Angiosperm Phylogeny Poster

Flowering Plant Systematics

EARLY ANGIOSPERMS

woody
vessels absent
eustele
sieve tube plastids
with starch grains
lvs simple, persistent, entire
flw strobilar, perfect, parts free
P parts varying, often in threes,
weakly differentiated
anthers tetrasporangiate
stamen with broad filaments
pollen monosulcate
G apocarpous (style short in most)
compitum (if present) extragynoecial
nectaries absent
siphonogamy
double fertilization > endosperm
embryo very small

ethereal oils in spherical idioblasts (pellucid dots)
tension wood +

benzylisoquinoline alkaloids
embryo sac 8-nucleate
endosperm triploid

ANA GRADE

woody; vessels lacking
dioecious; flw T5–8, A∞, G5–8, ovule 1/carpel, embryo sac 9-nucleate
1 species, New Caledonia — 1/1/1

herbaceous, aquatic; cambium absent; aerenchyma; flw T4–12, A1–∞, embryo sac 4-nucleate
seeds operculate, perisperm
mucilage; alkaloids (no benzylisoquinolines) — 2/680

woody, vessels solitary
flw T>10, A∞, G ca.9, embryo sac 4-nucleate
tiglic acid, aromatic terpenoids — 3/5/100

lvs opposite, interpetiolar stipules
nodes swollen
flw small T0–3, A1–5, G1, ovule 1 (apical)/carpel — 1/4/75

sesquiterpenes

MAGNOLIIDS
features as in "Early Angiosperms"

woody; foliar sclereids
K and C distinct
aromatic terpenoids — 2/10/125

nodes trilacunar

± herbaceous; lvs two-ranked, leaf base sheathing
single adaxial prophyll
nodes swollen — 4/71/4170

woody; lvs opposite
flw with hypanthium, staminodes frequent
anthers often valvate; ovule 1/carpel; embryo large — 7/972/8958

woody; pith septate; lvs two-ranked
ovules with obturator
endosperm ruminate — 6/1283/5140

infl spadix with spathe; lvs axils with mucilaginous intravaginal squamules
ovules atropous, seeds with epidermal perisperm and copious endosperm
ethereal oils — 1/1/2–4

Ca oxalate raphides
endosperm nuclear helobial

mostly herbs and aquatics; rhizomatous
infl ± scapose; G often apocarpous
placentation often laminar; endosperm helobial — 14/1664/4765

twining vines (often); lvs often reticulate
ovary often inferior, style short, branched
steroidal sapogenins/alkaloids — 5/21–1000

some woody (with terminally tufted lvs)
infl sometimes with spathe + spadix — 3/36/1545

geophytes (bulbs, tubers, rhizomes); leaf bases often not sheathing
flw T sometimes spotted, nectaries on T, anthers extrorse
seeds ∞
phytomelan lacking; fructans in stems, chelidonic acid — 10/67/1358

stem with ring of bundles
fr follicle
East Asia — 1/2/3

often geophytes
fr capsule or berry
seed coat obliterated or with phytomelan — 4/11/2/36265

woody, often monopodial
lvs often palmately or pinnately pseudocompound, reduplicate-plicate
intense primary growth, large apical meristem, infl often with spathe
alkaloids — 1/192–>2000

herbs (mostly); lvs grassy; epidermis siliceous
mycorrhiza – (in most)
flw often anemophilous, minute, chaffy, without nectaries — 14/997/18975

COMMELINIDS
UV-fluorescing cell walls
(ferulic/coumaric acids)
silicic acid in leaves
cuticular waxes often in rodlets
aggregated into scallops

infl thyrsus of scorpioid cymes
flw monosymmetric or not, stamens few fertile
phenylphenalenones — 5/68/812

herbs, rhizomatous, large-leafed; pseudostem common
flw irregular/monosymmetric, septal nectaries
A often strongly modified/reduced, G inferior; seeds often arillate
silicic acid — 5/42–>2500

aquatic; herbaceous; monoecious
lvs whorled, no pellucid dots; vessels lacking
flw T0 or 9–10°, A1, G1, 1 apical ovule/carpel
pollen inaperturate, pollen tube branched, hydrophilous — 1/1/1–5

extrafloral nectaries

MONOCOTS
scattered bundles in stem
no secondary thickening
mostly herbaceous
pollen monosulcate
sieve tube plastids with
protein crystals
sympodial branching
lvs parallel-veined, entire
no glandular teeth
flw pentacyclic
P 3-merous, A opp. P
filaments narrow
anthers broadly attached
septal nectary
single cotyledon
radicle not persistent
stem-borne roots numerous

lvs often divided
flw parts whorled, P single or multiple whorls
G apocarpous/paracarpous, superior
berberines — 7/1199–>4500

ethereal oils

not in idioblasts

mostly woody
flw T often 4-merous
A epitepalous, connectives sometimes with apical appendage — 4/851/1790

