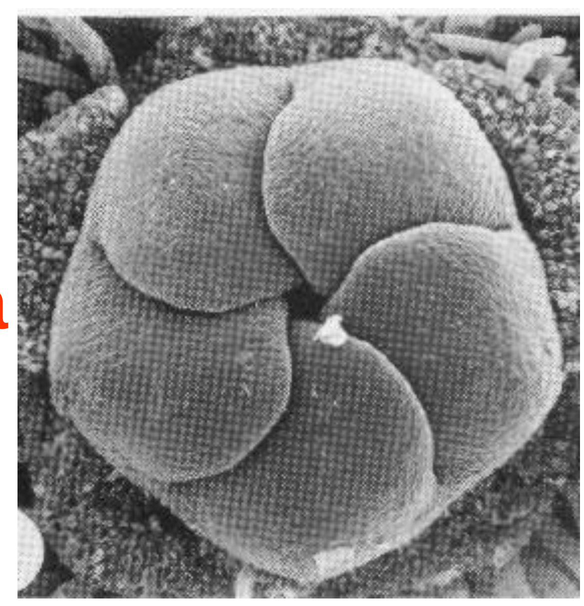
Sinapomorfias:

- folhas opostas
- estípulas
- coléteres
- floema interno
- alcalóides indólicos





