The “how” and “why” of botanical nomenclature

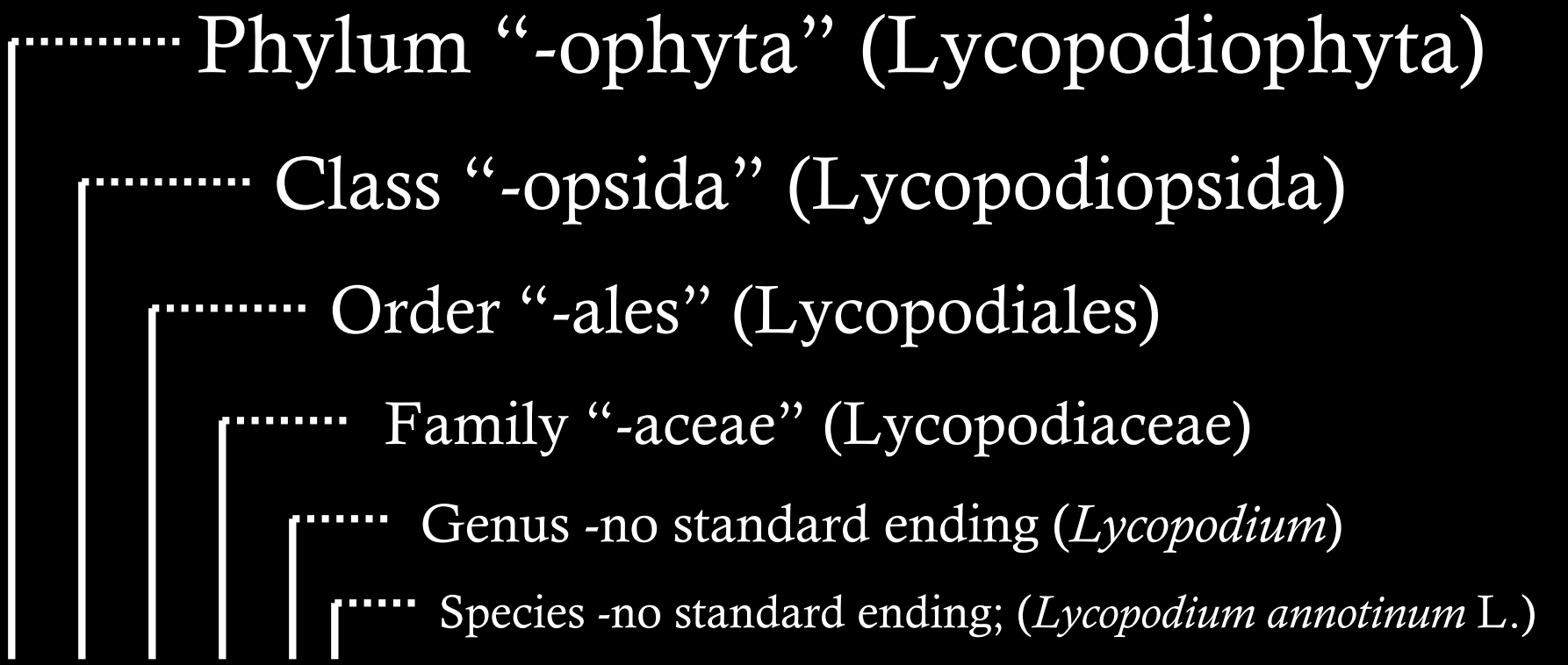
P.J. Alexander
New Mexico State University

Why bother?

- most plants have informal names in English, why not just use those?
  - communication across languages
  - precision & ability to track names through time:
    is your "catclaw" the same as my "catclaw"?
  - information about relationships:
    "Syrian rue", "common rue", and "meadow rue" are not closely related!
  - all research in biology is going to depend, to some extent, on the identity of organisms!

Formal scientific names…

- named units in our classification are called "taxa" (singular "taxon");
- taxa belong to hierarchical ranks; ranks above "genus" are indicated by standard endings.



How we make names…

Formal botanical names are governed by the International Code of Botanical Nomenclature (ICBN). You can find the current version online: http://ibot.sav.sk/icbn/main.htm

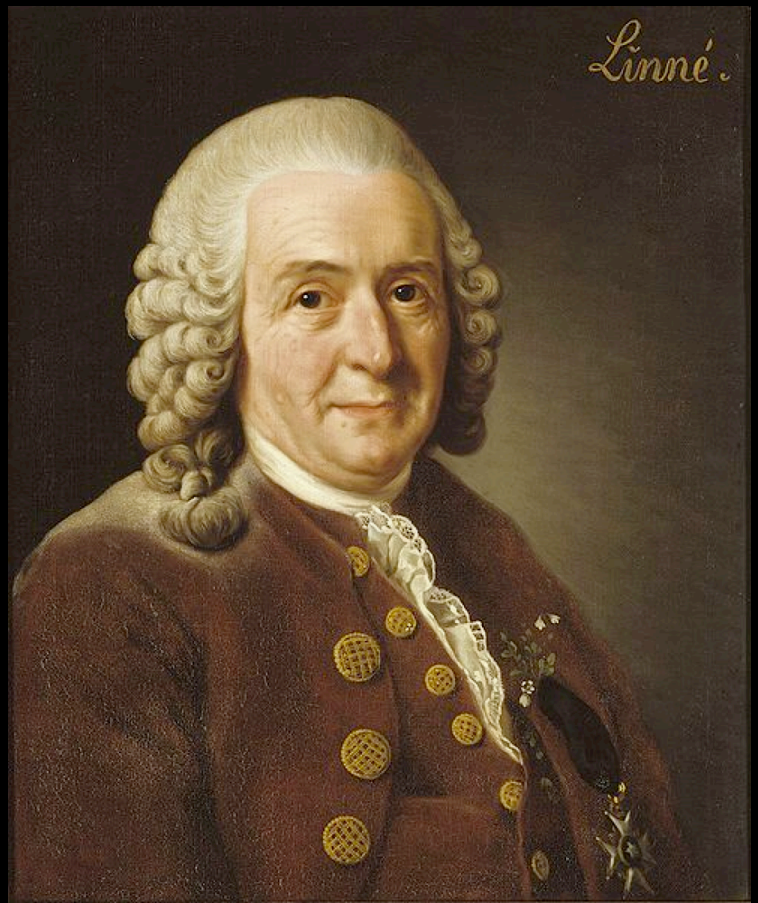
These rules don't tell you *what* to name, but describe *how* you can put names on taxa and what to do if there are multiple names published in the literature that refer to the same taxon (*synonyms*).

Carolus Linnaeus (or Carl von Linné)

Swedish botanist, physician, and zoologist, 1707-1778.

Linnaeus was the first to consistently use many formal aspects of modern nomenclature (most of the same ranks, and binomials for species).

His work, specifically the *Species Plantarum* of 1753 is recognized as the beginning point of modern botanical nomenclature under the ICBN.



So, how do we name a new species?

We'll limit ourselves to the formal process for the moment & ignore *why* we think something is a new species… the ICBN gives four requirements:

- Give it a binomial!
- Provide a type specimen.
- Provide a Latin diagnosis.
- Get it published.

How do we name a new species?

- Give it a binomial!

Stellaria porsildii Chinnappa, sp. nov. (fig. 1).—TYPE: U.S.A., New Mexico, Grant Co., Signal Peak, along the slopes, Gila National Forest, Pinos Altos Range, ponderosa pine-Douglas fir zone, in shaded area, ca. 2400 m, access road to Signal Peak, Rt. 157 off State Hwy. 15 N of Silver City past Pinos Altos, 14 Jun 1987, *Chinnappa et al. 2934* (holotype: UAC; isotypes: CAN, DAO, NMC).—PARATYPES: U.S.A., Arizona, Cochise Co., Chiricahua Mts., Fly Park, 7 Jul 1907 (fl), *Blumer 1602* (ARIZ, DS, NMC, RM); Chiricahua Mts., *Blumer 17* (ARIZ); Meadows, Rustler's Park, 18–19 Jun 1930, *Goodman & Hitchcock 1188* (ARIZ, DS, RM, UC). New Mexico type locality, 2 June 1968 (fl), *Hess 1963* (NMC, OKL, RM, UNM, WTU).

Herba recta rhizomatis tenuibus perennans; caulibus rectis uniformiter in umbris sparsis; interdum in globis crescens sed numquam dense implicata; caulis 9–18 (13) cm longis, glabris; foliis viridibus, linearibus vel lineari-lanceolatis 27–35 (31) mm longis, in base ciliatis. Flores solitarii in normalium foliorum viridium axillis, pedunculi 18–32 (26) mm longis; sepalis viridibus, glabris, ovato-lanceolatis 4–6 (5) mm longis; petalis latissimis calycem superantibus. Flores protandri, sibi congruentes. Capsulae oblongae, nigrae, 6–8 (7) mm longis; seminibus fuscis 0.8–1.0 (0.9) mm in diametro. Chromosomatum numerus $2n = 26$.

How do we name a new species?

- Give it a binomial!

Heuchera woodsiaphila P.J. Alexander, sp. nov. (**Figs. 1–3**). TYPE: U.S.A. NEW MEXICO. Lincoln Co.: NE side of Capitan Peak on the upper part of the Capitan Peak Trail, 33° 35' 37"N 105° 15' 31.5"W, elev. 9200 ft, steep NE slope, duff soil among granite boulders in stabilized, forested talus, 17 Jul 2006, *P.J. Alexander 390*. (HOLOTYPE: NMC; ISOTYPES: UNM, ARIZ, ALA, MO, DUKE).

Species novum characteribus *Heuchera* sect. *Holochloa* Nutt. subsect. *Cylindricae* Rydb., maxime similis a *Heuchera saxicola* E. Nels. (Idaho, Montana, Oregon) a qua differt foliis basibus cordatis, pubescentia viscido carenti, et bracteis superis brevioribus (a 5 mm). Differt a *Heuchera* cetera in New Mexico floribus petala carentibus ac sepala erectas viridi-albas vel cremeas.

How do we name a new species?

- Provide a type specimen.

Stellaria porsildii Chinnappa, sp. nov. (fig. 1).—TYPE: U.S.A., New Mexico, Grant Co., Signal Peak, along the slopes, Gila National Forest, Pinos Altos Range, ponderosa pine-Douglas fir zone, in shaded area, ca. 2400 m, access road to Signal Peak, Rt. 157 off State Hwy. 15 N of Silver City past Pinos Altos, 14 Jun 1987, *Chinnappa et al. 2934* (holotype: UAC; isotypes: CAN, DAO, NMC).—PARATYPES: U.S.A., Arizona, Cochise Co., Chiricahua Mts., Fly Park, 7 Jul 1907 (fl), *Blumer 1602* (ARIZ, DS, NMC, RM); Chiricahua Mts., *Blumer 17* (ARIZ); Meadows, Rustler's Park, 18–19 Jun 1930, *Goodman & Hitchcock 1188* (ARIZ, DS, RM, UC). New Mexico type locality, 2 June 1968 (fl), *Hess 1963* (NMC, OKL, RM, UNM, WTU).