EUDICOTS
pollen tricolpate
protandry common
flw K/C/P opp A
filaments rather narrow
nodes 3:3
stomata anomocytic
microsporogenesis
simultaneous

recepta-cular nectary common

woody; vessels lacking
flw T 0, A∞, G>5 laterally connate with abaxial nectaries
fr aggregate of follicles — 1/2/2

absent

benzylisoquinolines

mostly woody; lvs evergreen, stomata cyclocytic
mostly monoecious, flw unisexual, T ± uniform or missing
pregnane pseudoalkaloids — 1/7/120

lvs toothed, sec. veins palmate
dioecious, flw unisexual, T small to lacking
ellagic acid — 2/2/~50

ellagic and gallic acids

mostly woody; lvs if veins strong, proceed to apex of teeth
flw mostly K5, persisting, mostly A∞, G mostly slightly connate
seeds often with aril; fr usu. follicles — 1/11/~300

lvs with glandular teeth; often hypanthium, apically unfused carpels, stigma decurrent
fr mostly dry, dehiscent
myricetin, flavonols — 15/112/2000

often tendrillar vines; lvs often divided and with glandular teeth
A epipetalous, ovules 2/carpel; raphides, pearl glands
berries — 1/148/350

stipules

SUPERROSIDS

cork origin deep-seated
endosperm lacking
resinous, lignans/neolignans, harman alkaloids — 2/24/345

lvs often compound, pulvini (sleep movement)
flw A5 or multiple, branched style common
mucilage cells
oxalates — 7/68/1845

ROSIDS

FABIDS

COM clade

infl cymose, flw small
G often 3-merous, nectary often intrastaminal disk
seeds often arillate (red-orange) or winged — 2/94/1355

habits and habitats extremely diverse
lvs margins toothed; pedicels often articulated
flw G3 (often) — 36/716/19665

flw often "papilionaceous": wing, standard, keel, C clawed, G1 (most), A10 (most)
fr pod
symbiosis with root nodule bacteria
diverse alkaloids, NP amino acids, lectins (in Fabaceae) — 47/62–>8400

N fix
embryo large
endosperm scanty

lvs mostly simple with stipules
flw K valvate (and hypanthium) persisting
stigma dry, ovule 1/carpel
dihydroflavonols — 9/263–>8500

lvs mostly alternate
flw often unisexual, G mostly inferior
parietal placentation
cucurbitacins — 7/109–>3000

mostly trees; lvs mostly undivided; flw small, unisexual
anemophilous, thus T reduced or lacking, G mostly inferior
infl spikes or catkins; fr mostly nuts; seed 1
ectomycorrhiza; tannins, dihydroflavonols — 7/33/1175

stems jointed at nodes (in some); lvs with glandular teeth
flw A obdiplostemonous, nectary outside A; fr capsule
ethereal oils, ellagic acid — 2/31/77–>900

MALVIDS

lvs opposite, colleters (glandular hair on adaxial surface of petiole base)
stipules small (if any), cork deep seated
flw K valvate, persisting; A incurved in bud, ovary inferior, ovules many
endosperm scanty, scaly bark; flavonols, myricetin — 9/380/12000

woody
stylodia free
hypanthium with nectary — 7/72/98

trees, dioecious, lvs compound
extrafloral nectaries, staminate flw: A = and opposite C
bark bitter, anthraquinones — 1/4/30

mostly woody (silica/silicified)
lvs often alternate, odd-pinnately compound
flw often imperfect, intrastaminal disk
ethereal oils — 9/479/6570

embryo large
endo-sperm scanty

vessel elements with scalariform perforations; mucilage cells
lvs margins toothed, stipules cauline
flw small, A = and opposite K, ovules 1-2/carpel — 4/6/29

bark fibrous; hairs often stellate
flw K often valvate, petals contorted, A often ∞; mucilage
cyclopropenoid fatty acids, flavones — 10/338/6000

woody or herbs
infl racemose; flw often 4-merous, petals often clawed
myrosin cells, glucosinolates — 10/400–>3000

woody; (semi-)parasites; mycorrhiza absent; lvs margins entire
flw A epipetalous; perianth often simple, valvate, persisting
carpels/ovaries/ovules often reduced, placentation free-central; fr drupe, one-seeded
polyacetylenes, triterpene sapogenins, silicic acid — 14/151/~2000