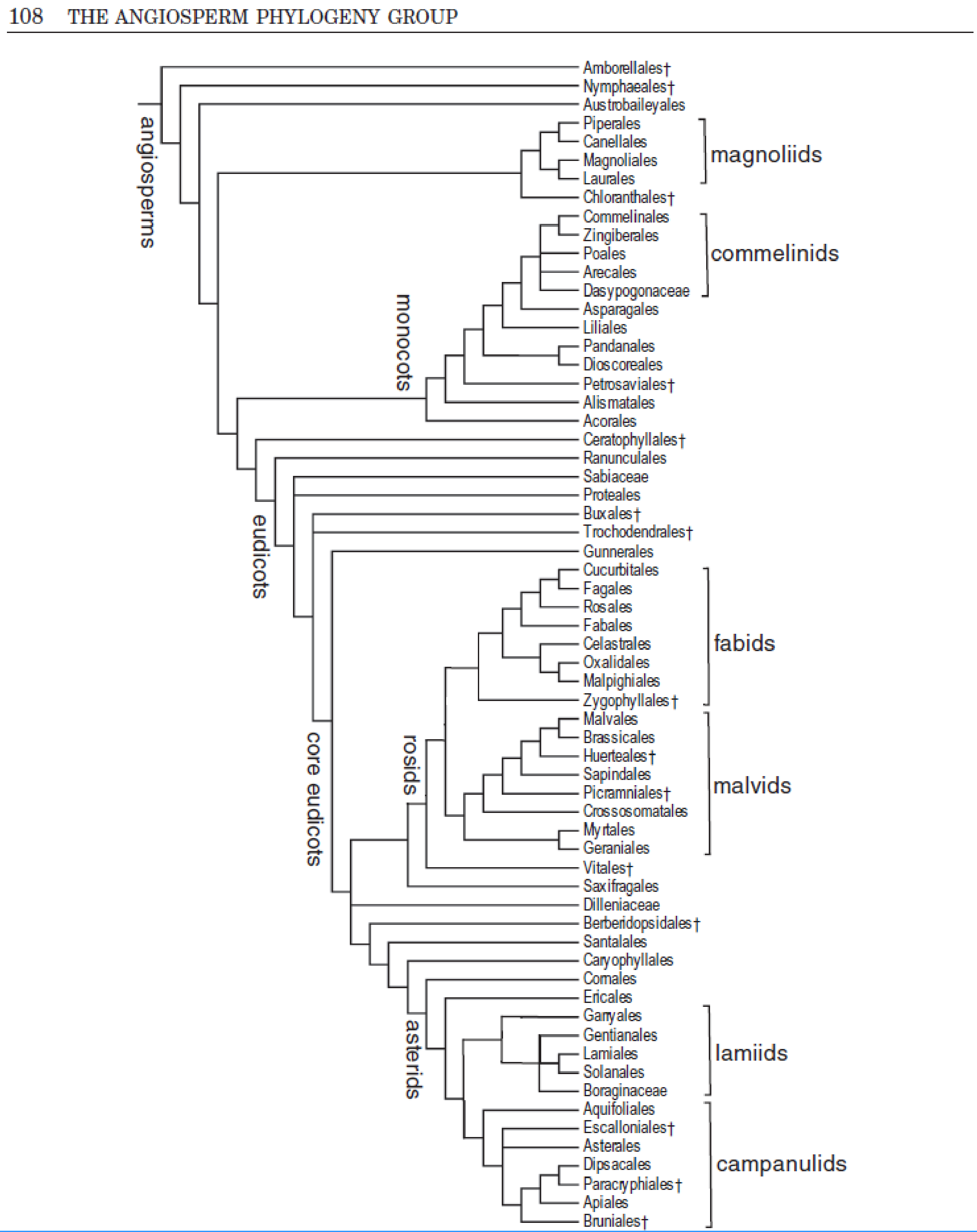
- corola contorcida



APG-III
2009

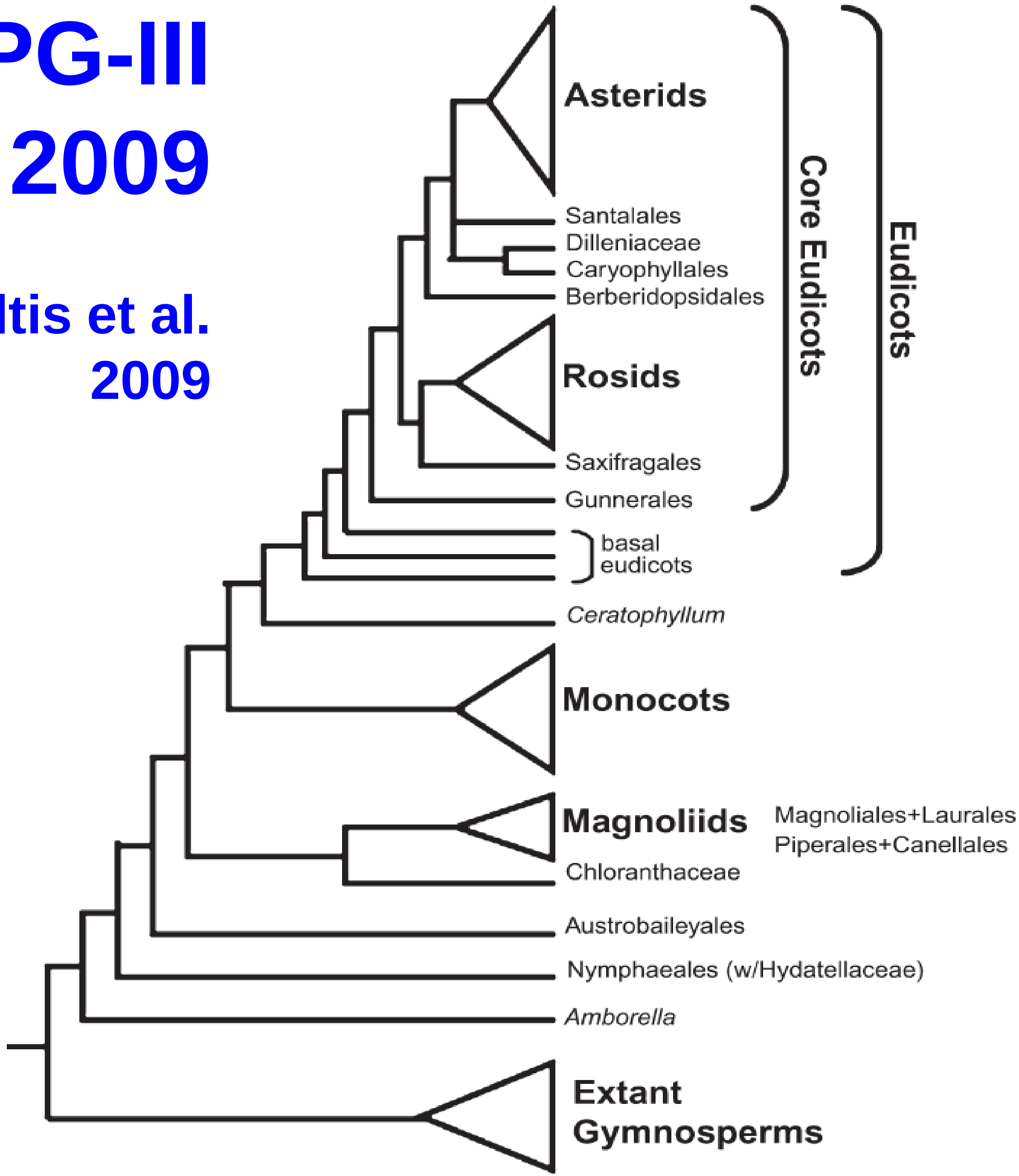
18S rDNA
***rbc*L**
atp*B*
***atp*1**
***mat*R**