Herba recta rhizomatis tenuibus perennans; caulibus rectis uniformiter in umbris sparsis; interdum in globis crescens sed numquam dense implicata; caulis 9–18 (13) cm longis, glabris; foliis viridibus, linearibus vel lineari-lanceolatis 27–35 (31) mm longis, in base ciliatis. Flores solitarii in normalium foliorum viridium axillis, pedunculi 18–32 (26) mm longis; sepalis viridibus, glabris, ovato-lanceolatis 4–6 (5) mm longis; petalis latissimis calycem superantibus. Flores protandri, sibi congruentes. Capsulae oblongae, nigrae, 6–8 (7) mm longis; seminibus fuscis 0.8–1.0 (0.9) mm in diametro. Chromosomatum numerus $2n = 26$.

How do we name a new species?

- Provide a type specimen.

How do we name a new species?

- Provide a type specimen.

Heuchera woodsiaphila P.J. Alexander, sp. nov. (**Figs. 1–3**). TYPE: U.S.A. NEW MEXICO. Lincoln Co.: NE side of Capitan Peak on the upper part of the Capitan Peak Trail, 33° 35' 37"N 105° 15' 31.5"W, elev. 9200 ft, steep NE slope, duff soil among granite boulders in stabilized, forested talus, 17 Jul 2006, *P.J. Alexander 390*. (HOLOTYPE: NMC; ISOTYPES: UNM, ARIZ, ALA, MO, DUKE).

Species novum characteribus *Heuchera* sect. *Holochloa* Nutt. subsect. *Cylindricae* Rydb., maxime similis a *Heuchera saxicola* E. Nels. (Idaho, Montana, Oregon) a qua differt foliis basibus cordatis, pubescentia viscido carenti, et bracteis superis brevioribus (a 5 mm). Differt a *Heuchera* cetera in New Mexico floribus petala carentibus ac sepala erectas viridi-albas vel cremeas.

How do we name a new species?

- Provide a type specimen.

How do we name a new species?

- Provide a Latin diagnosis.

Stellaria porsildii Chinnappa, sp. nov. (fig. 1).—TYPE: U.S.A., New Mexico, Grant Co., Signal Peak, along the slopes, Gila National Forest, Pinos Altos Range, ponderosa pine-Douglas fir zone, in shaded area, ca. 2400 m, access road to Signal Peak, Rt. 157 off State Hwy. 15 N of Silver City past Pinos Altos, 14 Jun 1987, *Chinnappa et al. 2934* (holotype: UAC; isotypes: CAN, DAO, NMC).—PARATYPES: U.S.A., Arizona, Cochise Co., Chiricahua Mts., Fly Park, 7 Jul 1907 (fl), *Blumer 1602* (ARIZ, DS, NMC, RM); Chiricahua Mts., *Blumer 17* (ARIZ); Meadows, Rustler's Park, 18–19 Jun 1930, *Goodman & Hitchcock 1188* (ARIZ, DS, RM, UC). New Mexico type locality, 2 June 1968 (fl), *Hess 1963* (NMC, OKL, RM, UNM, WTU).

Herba recta rhizomatis tenuibus perennans; caulibus rectis uniformiter in umbris sparsis; interdum in globis crescens sed numquam dense implicata; caulis 9–18 (13) cm longis, glabris; foliis viridibus, linearibus vel lineari-lanceolatis 27–35 (31) mm longis, in base ciliatis. Flores solitarii in normalium foliorum viridium axillis, pedunculi 18–32 (26) mm longis; sepalis viridibus, glabris, ovato-lanceolatis 4–6 (5) mm longis; petalis latissimis calycem superantibus. Flores protandri, sibi congruentes. Capsulae oblongae, nigrae, 6–8 (7) mm longis; seminibus fuscis 0.8–1.0 (0.9) mm in diametro. Chromosomatum numerus $2n = 26$.

How do we name a new species?

- Provide a Latin diagnosis.

Heuchera woodsiaphila P.J. Alexander, sp. nov. (**Figs. 1–3**). TYPE: U.S.A. NEW MEXICO. Lincoln Co.: NE side of Capitan Peak on the upper part of the Capitan Peak Trail, 33° 35' 37"N 105° 15' 31.5"W, elev. 9200 ft, steep NE slope, duff soil among granite boulders in stabilized, forested talus, 17 Jul 2006, *P.J. Alexander 390*. (HOLOTYPE: NMC; ISOTYPES: UNM, ARIZ, ALA, MO, DUKE).

Species novum characteribus *Heuchera* sect. *Holochloa* Nutt. subsect. *Cylindricae* Rydb., maxime similis a *Heuchera saxicola* E. Nels. (Idaho, Montana, Oregon) a qua differt foliis basibus cordatis, pubescentia viscido carenti, et bracteis superis brevioribus (a 5 mm). Differt a *Heuchera* cetera in New Mexico floribus petala carentibus ac sepala erectas viridi-albas vel cremeas.

Diagnosis & type specimen: two kinds of definition

The type specimen provides an extensive definition, "pointing at" the organism. Designating a type specimen means that your binomial refers to "whatever set of individuals is in the same species as *that plant*".

The Latin diagnosis provides an intensive definition, describing features of the taxon that allow it to be distinguished from closely related species.

If we're in doubt later on, the type specimen "trumps" the diagnosis.

How do we name a new species?

- Get it published.

Stellaria porsildii Chinnappa was published in the journal *Systematic Botany* in 1992.

Heuchera woodsiaphila P.J.Alexander was published in the *Journal of the Botanical Research Institute of Texas* in 2008.

A name is validly published:

"by distribution of printed matter to the general public or at least to botanical institutions with libraries accessible to botanists generally."

Supraspecific nomenclature

- nomenclature at the genus & family ranks follows the same process as naming species:

  except that the type specimen of a genus must also be the type specimen of a species (so sometimes the species is referred to as the "type");

  and family names must be based on genus names (as in Asteraceae, Ranunculaceae, Brassicaceae, etc.).

Johnstonia Tortosa, gen. nov. TYPE: *Johnstonia axilliflora* (M. C. Johnston) Tortosa.

Rhamnacearum, a genere *Gouaniam* lobulis disci carentibus, floribus geminis ad axillam foliorum, absentia ramulorum in capreolos terminantes differt; *Alvimianthae* et *Reissekiae* affinis, sed floribus geminatis sessilibus ab eis recedens, ab *Alvimiantha* differt mericarpiis integris.

1. Johnstonia axilliflora (M. C. Johnston) Tortosa, comb. nov. Basionym: *Gouania axilliflora* M. C. Johnston, Syst. Bot. 13: 493. 1988. TYPE: Peru. Department of Cajamarca, Province of Cajabamba, Condebamba valley, Cajabamba–Cajamarca road, 15 Feb. 1983, *D. N. Smith & R. Vásquez M. 3396* (holotype, TEX; isotypes (not seen) AMAZ, CPUN, HUT, MO, USM).

Above the family rank things get a little bit odd, but we'll ignore that for the moment…

Synonyms

Synonyms are names that mean the same thing; just like in ordinary English, except that now we're talking about formal names governed by the ICBN. Synonyms refer to the same taxon.

We can have synonyms for a few reasons:

1 changes in our understanding about whether species are or are not distinct;

2 a species has been moved from one genus to another;

3 the rank of a species, subspecies, or variety has changed.

Synonyms

Here's an example:

- in 1887 Sereno Watson (abbreviated "S.Wats.") published the new name "*Arabis perennans* S.Wats.";
- in 1982, William Weber moved *Arabis perennans* from the genus *Arabis* to the genus *Boechera*; he published the new combination "*Boechera perennans* (S.Wats.) W.A.Weber".

Arabis perennans S.Wats. and *Boechera perennans* (S.Wats.) W.A.Weber are synonyms.

Synonyms

3. Dieteria canescens (Pursh) Nutt., Trans. Amer. Philos. Soc., ser. 2, 7:300. 1840. BASIONYM: *Aster canescens* Pursh, Fl. Amer. Sept. 2:547, 1813. *Machaeranthera canescens* (Pursh) A. Gray, Pl. Wright. 1:89. 1852. TYPE: U.S.A. NORTH DAKOTA: "on the denuded banks of the Missouri" (vicinity of Fort Mandon), 1811, *Nuttall s.n.* (HOLOTYPE: BM; possible ISOTYPE: NDG).

Dieteria viscosa Nutt., Trans. Amer. Philos. Soc., ser. 2, 7:301. 1840. *Aster canescens* Pursh var. *viscosus* (Nutt.) A. Gray, Proc. Amer. Acad. Arts 16:99 1880. *Machaeranthera viscosa* (Nutt.) Greene, Pittonia 4:22. 1899. *Machaeranthera canescens* (Pursh) A. Gray var. *viscosa* (Nutt.) Piper, Contr. U.S. Natl. Herb. 11:576. 1905. TYPE: U.S.A. NEBRASKA. Scotts Bluff Co.: "near Scott's Bluff, on the Platte," 1834, *Nuttall s.n.* (HOLOTYPE: BM).

Dieteria divaricata Nutt., Trans. Amer. Philos. Soc., ser. 2, 7:301. 1840. *Machaeranthera divaricata* (Nutt.) Greene, Pittonia 4:23. 1899. TYPE: U.S.A.: "denudated plains of the Rocky Mountains and Oregon, common," 1834, *Nuttall s.n.* (HOLOTYPE: GH).

Dieteria pulverulenta Nutt., Trans. Amer. Philos. Soc., ser. 2, 7:300. 1840. *Machaeranthera pulverulenta* (Nutt.) Greene, Pittonia 4:23. 1899. TYPE: U.S.A.: "arid plains towards the sources of the Platte," 1834, *Nuttall s.n.* (HOLOTYPE: PH).