CORE EUDICOTS

flw 5-merous
parts whorled
K + C free
diplostemonous
pollen tricolporate
G connate
style +
endosperm nuclear

PENTAPETALAE

SUPERASTERIDS

woody
lvs stomata cyclocytic, petiole bundles annular
fr indehiscent (more or less fleshy)
calcium oxalate as crystals — 2/3/4

mostly herbaceous; without mycorrhiza
G often unilocular with free-central placentation
pollen colpate, surface spiny
betalains or anthocyanins (latter, e.g., in Caryophyllaceae) — 37/140/11620

seed exo-testal
embryo long

mostly woody; lvs mostly undivided, hydathode teeth
flw often 4-merous, K much smaller than C, persisting
intrastaminal disk, G inferior; fr drupaceous
diverse iridoids — 6/51/1990

lvs teeth often theoid; nodes unilacunar
flw 5-merous, pentacyclic
nonhydrolyzable tannins, ellagic acid
triterpenoids, hydroquinones — 22/348/12000

trop. trees; lvs exstipulate/entire; nodes often unilacunar
pedicels articulated; style short; embryo long
endosperm copious
indole and quinoline alkaloids (camptothecin) — 2/22/~200

ASTERIDS

mostly sympetalous
C enclosing
A and G in bud
G(2)
style single, long
nectary gynoecial
ovules unitegmic
endosperm cellular
iridoids +

trop. trees; few shared features; nodes usu. trilacunar
alkaloids, iridoids — 7/49/4489

Metteniusa: lvs alternate; flw bisexual, fragrant; anthers sagittate; pollen sacs moniliform, dehisce longitudinally
infl axillary cyme; G(5) unilocular; NE Andes, cloud montane forest — 1/1/185

A=C polyandry rare

infl cymose
fr drupe
ellagic acid lacking

late sympetaly

LAMIIDS

woody; dioecious
flw small, C valvate, G unilocular
fr indehiscent
iridoids (aucubin), gutta — 2/3/18

lvs opposite; nodes 1:1
flw mostly monosymmetric
A often 2(+2); gland-headed hairs with radially arranged cells
6-oxygenated flavones, oligosaccharides cornoside, verbascoside (acetoside) — 24/1698–>2800

C forming distinct tube

herbaceous; lvs opposite, glandular-pubescent
flw < 5 mm across, K valvate, G(3) inf, nectary
fr septicidal capsule, K/C/A persistent; seeds minute
Africa to India; iridoids — 1/1/8

A epipetalous

lvs spiral, simple; nodes unilacunar
flw petals plicate
K persistent in fruit
alkaloids diverse, no iridoids — 5/163–>600

lvs opposite
interpetiolar stipules or nodal line/ridge, colleters
flw corolla convolute in bud
indole alkaloids, iridoids — 5/12/120145

lvs roughly hairy; nodes unilacunar
infl scorpioid
mostly 4 ovules
isokestose, higher inulins, pyrrolizidine alkaloids — 6-11/150/3120

early sympetaly
flw small
embryo short

CAMPANULIDS

woody; lvs serrate
flw 1-2 ovules/carpel, C ± free, K slightly connate
fr usu. drupe with broad stigma — 5/21/536

herbs or shrubs; nodes trilacunar
flw often monosymmetric
plunger sec. pollination device (long style)
inulin, sesquiterpenes, secoiridoids — 11/174/2680

mostly woody
infl racemose, C free
anthers basifixed, nectary disk — 1/16/131

woody; evergreen
nodes 1:1
flw polysymmetric, anthers basifixed — 2/14/79

G inferior

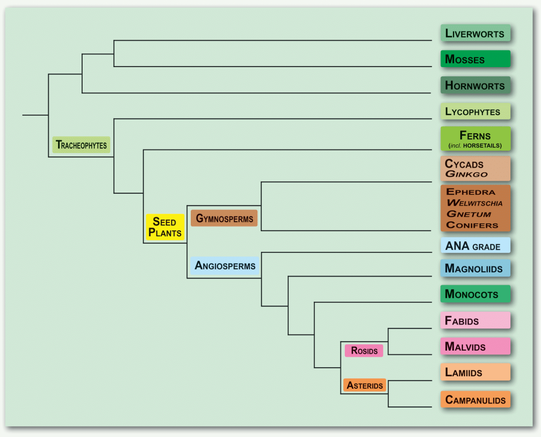
woody (except Apiaceae)
lvs often divided; nodes usu. multilacunar
infl mostly umbel; fr drupe or schizocarp
(Apiaceae: mericarp/carpophore) — 7/494/3489

