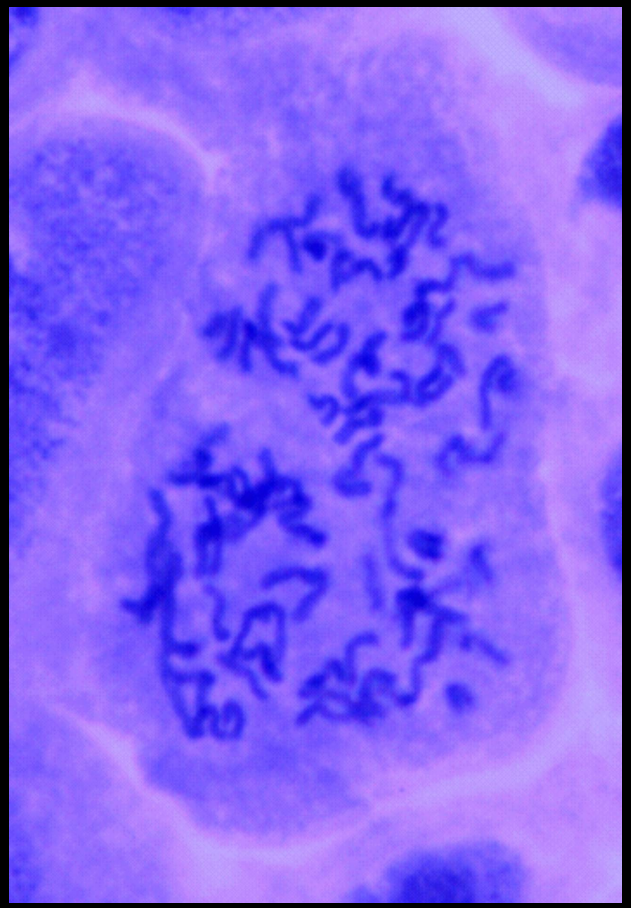
Plant of the Day

Cyperus esculentus - Cyperaceae
Chufa (tigernut)
8,000 kg/ha, 720 kcal/sq m per month
Top Crop for kcal productivity!
One of the world's worst weeds

Big Questions

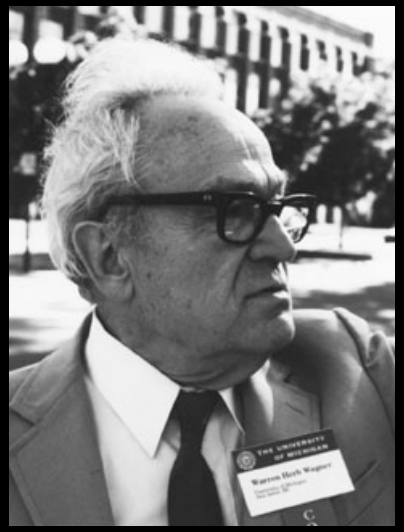
- Is polyploidy an evolutionary dead-end?
- If so, why are all plants the products of multiple polyploidization events?
- How do polyploid genomes diploidize (i.e., what are the rules)?

Paleopolyploidy

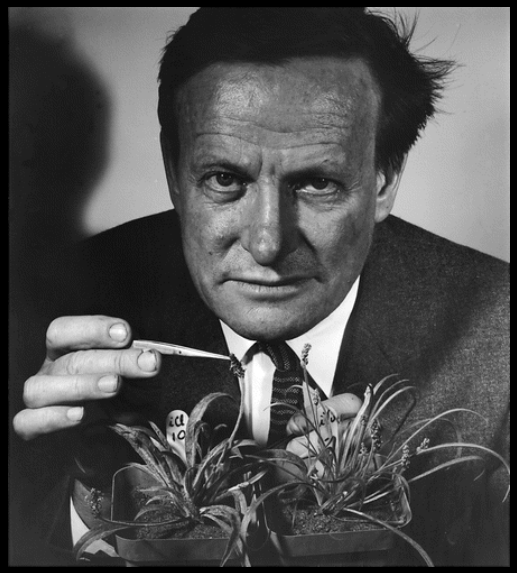


- Ancient whole genome duplication
- No different from neopolyploidy – except that it happened a long time ago
- Track the historical contribution of polyploid speciation to evolution

Polyploidy = Evolutionary noise (1970)