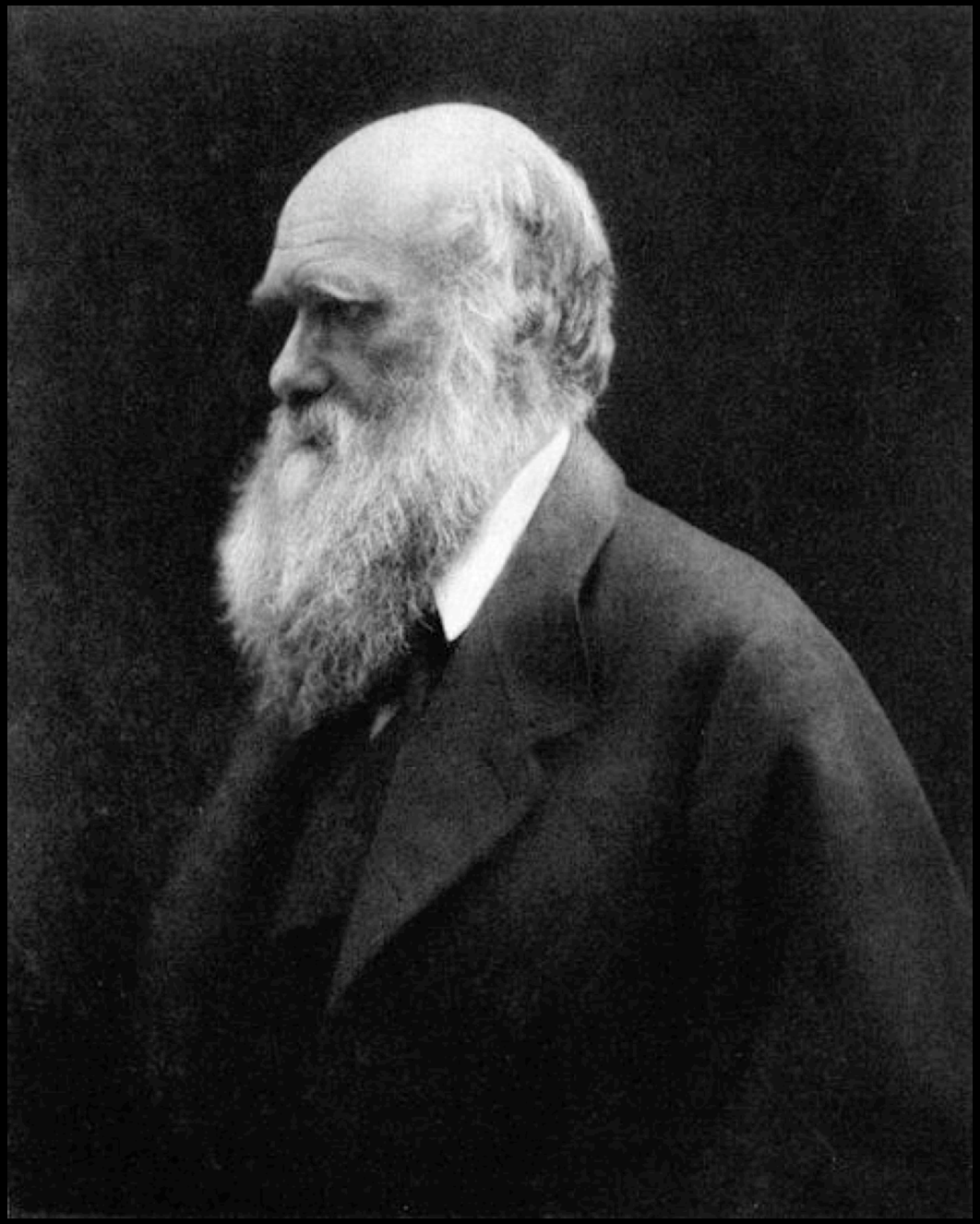
Machaeranthera laetevirens Greene, Pittonia 3:61. 1896. *Aster leiodes* Blake, Contr. U.S. Natl. Herb. 25:563. 1925, nom. nov., non Aster *laetevirens* Greene (1900). TYPE: U.S.A. NEVADA. Elko Co.: Clover Mountains, 26 Jul 1894, *E.L. Greene s.n.* (HOLOTYPE: NDG; ISOTYPE: NDG).

Machaeranthera latifolia A. Nelson, Proc. Biol. Soc. Wash. 20:38. 1907. *Machaeranthera canescens* (Pursh) A. Gray var. *latifolia* (A. Nelson) S.L. Welsh, Great Basin Naturalist Mem. 9:213. 1987. *Machaeranthera canescens* (Pursh) A. Gray var. *monticola* Dorn, Vascular Pl. Wyo. 295. 1988. TYPE: U S.A. UTAH. Salt Lake Co.: Big Cottonwood Canyon, 8950 ft, 9 Aug 1933, *A. O. Garrett 1933* (HOLOTYPE: RM!; ISOTYPES: GH, LL!, US).

Why we change names…

This guy introduced the idea that species are historically related to each other through evolutionary processes.

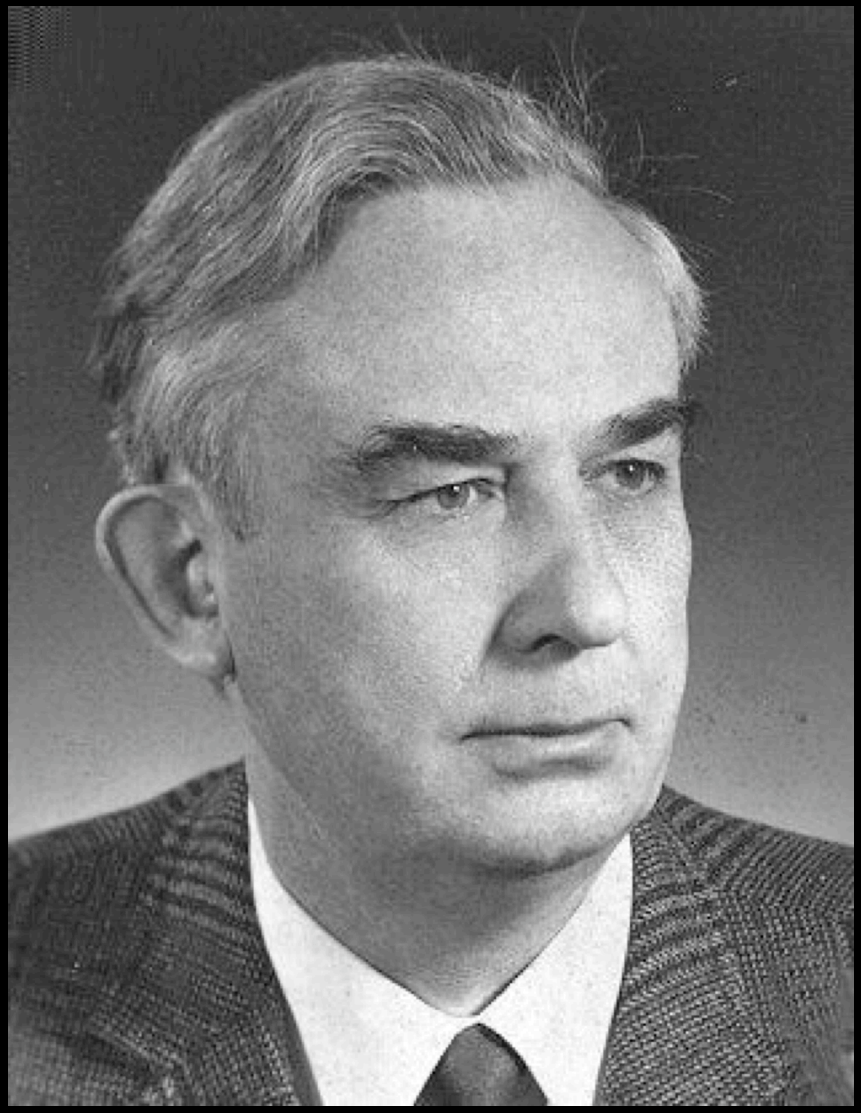
If these species are all related to each other, shouldn't our classification be based on those shared relationships?



The "Natural System"

Willi Hennig, went further. He argued that our classification should only name monophyletic groups (also called clades).

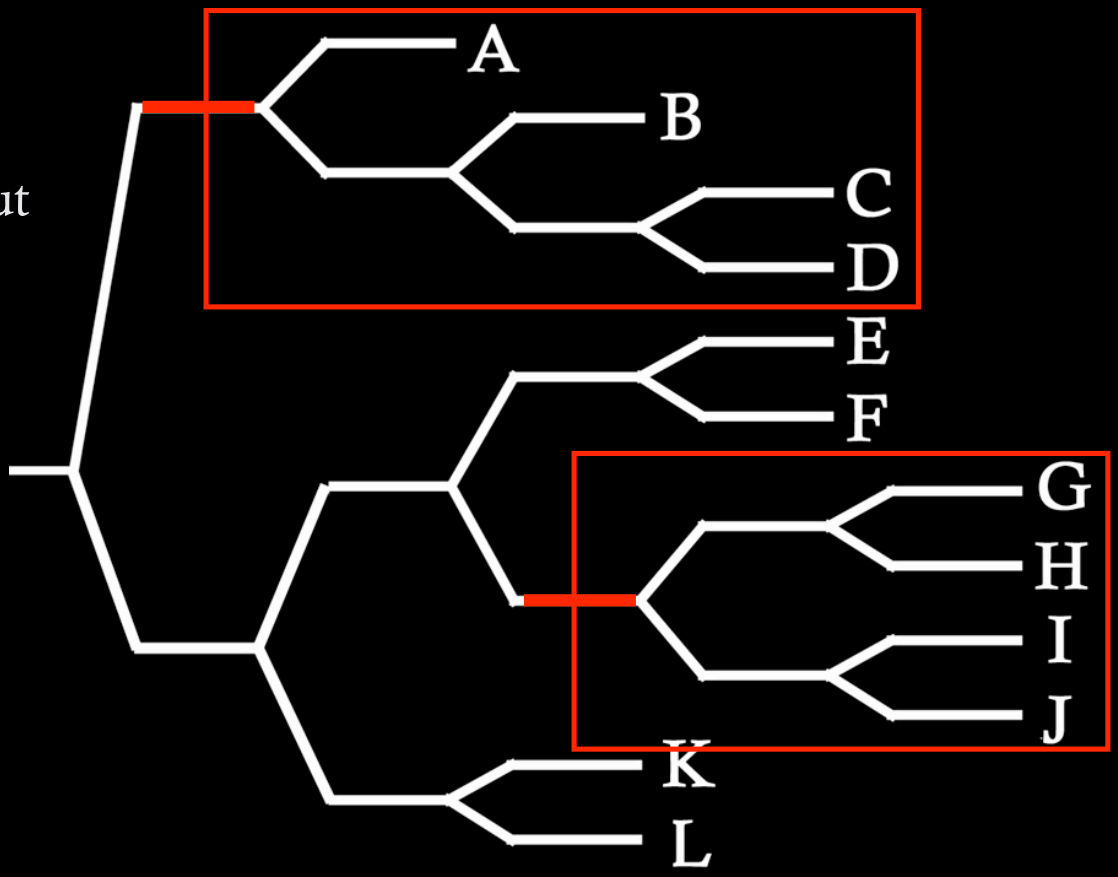
Most of the time, when species move between genera or genera move between families, this is based on new information indicating that the old classification recognized paraphyletic groups; so we change the classification to avoid this.