fr usually 1–few-seeded

woody
infl racemose, flw 4-merous, filaments stout
capsule septicidal — 1/2/38

lvs opposite, often basally connate
buds with scales; flw often monosymmetric
K persistent in fruit
secoiridoids — 2/48/1090

AMBORELLALES	Amborellaceae
NYMPHAEALES	Cabombaceae · Hydatellaceae · Nymphaeaceae
AUSTROBAILEYALES	Austrobaileyaceae · Schisandraceae (*incl.* Illiciaceae) · Trimeniaceae
CHLORANTHALES	Chloranthaceae
CANELLALES	Canellaceae · Winteraceae
PIPERALES	Aristolochiaceae (*incl.* Hydnoraceae) · Piperaceae · Saururaceae
LAURALES	Calycanthaceae · Hernandiaceae · Monimiaceae Gomortegaceae · Lauraceae · Siparunaceae
MAGNOLIALES	Annonaceae · Eupomatiaceae · Magnoliaceae Degeneriaceae · Himantandraceae · Myristicaceae
ACORALES	Acoraceae
ALISMATALES	Alismataceae · Butomaceae · Posidoniaceae · Scheuchzeriaceae Aponogetonaceae · Hydrocharitaceae · Potamogetonaceae · Tofieldiaceae Araceae · Juncaginaceae · Ruppiaceae · Zosteraceae
DIOSCOREALES	Burmanniaceae · Dioscoreaceae · Nartheciaceae · Taccaceae · Thismiaceae
PANDANALES	Cyclanthaceae · Pandanaceae · Triuridaceae · Velloziaceae
LILIALES	Alstroemeriaceae · Corsiaceae · Melanthiaceae · Philesiaceae Colchicaceae · Liliaceae · Petermanniaceae · Smilacaceae
PETROSAVIALES	Petrosaviaceae
ASPARAGALES	Amaryllidaceae (*incl.* Agapanthaceae, Alliaceae) · Hypoxidaceae · Iridaceae Asparagaceae (*incl.* Agavaceae, Hyacinthaceae, Ruscaceae) · Lanariaceae · Orchidaceae Tecophilaeaceae · Asphodelaceae (*incl.* Xanthorrhoeaceae, Hemerocallidaceae)
ARECALES	Arecaceae · Dasypogonaceae
POALES	Bromeliaceae · Eriocaulaceae · Poaceae · Restionaceae · Xyridaceae Cyperaceae · Juncaceae · Rapateaceae · Typhaceae (*incl.* Sparganiaceae)
COMMELINALES	Commelinaceae · Haemodoraceae · Hanguanaceae Philydraceae · Pontederiaceae
ZINGIBERALES	Cannaceae · Heliconiaceae · Marantaceae · Strelitziaceae Costaceae · Lowiaceae · Musaceae · Zingiberaceae
CERATOPHYLLALES	Ceratophyllaceae
RANUNCULALES	Berberidaceae · Eupteleaceae · Menispermaceae · Ranunculaceae Circaeasteraceae · Lardizabalaceae · Papaveraceae
PROTEALES	Nelumbonaceae · Platanaceae · Proteaceae · Sabiaceae
TROCHODENDRALES	Trochodendraceae
BUXALES	Buxaceae (*incl.* Haptanthaceae)
GUNNERALES	Gunneraceae · Myrothamnaceae
DILLENIALES	Dilleniaceae
SAXIFRAGALES	Altingiaceae · Cynomoriaceae · Haloragaceae · Peridiscaceae Cercidiphyllaceae · Daphniphyllaceae · Hamamelidaceae · Paeoniaceae Crassulaceae · Grossulariaceae · Iteaceae · Saxifragaceae
VITALES	Vitaceae
ZYGOPHYLLALES	Krameriaceae · Zygophyllaceae
OXALIDALES	Brunelliaceae · Connaraceae · Elaeocarpaceae Cephalotaceae · Cunoniaceae · Huaceae · Oxalidaceae
CELASTRALES	Celastraceae (*incl.* Hippocrateaceae, Brexiaceae, Parnassiaceae) · Lepidobotryaceae
MALPIGHIALES	Achariaceae · Euphorbiaceae · Rafflesiaceae · Ochnaceae · Podostemaceae Chrysobalanaceae · Hypericaceae · Passifloraceae · Rhizophoraceae Clusiaceae · Linaceae · Phyllanthaceae · Salicaceae Erythroxylaceae · Malpighiaceae · Picrodendraceae · Violaceae
FABALES	Fabaceae · Polygalaceae · Quillajaceae · Surianaceae
ROSALES	Barbeyaceae · Elaeagnaceae · Rosaceae Cannabaceae · Moraceae · Ulmaceae Dirachmaceae · Rhamnaceae · Urticaceae (*incl.* Cecropiaceae)
CUCURBITALES	Apodanthaceae · Begoniaceae · Corynocarpaceae · Datiscaceae Anisophyllaceae · Coriariaceae · Cucurbitaceae · Tetramelaceae