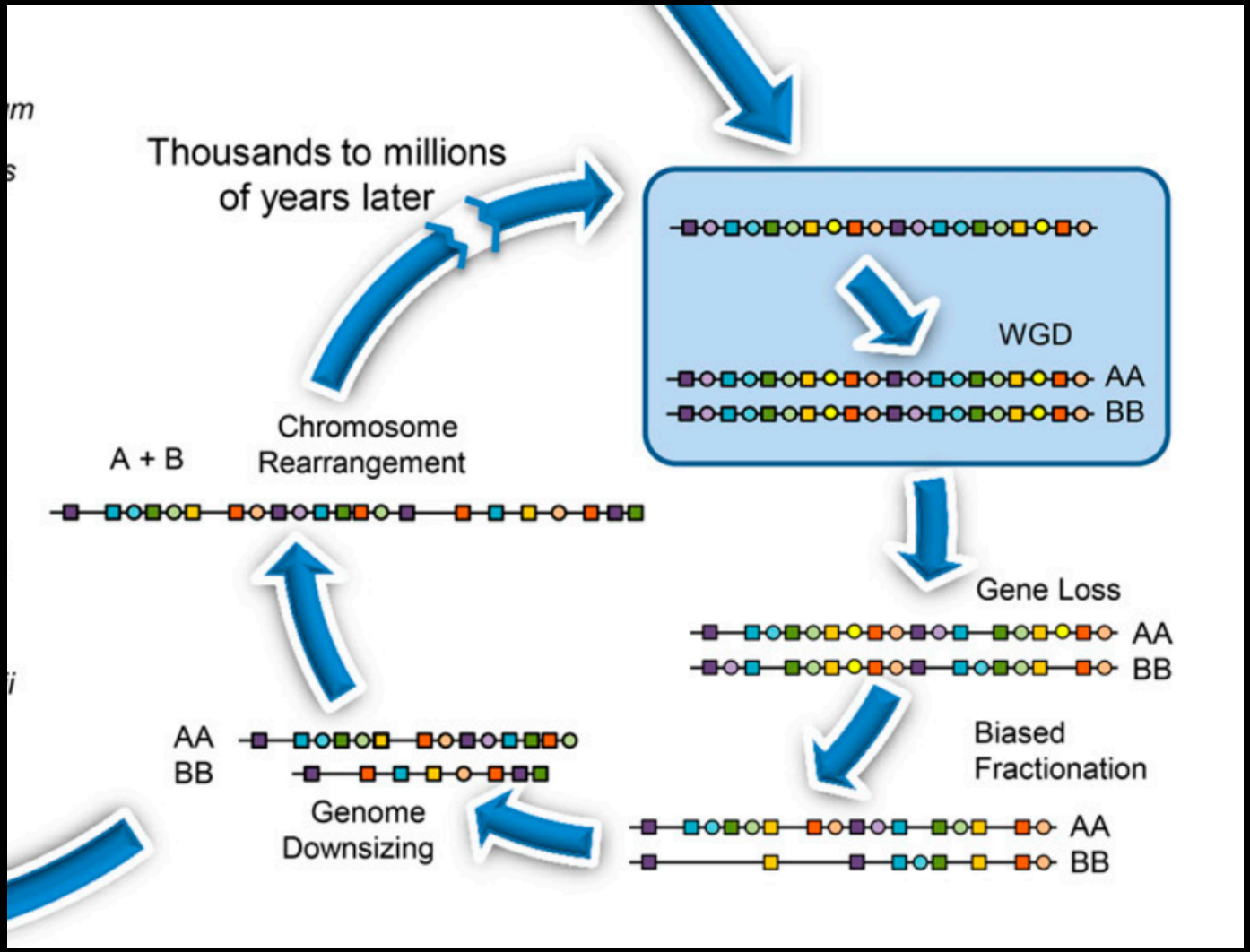
W. H. Wagner, Jr.



G. L. Stebbins

"…polyploidy has contributed little to progressive evolution" (1971)

Diploidization



Diploidization

- Obscures evidence of paleopolyploidy
- Return to a diploid genetic system
  - Restoration of full bivalent pairing
  - Gene and chromosome loss
  - Chromosomal rearrangements
- Proceeds at different rates in different lineages

Methods for Identifying Paleopolyploidy

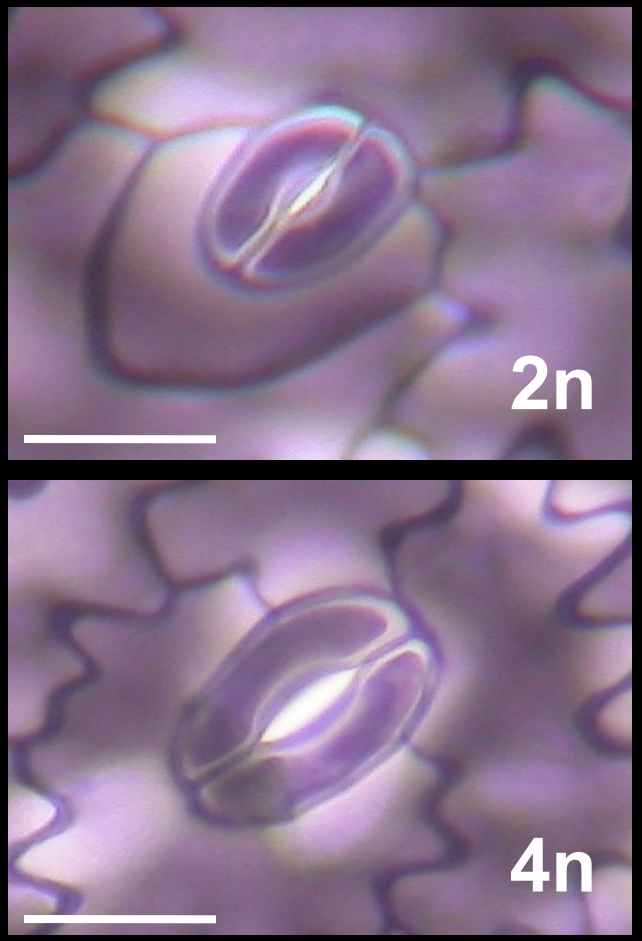
- Fossils
- Synteny relationships of duplicated genes – conserved gene order
- Age estimates of duplicate genes