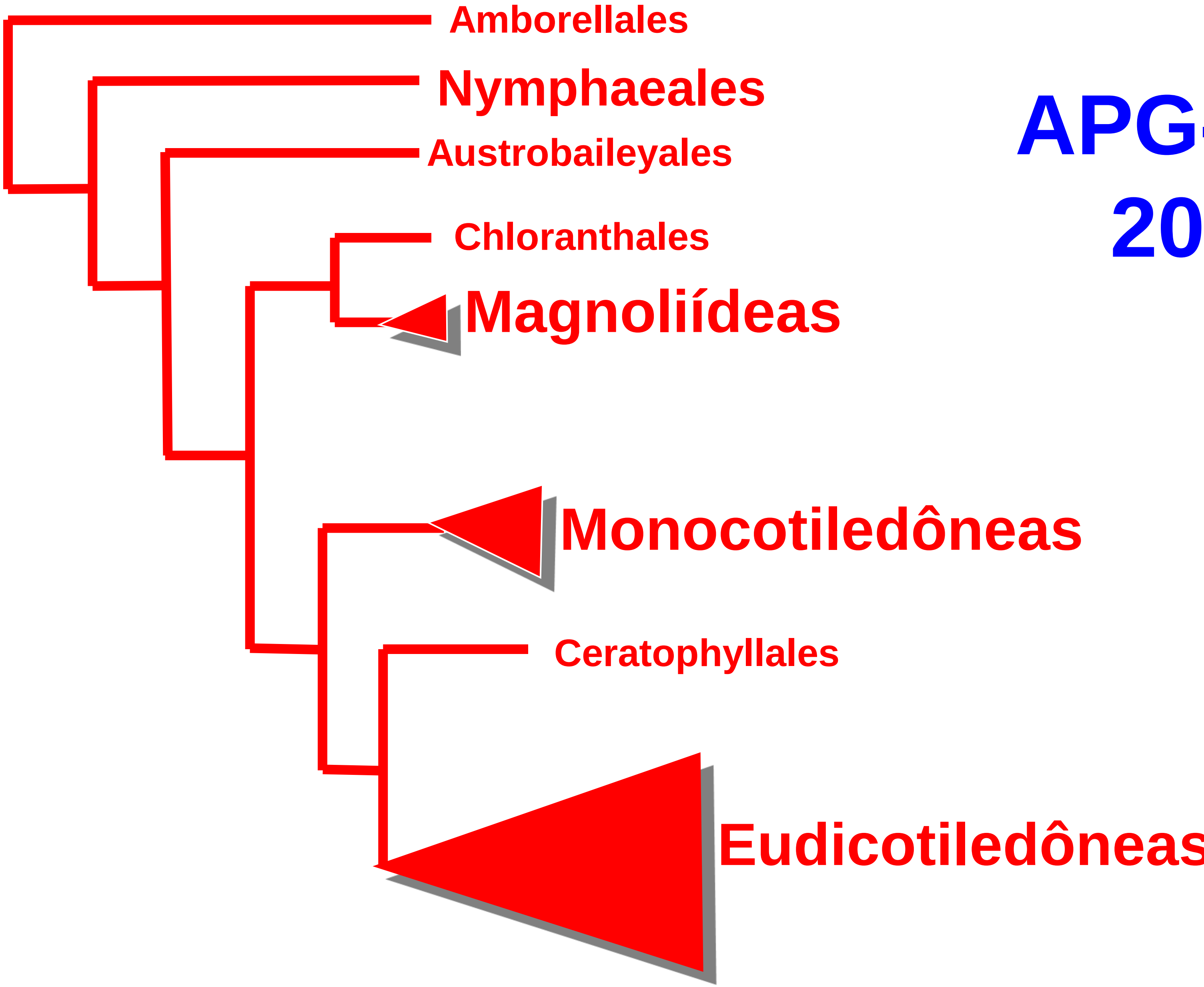
+ 61 genes de 45 táxons



APG-III 2009