Monophyly vs. paraphyly

•a monophyletic group is one that includes an ancestor and all of its descendants;

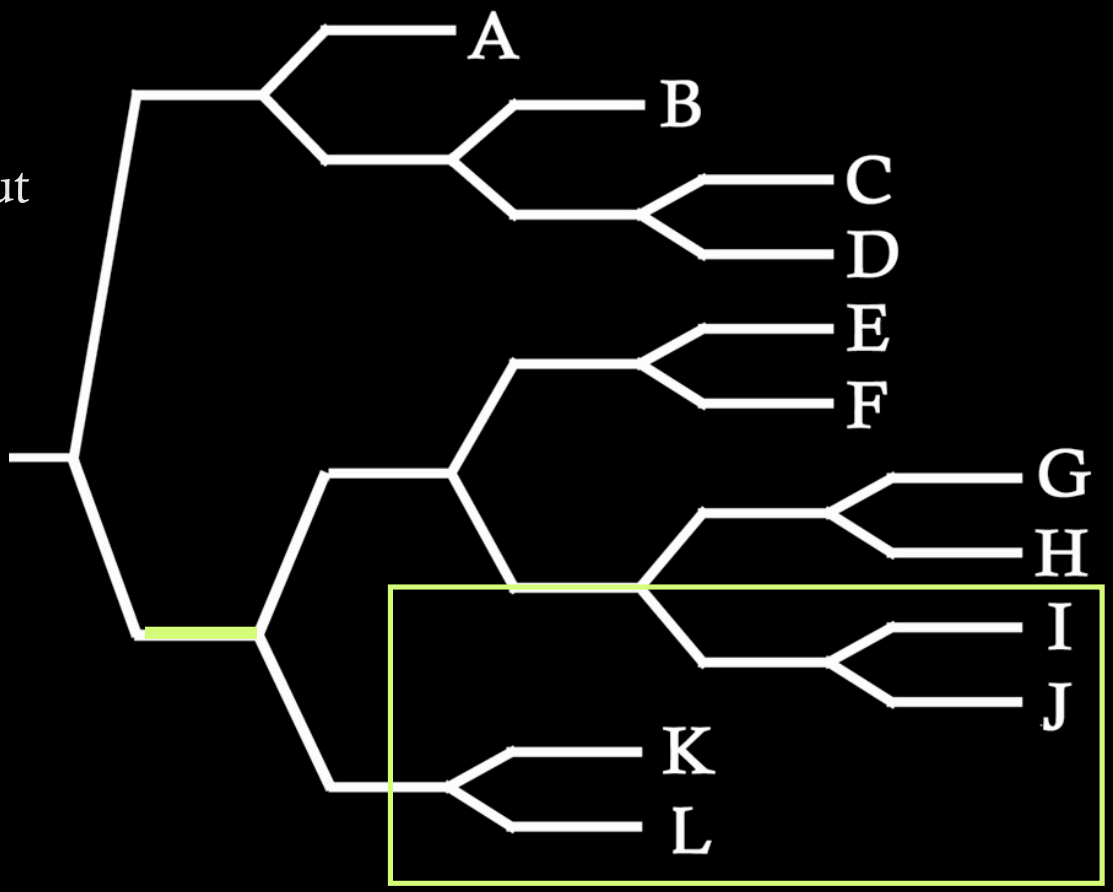
• a paraphyletic group is one that includes an ancestor and some, but not all, of its descendants.



Monophyly vs. paraphyly

•a monophyletic group is one that includes an ancestor and all of its descendants;

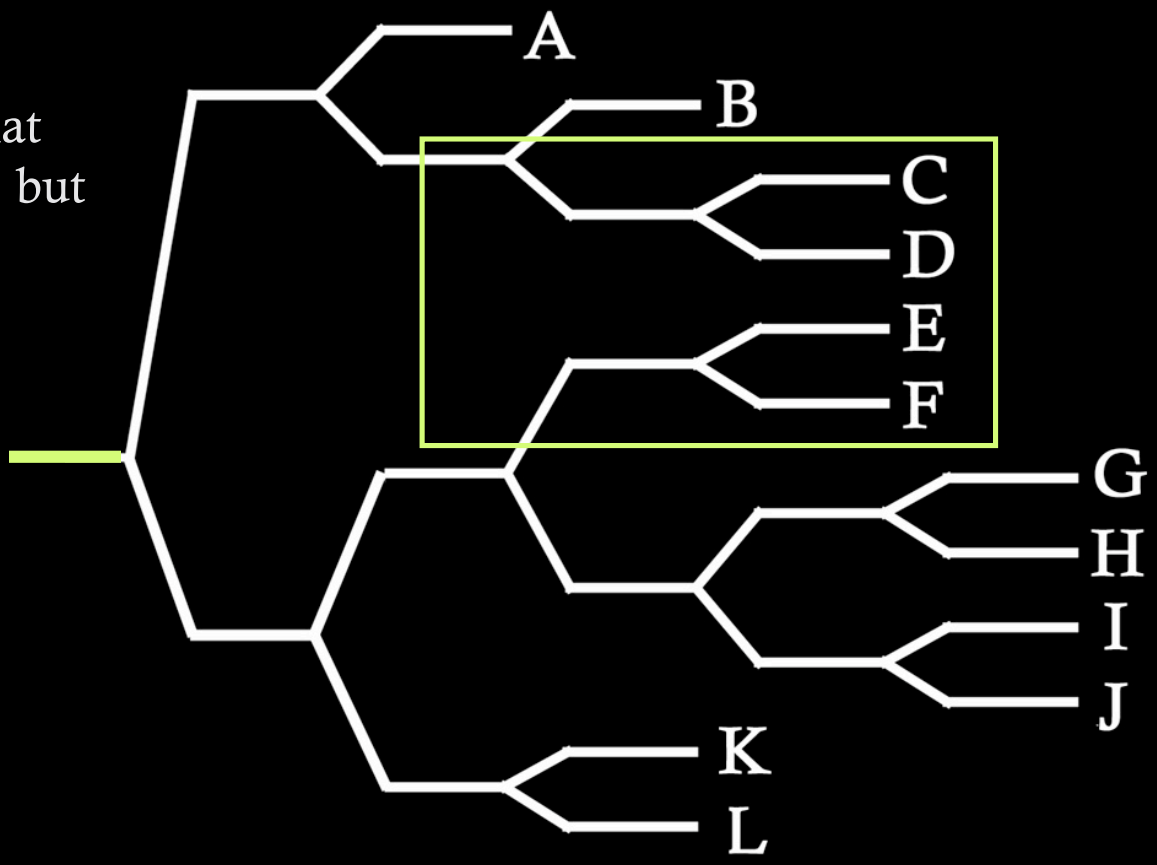
• a paraphyletic group is one that includes an ancestor and some, but not all, of its descendants.



Monophyly vs. paraphyly

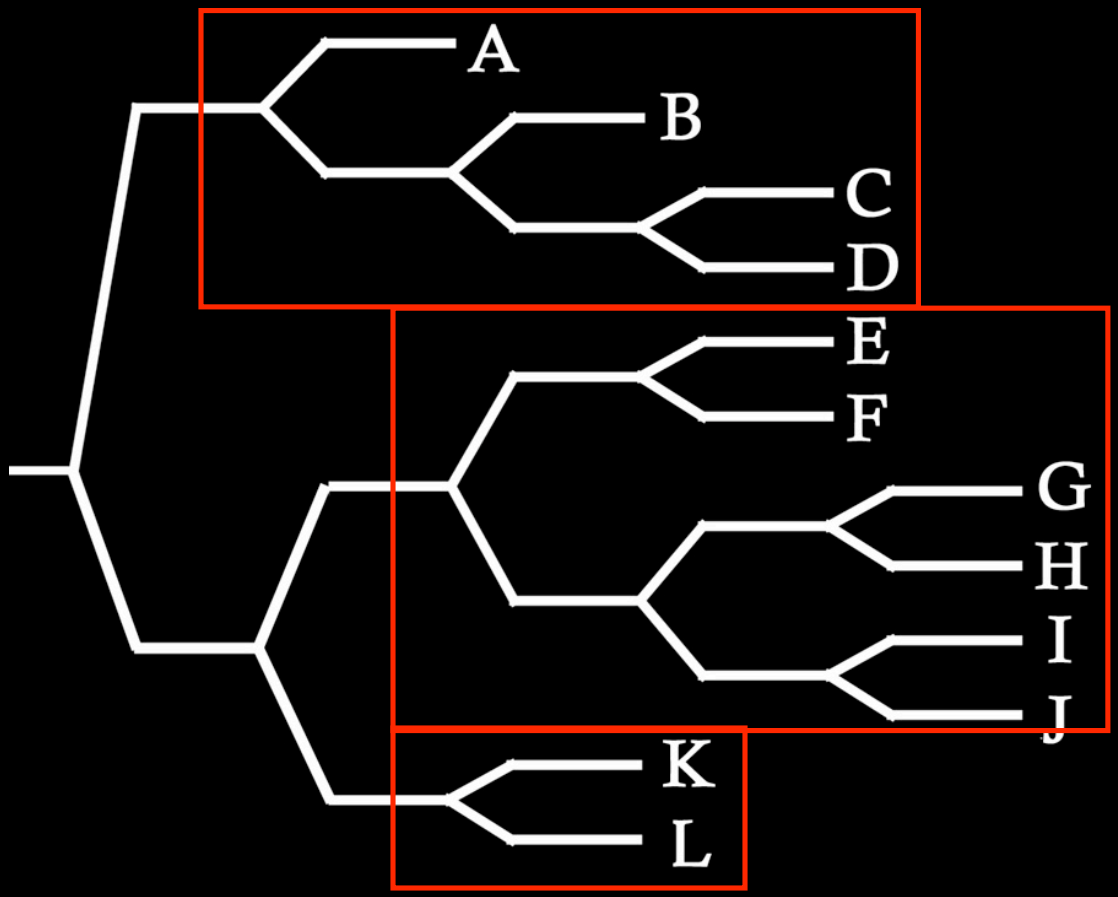
•a monophyletic group is one that includes an ancestor and all of its descendants;

• a paraphyletic group is one that includes an ancestor and some, but not all, of its descendants.