FAGALES	Betulaceae · Fagaceae · Myricaceae Casuarinaceae · Juglandaceae · Nothofagaceae · Ticodendraceae
GERANIALES	Geraniaceae · Francoaceae (*incl.* Ledocarpaceae, Melianthaceae, Vivianiaceae)
MYRTALES	Combretaceae · Myrtaceae · Penaeaceae (*incl.* Oliniaceae) Lythraceae (*incl.* Punicaceae, Sonneratiaceae, Trapaceae) Melastomataceae (*incl.* Memecylaceae) · Onagraceae · Vochysiaceae
CROSSOSOMATALES	Crossosomataceae · Stachyuraceae Geissolomataceae · Staphyleaceae · Strasburgeriaceae
PICRAMNIALES	Picramniaceae
SAPINDALES	Anacardiaceae · Burseraceae · Kirkiaceae · Nitrariaceae · Sapindaceae Biebersteiniaceae · Meliaceae · Rutaceae · Simaroubaceae
HUERTEALES	Dipentodontaceae · Gerrardinaceae · Petenaeaceae · Tapisciaceae
MALVALES	Bixaceae · Malvaceae (*incl.* Bombacaceae, Sterculiaceae, Tiliaceae) Cistaceae · Cytinaceae · Muntingiaceae · Sarcolaenaceae Dipterocarpaceae · Neuradaceae · Sphaerosepalaceae · Thymelaeaceae
BRASSICALES	Bataceae · Caricaceae · Limnanthaceae · Salvadoraceae Brassicaceae · Cleomaceae · Moringaceae · Tovariaceae Capparaceae · Koeberliniaceae · Resedaceae · Tropaeolaceae
SANTALALES	Balanophoraceae · Misodendraceae · Opiliaceae · Schoepfiaceae Loranthaceae · Olacaceae · Santalaceae · Viscaceae
BERBERIDOPSIDALES	Aextoxicaceae · Berberidopsidaceae
CARYOPHYLLALES	Aizoaceae · Caryophyllaceae · Molluginaceae · Polygonaceae Amaranthaceae · Didiereaceae · Nepenthaceae · Portulacaceae Chenopodiaceae · Droseraceae · Nyctaginaceae · Simmondsiaceae Basellaceae · Drosophyllaceae · Phytolaccaceae · Talinaceae Cactaceae · Frankeniaceae · Plumbaginaceae · Tamaricaceae
CORNALES	Cornaceae · Grubbiaceae · Loasaceae Curtisiaceae · Hydrangeaceae · Hydrostachyaceae · Nyssaceae
ERICALES	Actinidiaceae · Ericaceae · Pentaphylacaceae · Sarraceniaceae Balsaminaceae · Fouquieriaceae · Polemoniaceae · Styracaceae Clethraceae · Lecythidaceae · Primulaceae · Symplocaceae Diapensiaceae · Marcgraviaceae · Roridulaceae · Theaceae Ebenaceae · Myrsinaceae · Sapotaceae · Theophrastaceae
ICACINALES	Oncothecaceae · Icacinaceae
METTENIUSALES	Metteniusaceae
GARRYALES	Eucommiaceae · Garryaceae (*incl.* Aucubaceae)
LAMIALES	Acanthaceae · Lamiaceae · Orobanchaceae · Plantaginaceae Bignoniaceae · Lentibulariaceae · Paulowniaceae · Scrophulariaceae Byblidaceae · Martyniaceae · Pedaliaceae · Stilbaceae Calceolariaceae · Gesneriaceae · Oleaceae · Phrymaceae · Verbenaceae
VAHLIALES	Vahliaceae
SOLANALES	Convolvulaceae (*incl.* Cuscutaceae) · Solanaceae (*incl.* Nolanaceae) Hydroleaceae · Montiniaceae · Sphenocleaceae
GENTIANALES	Apocynaceae (*incl.* Asclepiadaceae) · Loganiaceae Gentianaceae · Gelsemiaceae · Rubiaceae
BORAGINALES	Boraginaceae · Codonaceae · Coldeniaceae · Cordiaceae · Ehretiaceae (+ Lennoaceae) Heliotropiaceae · Hydrophyllaceae · Namaceae · Wellstediaceae
AQUIFOLIALES	Aquifoliaceae · Cardiopteridaceae · Stemonuraceae
ASTERALES	Asteraceae · Goodeniaceae · Pentaphragmataceae Calyceraceae · Menyanthaceae · Rousseaceae Campanulaceae (*incl.* Lobeliaceae) · Stylidiaceae
ESCALLONIALES	Escalloniaceae
BRUNIALES	Bruniaceae · Columelliaceae (*incl. Desfontainia*)
APIALES	Apiaceae · Griseliniaceae · Pennantiaceae Araliaceae · Myodocarpaceae · Pittosporaceae
PARACRYPHIALES	Paracryphiaceae
DIPSACALES	Adoxaceae Caprifoliaceae (*incl.* Dipsacaceae · Diervillaceae · Linnaeaceae · Morinaceae · Valerianaceae)