Soltis et al. 2009





APG-III
2009

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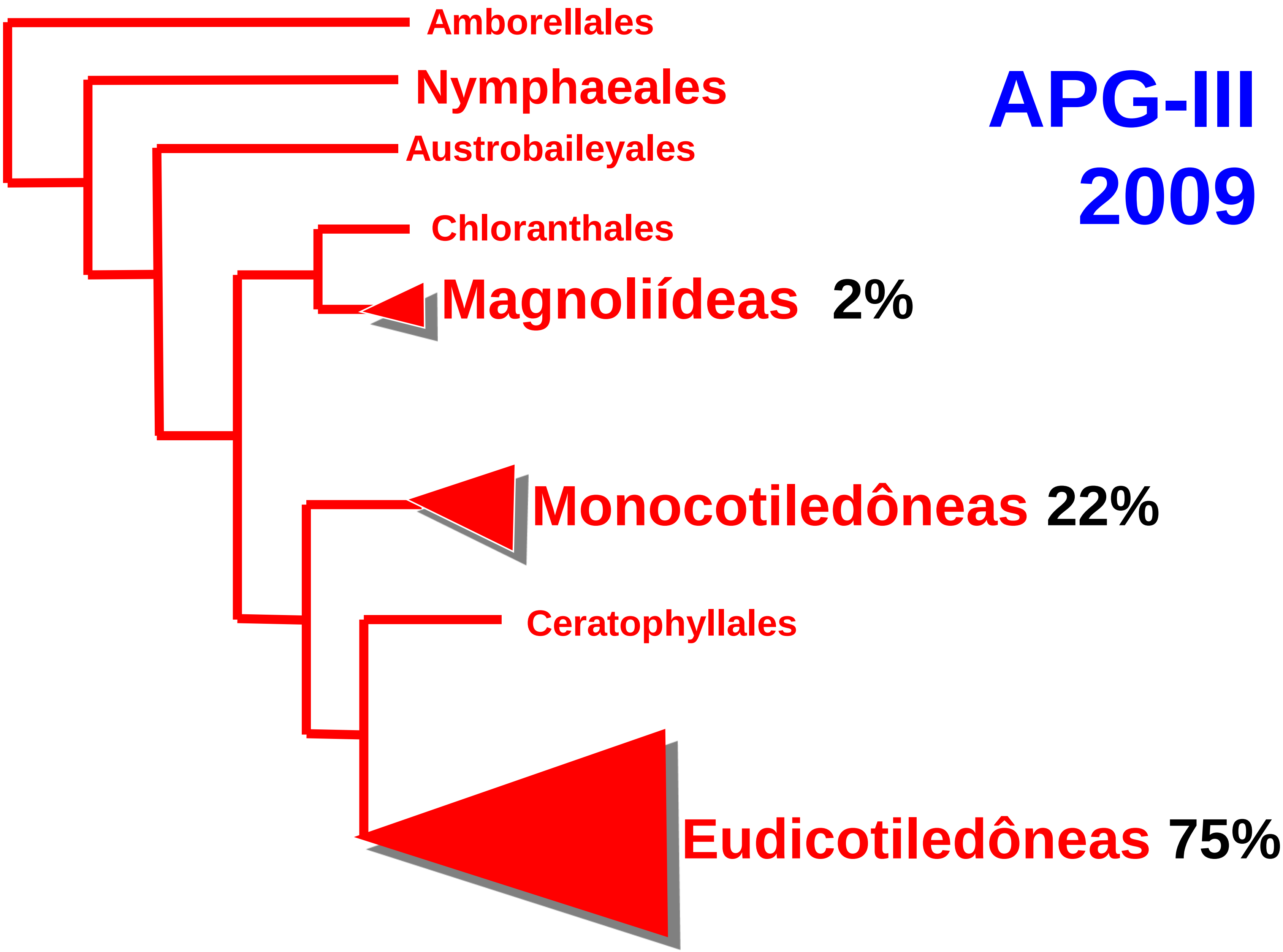
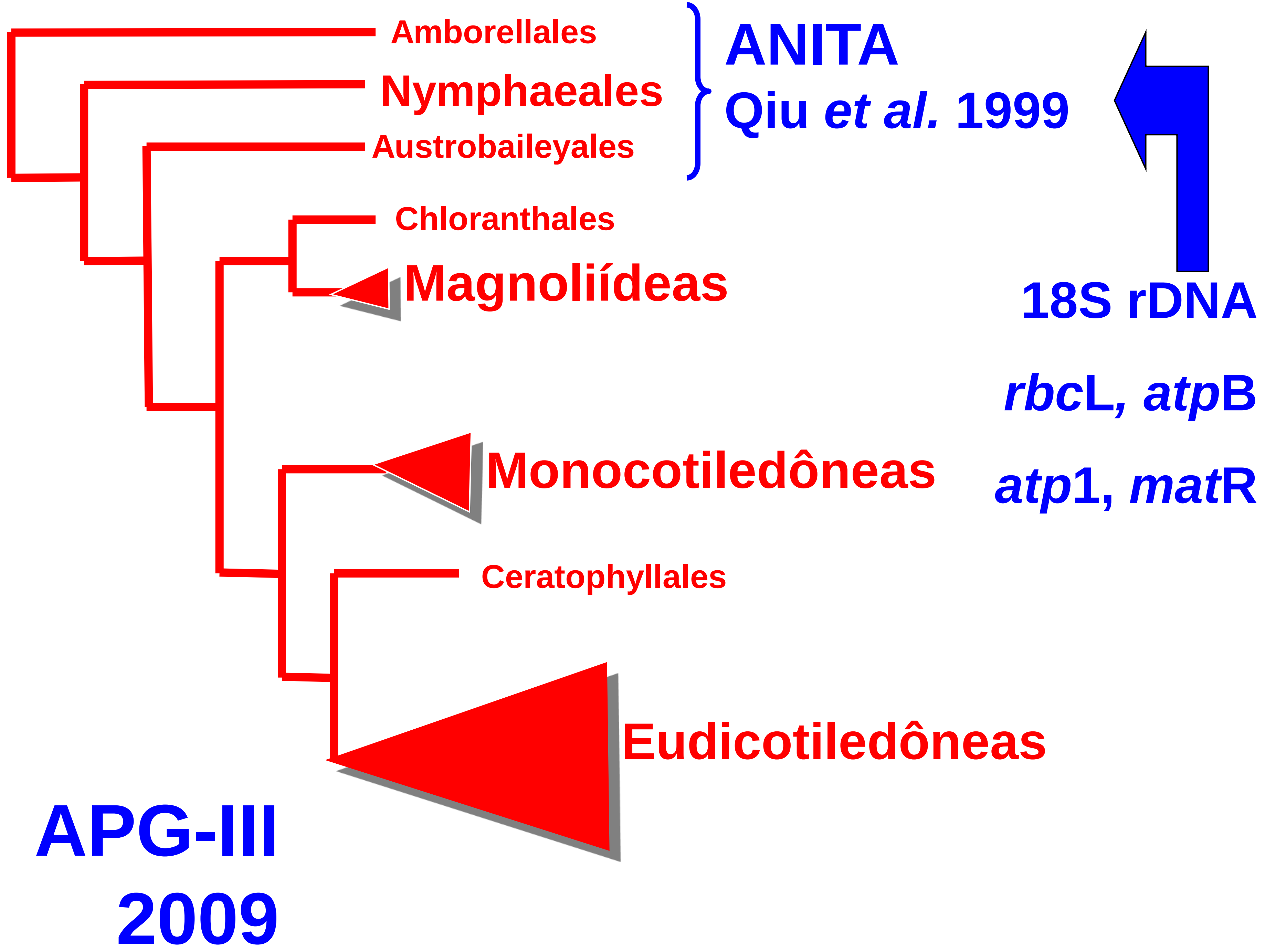
(Stevens 2010)