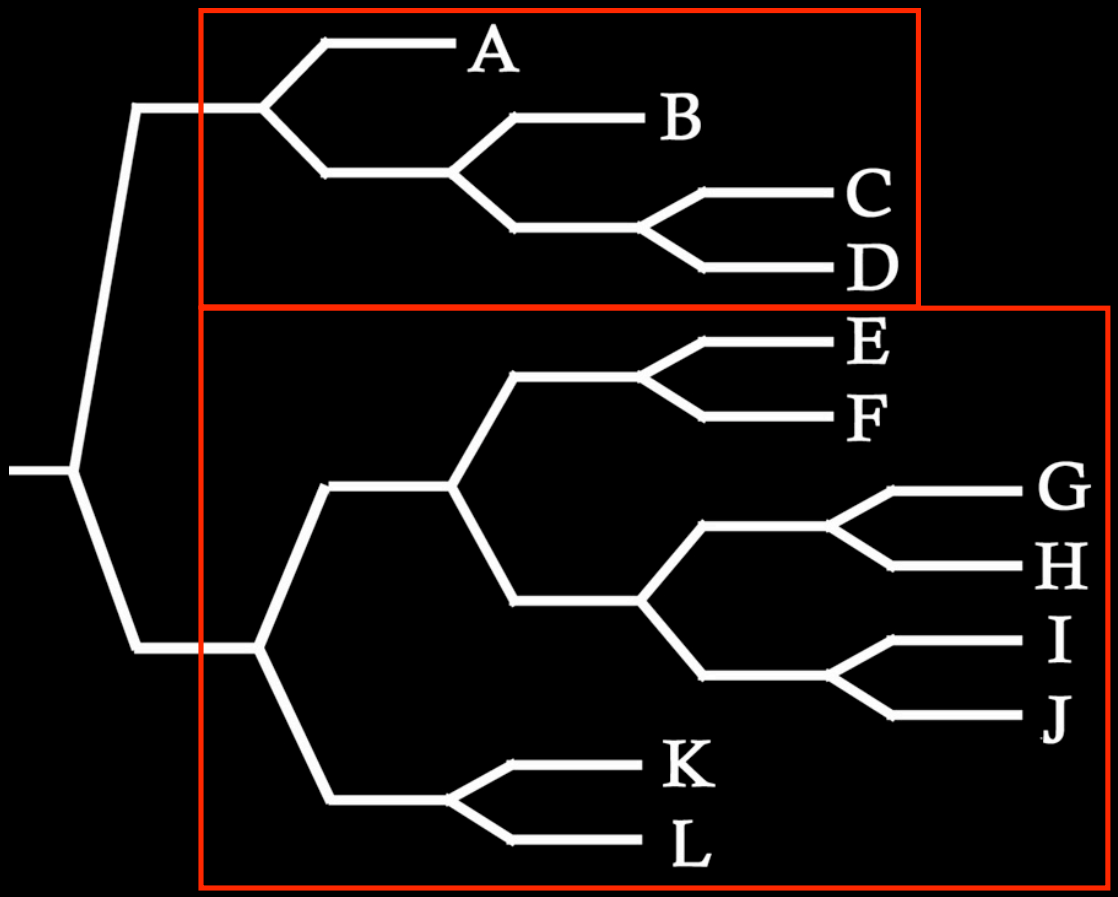
Monophyly vs. paraphyly

So, if we're cladists, we have a couple of different options if we're grouping species into genera…



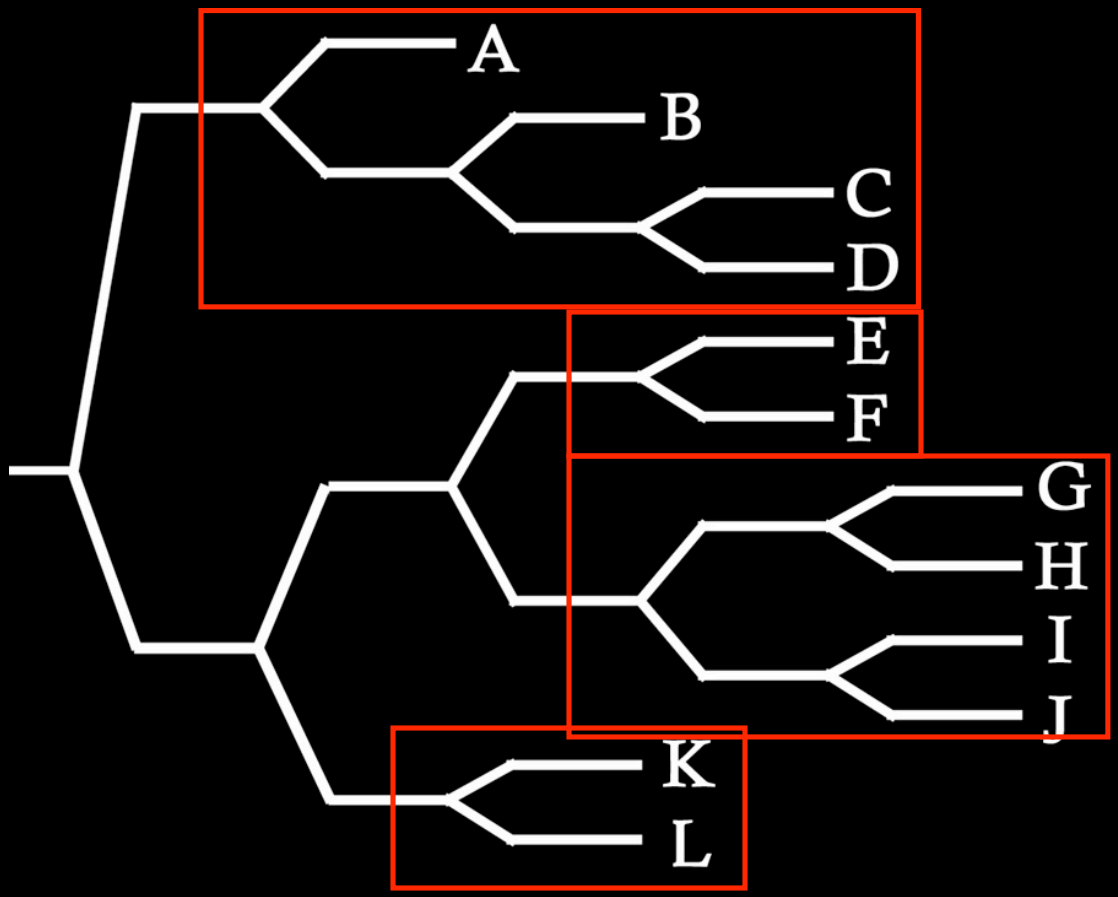
Monophyly vs. paraphyly

So, if we're cladists, we have a couple of different options if we're grouping species into genera…



Monophyly vs. paraphyly

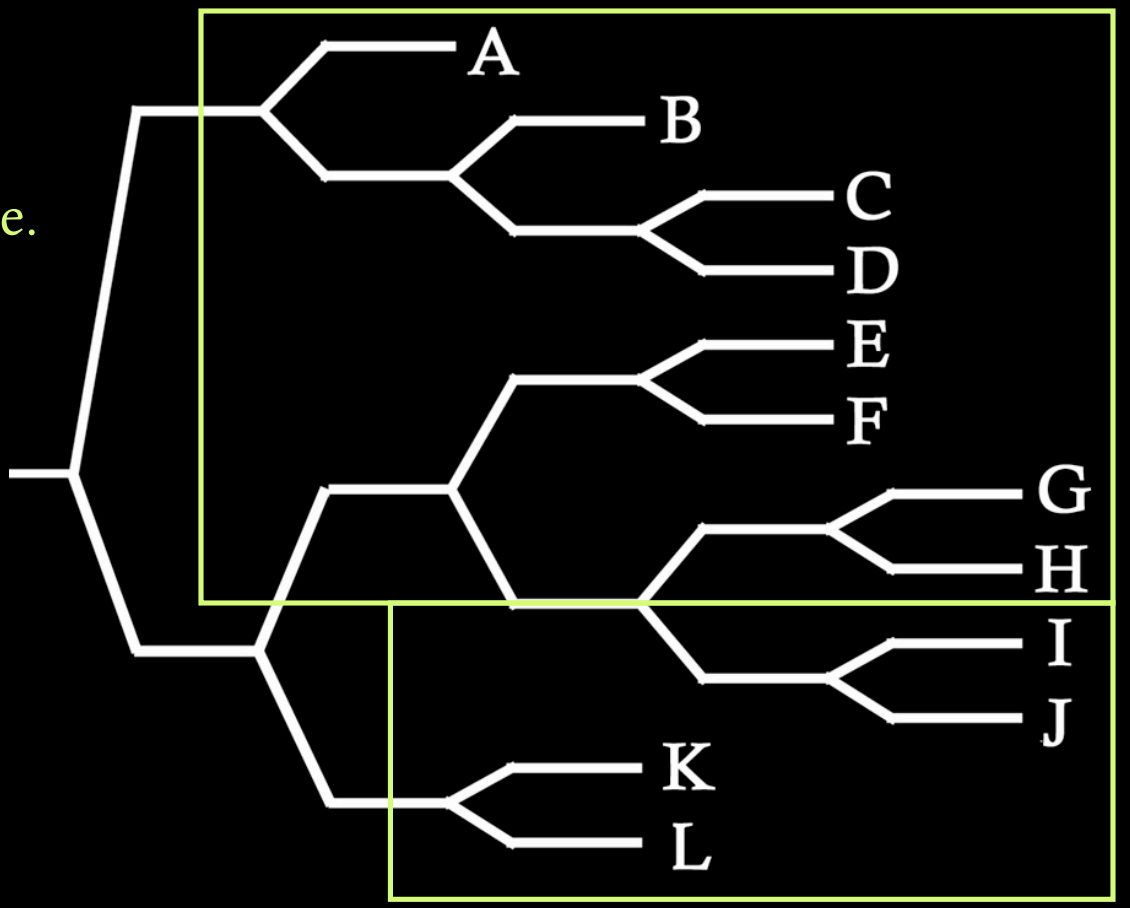
So, if we're cladists, we have a couple of different options if we're grouping species into genera…



Monophyly vs. paraphyly

So, if we're cladists, we have a couple of different options if we're grouping species into genera…

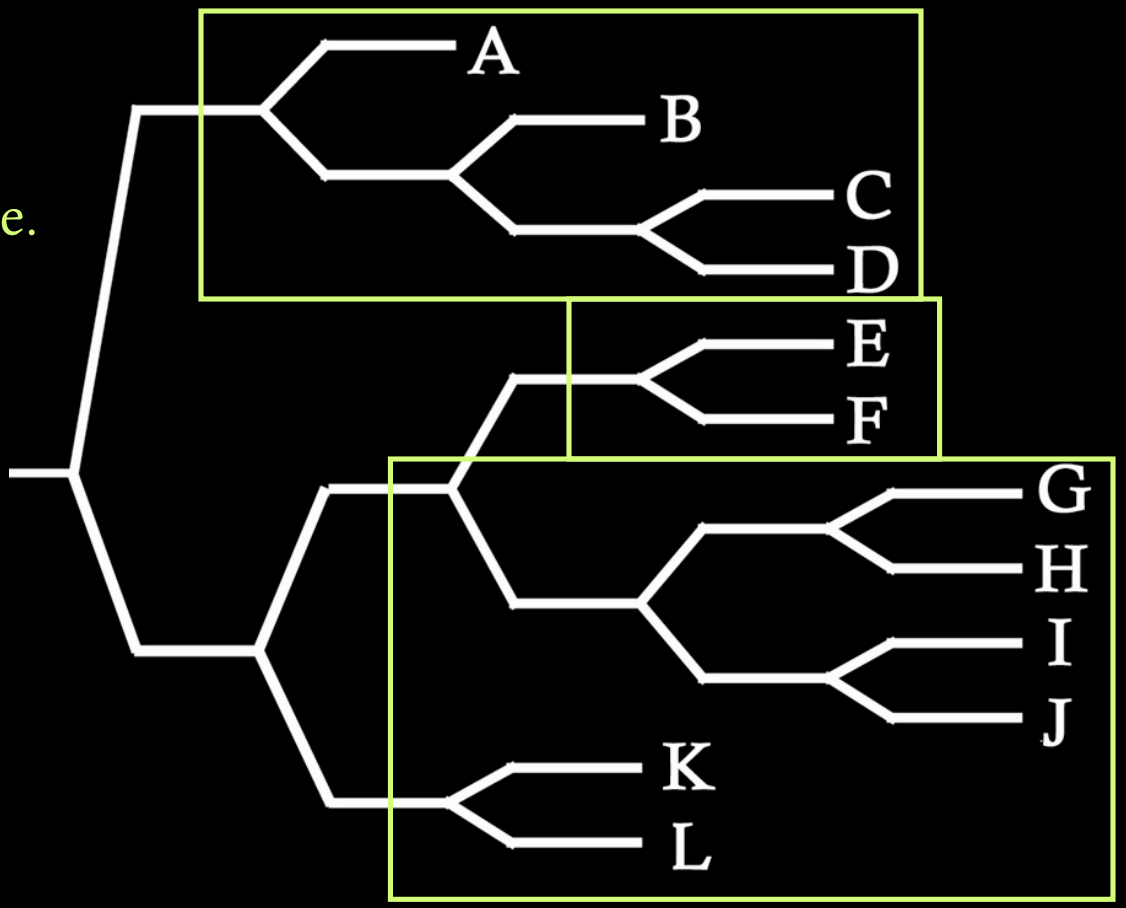
but some options aren't available.