PLANT PHYLOGENY POSTERS ON RESEARCHGATE

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COLE TCH, HILGER HH, STEVENS PF (2019) Angiosperm Phylogeny Poster (APP)

- hypothetical tree based on molecular phylogenetic (chiefly plastid) data
- phylogeny, classification, and features chiefly follow APweb, APG, and PPA (Plastid Phylogenomic Angiosperm see Li HT et al. 2019)
- 64 orders and around 420 families currently recognized by APG IV (some minor families omitted here)
- contrary to APG, but in compliance with APweb and other seminal sources, we here recognize several families within Boraginales
- branch lengths deliberate, not expressing actual time scale
- the characters listed do not necessarily apply to all members of a clade
- position of various characters on the tree uncertain
- for family characteristics see: FGVP, Kubitzki K, ed. (1990 ff)
- orders (and higher ranks) are linked to the according pages on APweb
- numbers set in gray next to orders refer to families, genera, and species

* *Ceratophyllum*: the alleged tepals could be bracts (issue being addressed in ongoing research and debate)

Poster available in various languages on ResearchGate

References: Stevens PF (2022) APweb – www.mobot.org/MOBOT/research/APweb
APG IV (2016); Judd W et al. (2016); Li HT et al. (2019); Simpson M (2020); Soltis DE et al. (2014); Watson/Dallwitz (2018)

Acknowledgements to our contributors, translators, and consultants: Rubina Abid, Julien B. Bachelier, Przemysław Baranow, Zoltán Barina, Fernanda Antunes Carvalho, Christoph Dobeš[†], Johannes Enroth, Ray F. Evert, Mohamed Fennane, Marc Gottschling, Zigmantas Gudžinskas, Michal Hroneš, Akitoshi Iwamoto, Chen-Kun Jiang, Anna Kagiampaki, Kent Kainulainen, Elizabeth A. Kellogg, Sangtae Kim, Aslı Doğru-Koca, Nikos Krigas, Sanjay Kumar, Luboš Majeský, Pavol Mártonfi, Diego Medan, Sergei L. Mosyakin, Sofi Mursidawati, Dashzeveg Nyambayar, Anastasiya V. Odintsova, Richard G. Olmstead, Batlai Oyuntsetseg, Peter H. Raven, Yasaman Salmaki, Federico Selvi, Paramjit Singh, Douglas E. Soltis, Stoyan Stoyanov, Bach The Tran, Pramote Triboun, Zoya M. Tsymbalyuk, Orzimat T. Turginov, Magsar Urgamal, Vladimir Vladimirov, Maximilian Weigend, Michael Wink, Shahin Zarre