APG-III 2009



www.mobot.org/MOBOT/research/APweb

(Stevens 2010)


Amborellales
Nymphaeales
Austrobaileyales
ANITA
Qiu et al. 1999
Chloranthales
Magnoliídeas
18S rDNA
rbcL, atpB
atp1, matR
Monocotiledôneas
Ceratophyllales
Eudicotiledôneas
APG-III
2009

Cinnamomum	...	...	...	---	---	---	---	---	---	...	---	...
Laurus	...	...	...	---	---	---	---	---	---	...	---	...
Cryptocarya	...	...	...	---	---	---	---	---	---	G..	---	...
Atherosperma	...	...	...	---	---	---	---	---	---	...	---	...
Daphnandra	...	...	...	---	---	---	---	---	---	...	---	...
Doryphora	...	...	...	---	---	---	---	---	---	...	---	...
Siparuna	...	...	...	---	---	---	---	---	---	...	---	...
Calycanthus	...	.T.	...	---	---	---	---	---	---	...	---	...
Chimonanthus	...	.T.	...	---	---	---	---	---	---	...	---	...
Idiospermum	...	..A	C..	---	---	---	---	---	---	...	---	...
Annona	C..	..G	...	---	---	---	---	---	---	.TC	---	...
Asimina	...	..G	...	---	---	---	---	---	---	.TA	---	...
Cananga	...	..G	...	---	---	---	---	---	---	.TA	---	...
Polyalthia	...	..G	...	---	---	---	---	---	---	.TA	---	...
Eupomatia	...	..G	...	---	---	---	---	---	---	.TA	---	...
Magnolia	...	...	...	---	---	---	---	---	---	...	---	...
Liriodendron	...	...	...	---	---	---	---	---	---	...	---	...
Degeneria	...	...	..A	---	---	---	---	---	---	.T.	---	...
Galbulimima	...	..G	...	---	---	---	---	---	---	.TA	---	...
Knema	...	..G	...	---	---	---	---	---	---	..T	---	T..
Myristica	...	..G	...	---	---	---	---	---	---	.TT	---	...
Mauloutchia	...	..G	...	---	---	---	---	---	---	.TA	---	...
Anemopsis	...	...	...	---	---	---	---	---	---	...	---	A..
Saururus	...	...	...	---	---	---	---	---	---	.T.	---	A..
Houttuynia	...	...	...	---	---	---	---	---	---	...	---	A..
Peperomia	...	...	..G	---	---	---	---	---	---	A..	---	A..
Piper	...	...	...	---	---	---	---	---	---	...	---	A..
Aristolochia	...	...	...	---	---	---	---	---	---	...	---	...
Thottea	...	...	...	---	---	---	---	---	---	...	---	...
Lactoris	C..	...	...	---	---	---	---	---	---	...	---	...
Asarum	...	...	...	---	---	---	---	---	---	...	---	...
Saruma	...	...	...	---	---	---	---	---	---	...	---	...
Belliolum	...	...	...	---	---	---	---	---	---	...	---	...
Drimys	...	...	...	---	---	---	---	---	---	...	---	...
Tasmannia	...	...	...	---	---	---	---	---	---	...	---	...
Canella	C..	...	...	---	---	---	---	---	---	...	---	...
Cinnamodendron	C..	...	...	---	---	---	---	---	---	...	---	...
Chloranthus	C..	...	...	---	---	---	---	---	---	...	---	...
Sarcandra	C..	...	...	---	---	---	---	---	---	...	---	...
Ascarina	C..	...	...	---	---	---	---	---	---	...	---	...
Hedyosmum	C..	...	...	---	---	---	---	---	---	...	---	...
Dioscorea	...	..G	...	---	---	---	---	---	---	.T.	---	...
Asparagus	...	..G	...	---	---	---	---	---	---	.T.	---	...
Croomia	...	..G	...	---	---	---	---	---	---	.T.	---	...
Carludovica	...	..G	...	---	---	---	---	---	---	.T.	---	...
Potamogeton	G.G	..G	...	---	---	---	---	---	---	.T.	---	...
Triglochin	G.G	..G	...	---	---	---	---	---	---	.T.	---	...
Alisma	G.G	..G	...	---	---	---	---	---	---	.T.	---	...
Orontium	...	..G	...	---	---	---	---	---	---	.T.	---	...
Spathiphyllum	...	..A	...	---	---	---	---	---	---	.T.	---	...
Pleea	...	..G	...	---	---	---	---	---	---	.T.	---	...
Tofieldia	..G	..G	...	---	---	---	---	---	---	.T.	---	...
Ceratophyllum_d	T..	C.A	..A	---	---	---	---	---	---	G..	---	...
Ceratophyllum_s	T..	C.A	..A	---	---	---	---	---	---	G..	---	...
Kadsura	T..	.TG	T..	ATA	TAT	ATA	TAT	ACA	TAT	G..	---	...
Schisandra	T..	.TG	T..	ATA	TAT	ATA	TAT	ACA	TAT	G..	---	...
Illicium	T..	.TA	T..	ACA	TAT	---	---	---	---	G..	---	...
Trimenia	T..	.TA	T..	ATA	TAT	ATA	TAT	---	---	G..	---	...
Austrobaileya	G..	.TA	T..	ATA	TAT	AGA	TAT	---	---	G..	---	...
Nymphaea	...	...	...	AAT	---	---	---	---	---	G..	---	...
Nupnar	...	...	...	AAT	---	---	---	---	---	G..	---	...
Brasenia	...	C.G	...	TAT	---	---	---	---	---	GA.	---	...
Cabomba	...	C.G	CT.	ACA	GTA	ACG	CAA	CCA	GTA	A.T	---	...
Amborella	...	...	TCA	AAT	---	---	---	---	---	G..	---	...
Gnetum	T.C	T..	...	ACT	ACC	CGG	---	---	---	G..	GGC	ATA
Welwitschia	T..	...	,CC	CAG	CAT	AAT	---	---	AGT	G..	GAC	ATT
Pinus	...	...	...	AAT	AAT	GGG	---	---	GTA	GC.	TTC	T..
Ginkgo	...	..G	...	GAT	AAT	AGG	---	---	GTA	GC.	TTC	T..
Cycas	...	..G	..G	AAG	AAC	AGG	---	---	GTA	GC.	TTC	T..
Zamia	...	..G	G.G	GAT	AAC	AGG	---	---	GTA	GC.	TTC	T..