Monophyly vs. paraphyly

So, if we're cladists, we have a couple of different options if we're grouping species into genera…

but some options aren't available.



How do we get those trees?

Usually with genetic sequence data. The very short version:

- start with a bunch of individual plant specimens;
- extract DNA from them;
- choose a particular portion of DNA to look at; maybe a particular gene;
- get sequences of that gene for each plant;
- use one of several methods of analysis to infer a set of relationships between those plants;

    for instance, parsimony is a method that looks among the various *possible* trees and chooses the tree that requires the fewest evolutionary changes in our sequence data.

An example… *Acacia*

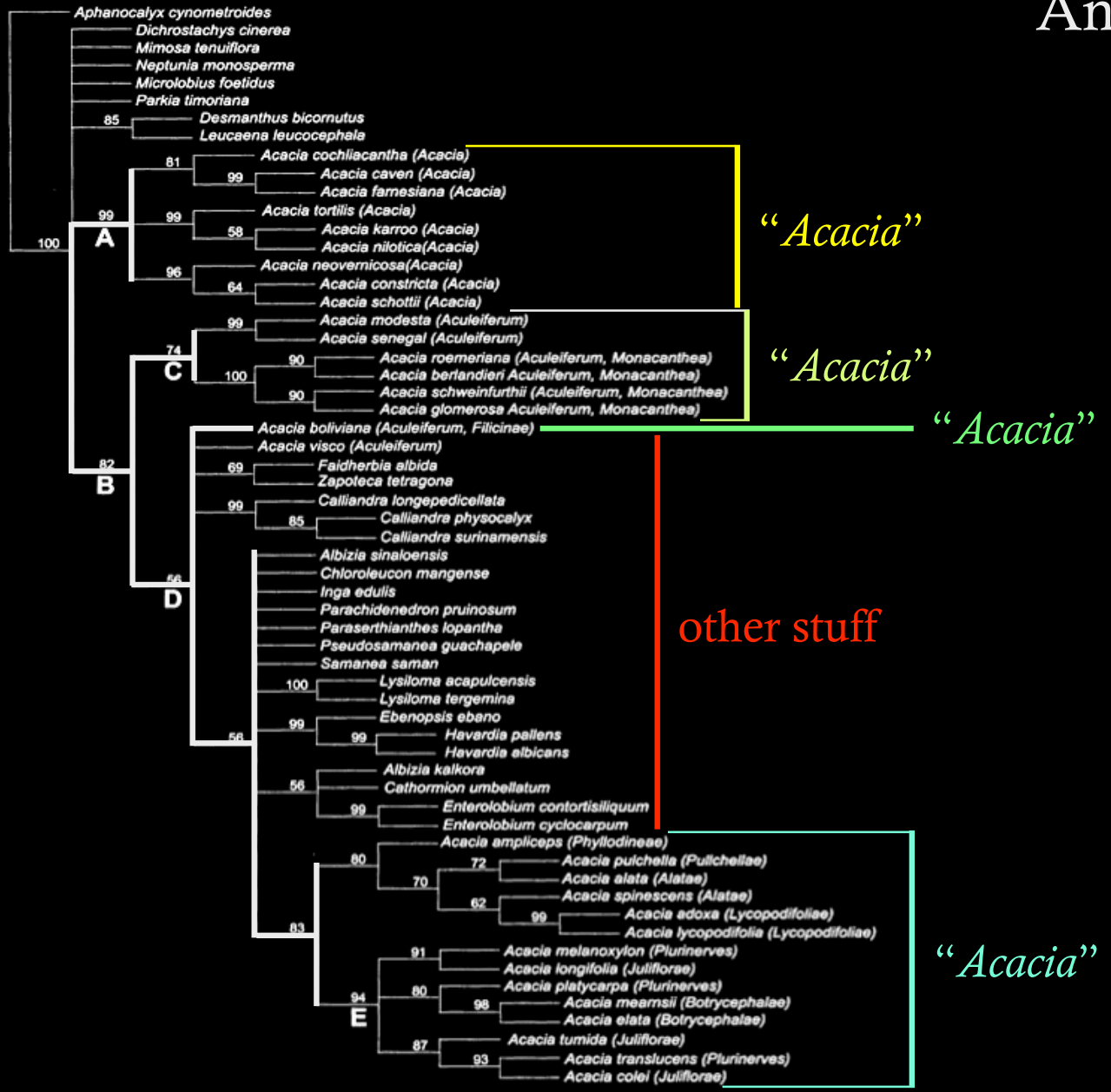


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

An example… *Acacia*

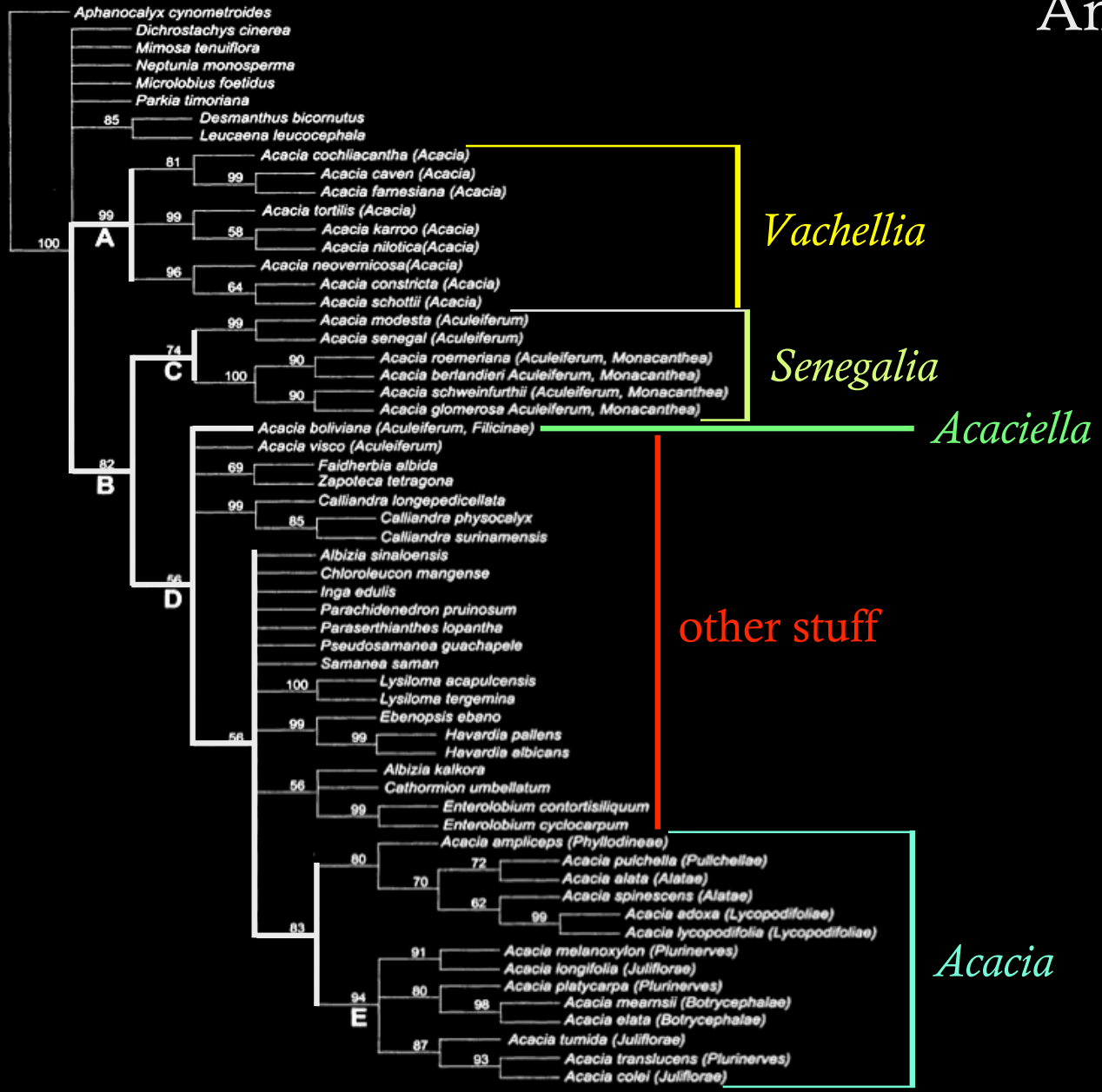


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

An example… *Acacia*

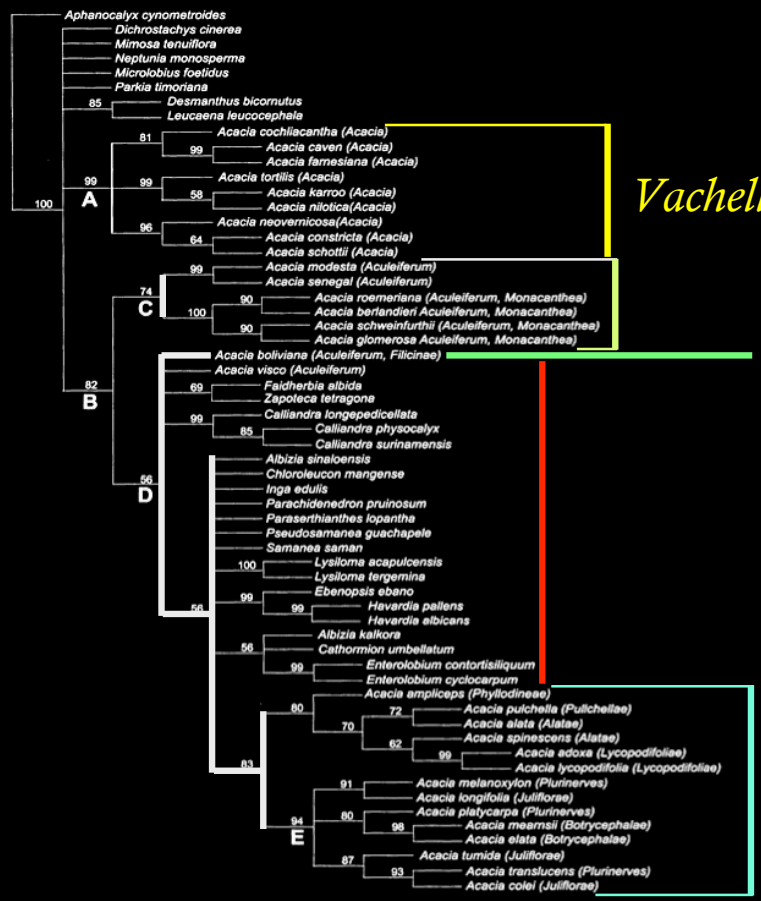


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

Vachellia constricta

An example… *Acacia*

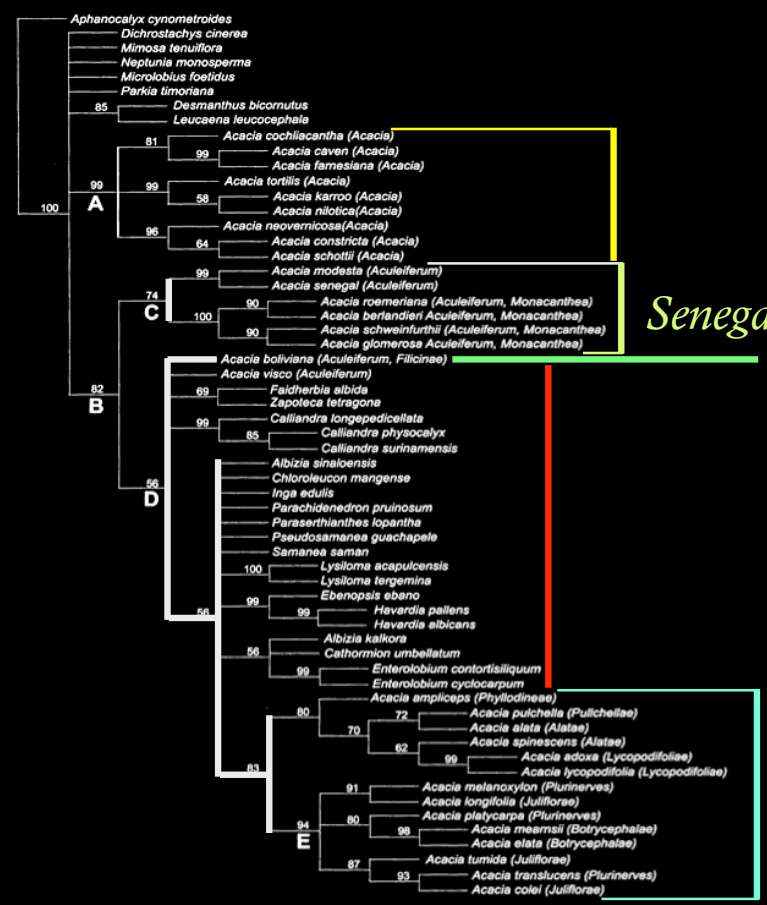


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

Senegalia roemeriana

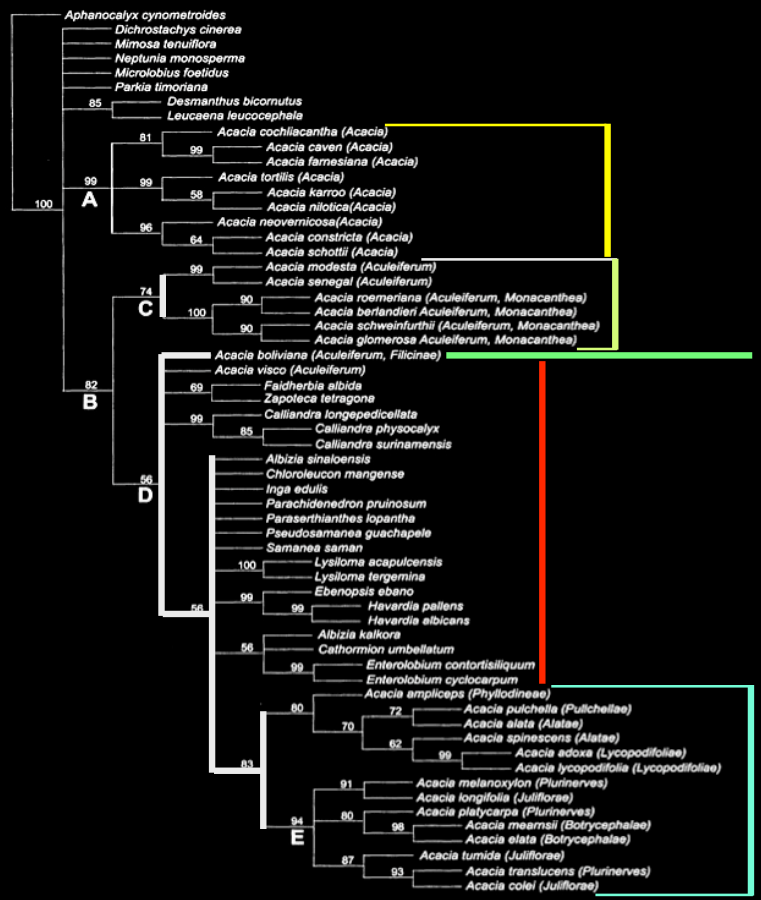


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

An example… *Acacia*

Acaciella angustissima

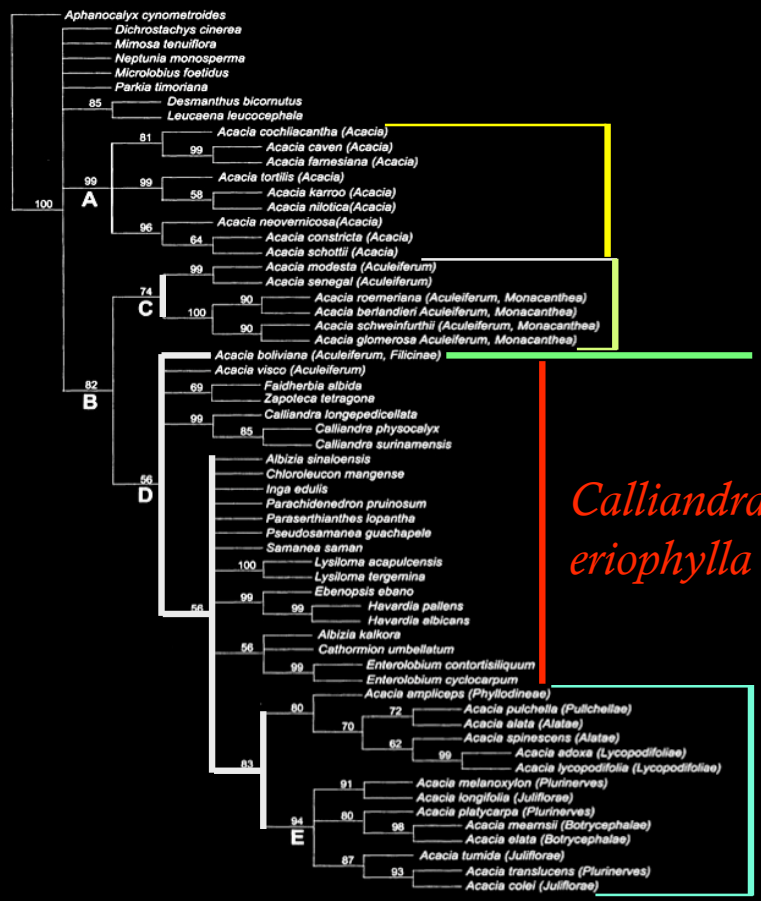


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

An example… *Acacia*

Calliandra eriophylla

An example… *Acacia*

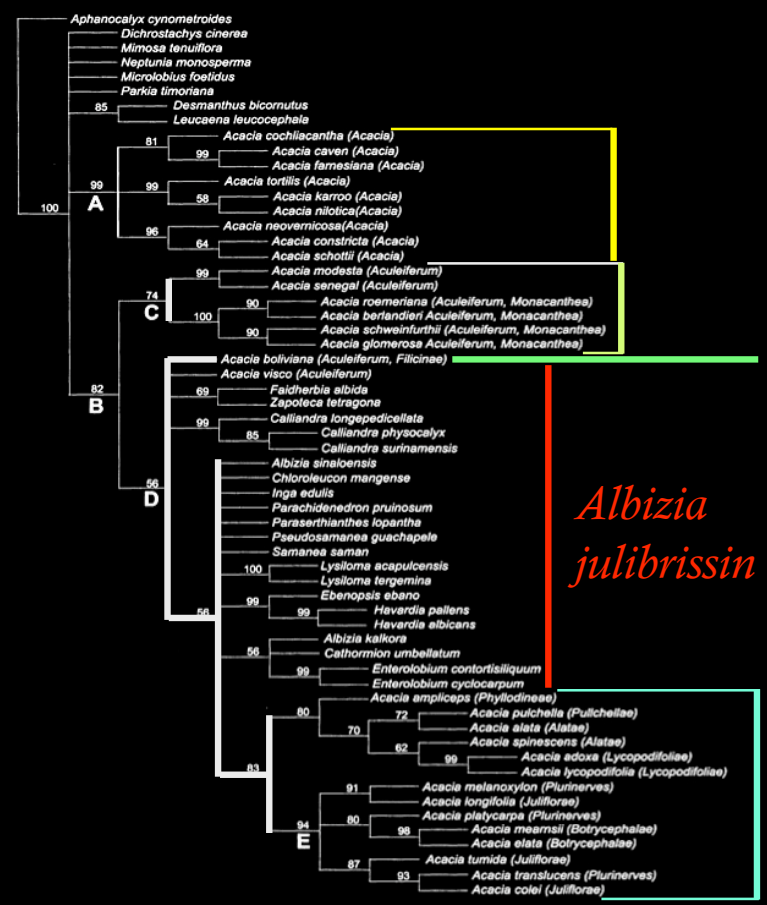


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

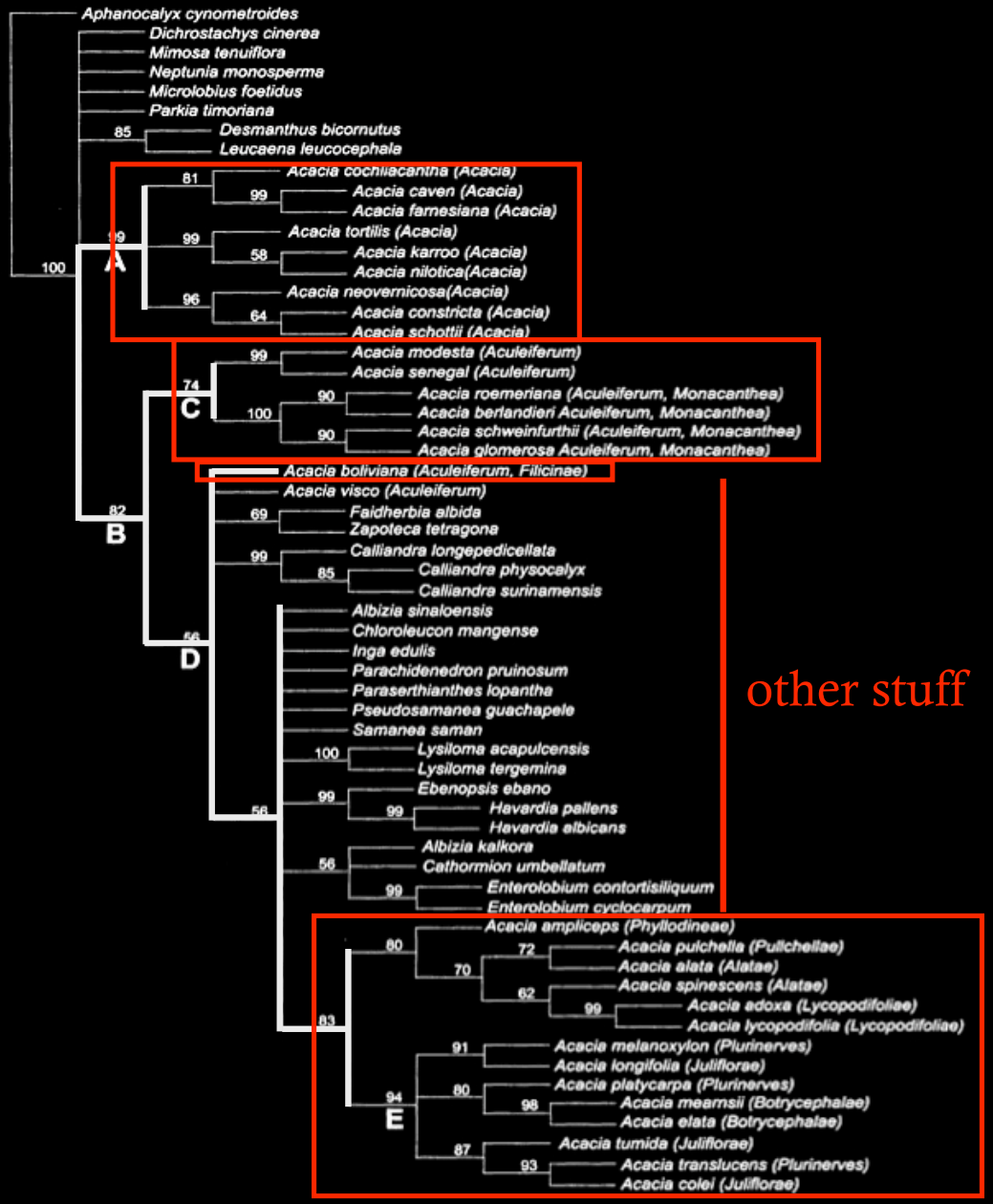


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

We can split…

other stuff

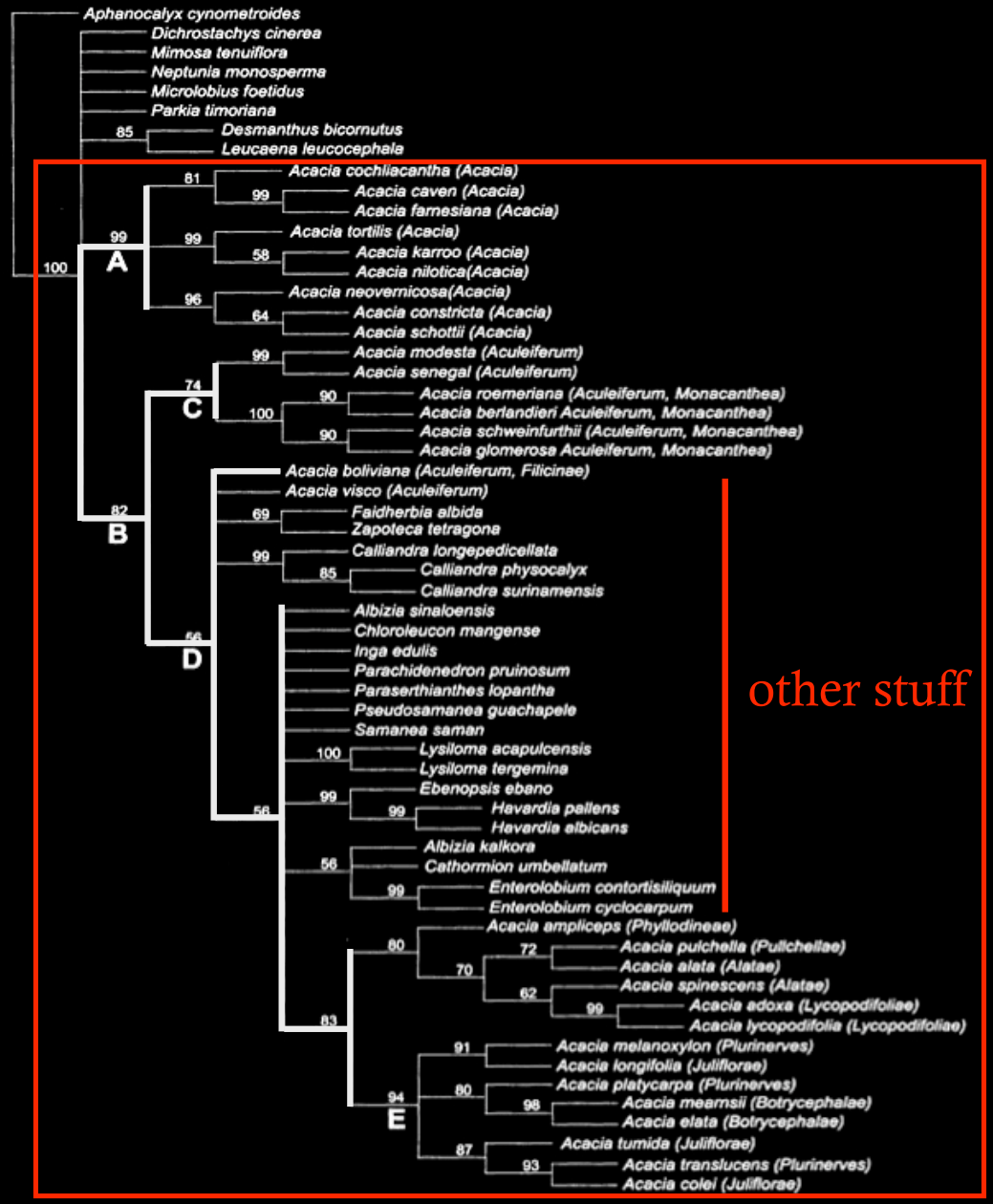


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.

…or we can lump…

…but we can't really just leave things alone.

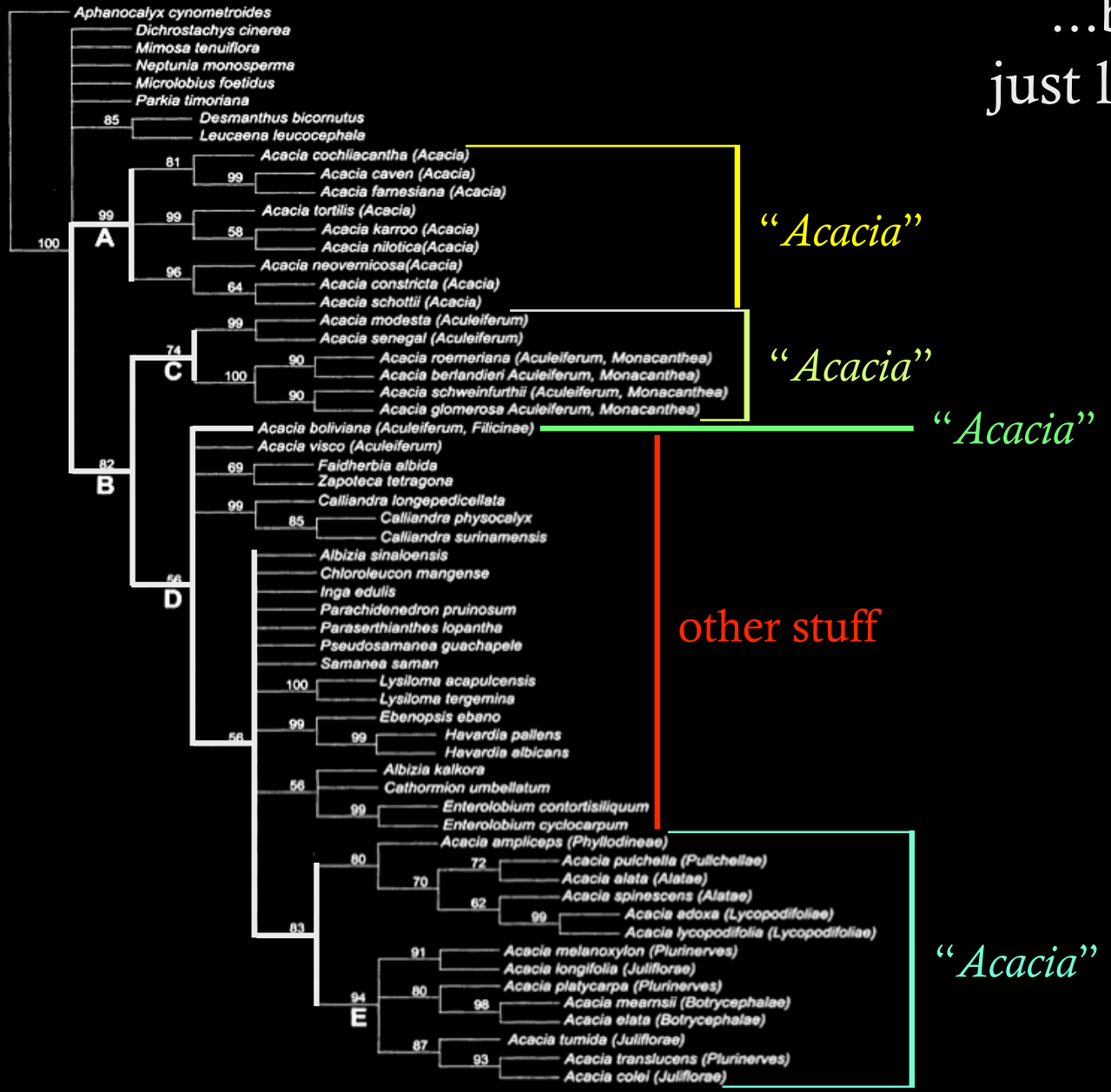


FIG. 1. Strict consensus of 384 trees (length = 2168, consistency index = 0.72, retention index = 0.70) derived from a parsimony analysis of the sequence data. Subgeneric labels given only for *Acacia*. Bootstrap values over 50% are shown above the branches. Boldface letters indicate major clades.