A N I T A

GIMNO

Arabidopsis	AAT	AAT	AAT	---	---	---	---	---	---	TGG	---	GCC
Oenothera	...	...	...	---	---	---	---	---	---	...	---	...
Vicia	...	...	...	---	---	---	---	---	---	.T.	---	...
Solanum	...	...	...	---	---	---	---	---	---	...	---	...
Triticum	...	..G	...	---	---	---	---	---	---	.T.	---	...
Sarcococca	...	...	...	---	---	---	---	---	---	...	---	...
Pachysandra	...	...	...	---	---	---	---	---	---	...	---	...
Buxus	...	...	...	---	---	---	---	---	---	...	---	...
Didymeles	...	---	...	---	---	---	---	---	---	G..	---	...
Tetracentron	...	...	...	---	---	---	---	---	---	...	---	...
Trochodendron	...	...	...	---	---	---	---	---	---	...	---	...
Sabia	...	...	...	---	---	---	---	---	---	...	---	...
Petrophile	...	...	...	---	---	---	---	---	---	...	---	...
Persoonia	...	...	...	---	---	---	---	---	---	...	---	...
Grevillea	...	...	...	---	---	---	---	---	---	...	---	...
Platanus	...	...	...	---	---	---	---	---	---	...	---	...
Nelumbo	...	...	...	---	---	---	---	---	---	...	---	...
Mahonia	...	...	...	---	---	---	---	---	---	...	---	...
Podophyllum	...	...	...	---	---	---	---	---	---	...	---	...
Ranunculus	...	...	...	---	---	---	---	---	---	...	---	...
Xanthorhiza	...	...	...	---	---	---	---	---	---	...	---	...
Cissampelos	T..	...	...	---	---	---	---	---	---	...	---	...
Cocculus	...	...	...	---	---	---	---	---	---	...	---	...
Lardizabala	...	...	...	---	---	---	---	---	---	...	---	...
Akebia	...	...	...	---	---	---	---	---	---	...	---	...
Sargentodoxa	...	...	...	---	---	---	---	---	---	...	---	...
Euptelea	...	...	...	---	---	---	---	---	---	...	---	...
Dicentra	...	...	...	---	---	---	---	---	---	...	---	...
Sanguinaria	...	...	...	---	---	---	---	---	---	...	---	...
Palmeria	...	...	...	---	---	---	---	---	---	.T.	---	...
Peumus	...	...	...	---	---	---	---	---	---	...	---	...
Hedycarya	...	...	...	---	---	---	---	---	---	...	---	...
Gyrocarpus	...	...	...	---	---	---	---	---	---	...	---	...
Cinnamomum	...	...	...	---	---	---	---	---	---	...	---	...

Qiu *et al.* 1999

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ATA	TAT	ATA	TAT	ACA	TAT
ATA	TAT	ATA	TAT	ACA	TAT
ACA	TAT	---	---	---	---
ATA	TAT	ATA	TAT	---	---
ATA	TAT	AGA	TAT	---	---
AAT	---	---	---	---	---
AAT	---	---	---	---	---
TAT	---	---	---	---	---
ACA	GTA	ACG	CAA	CCA	GTA
AAT	---	---	---	---	---
ACT	ACC	CGG	---	---	---
CAG	CAT	AAT	---	---	AGT
AAT	AAT	GGG	---	---	GTA
GAT	AAT	AGG	---	---	GTA
AAG	AAC	AGG	---	---	GTA
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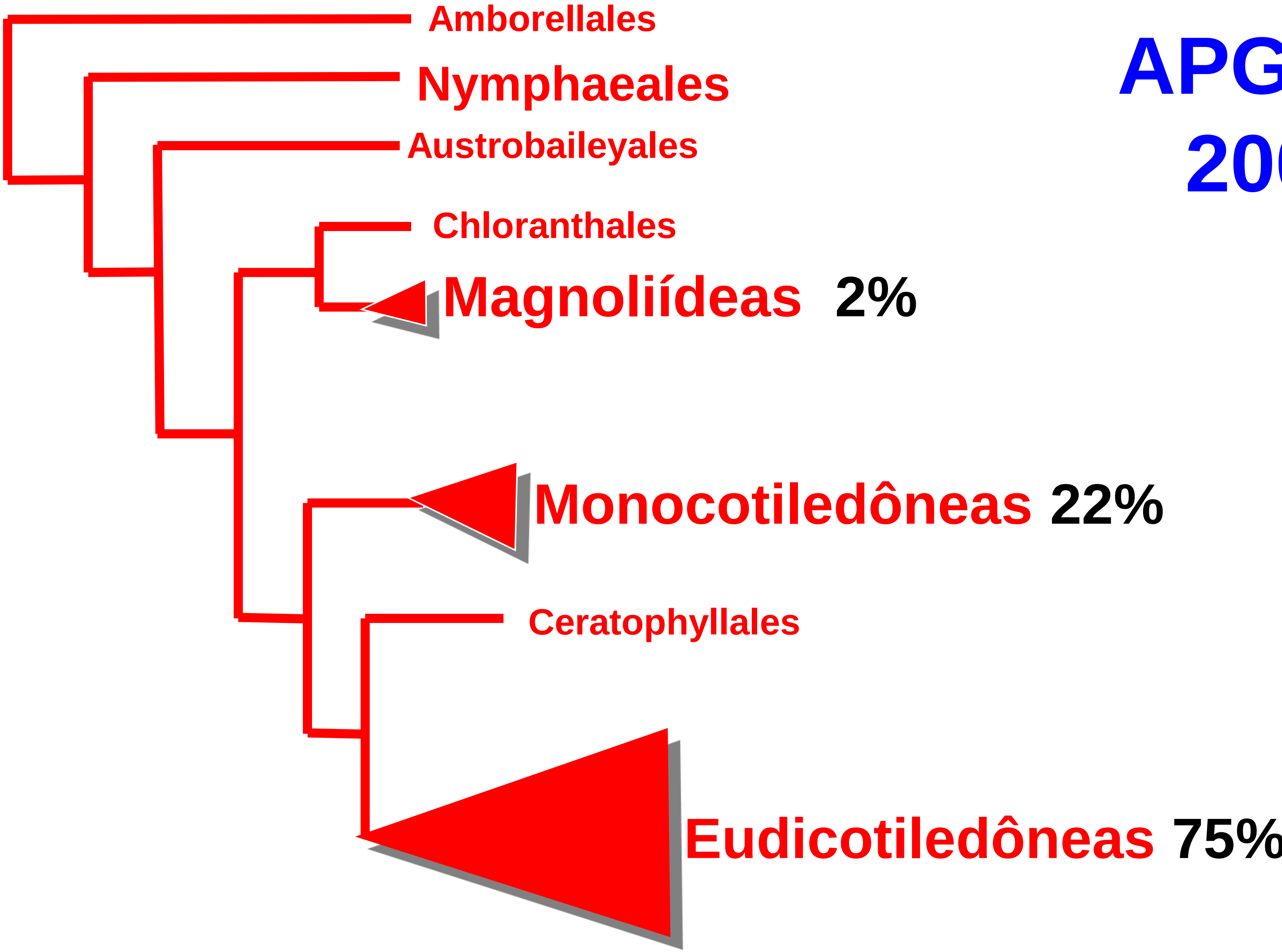

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(Stevens 2010)