Cell Size Increase

Consequence of genome size increase

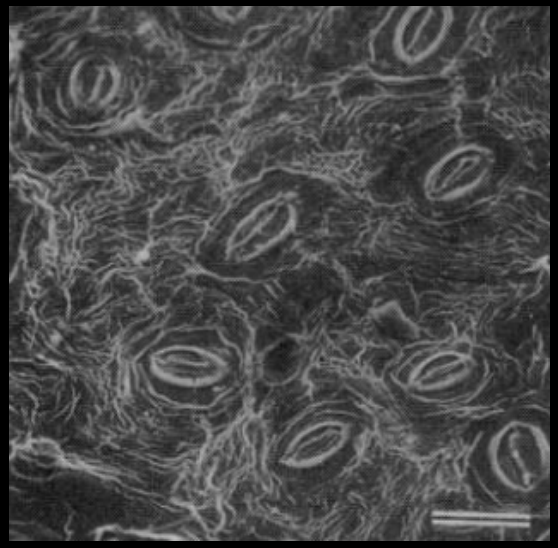
2 X increase in cell volume

1.58 X increase in cell surface area

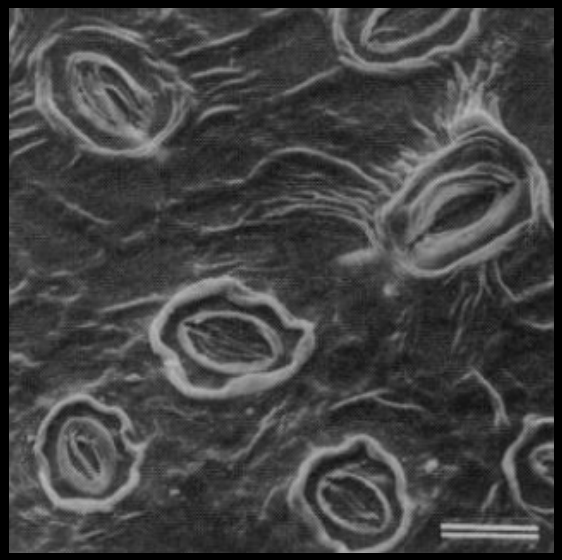


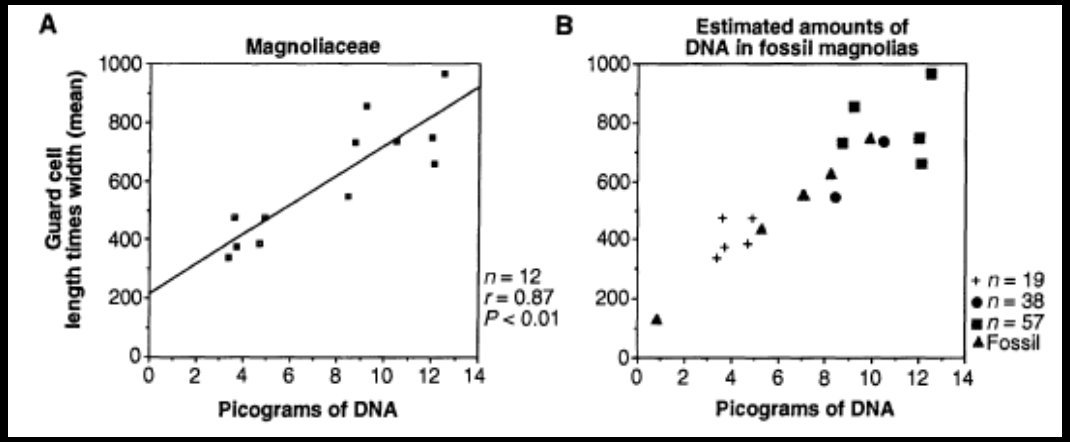
Fossil Estimates

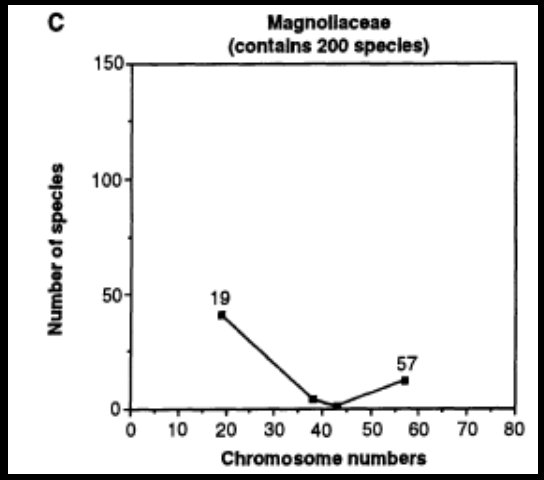
Miocene *Platanus*



Extant *Platanus*

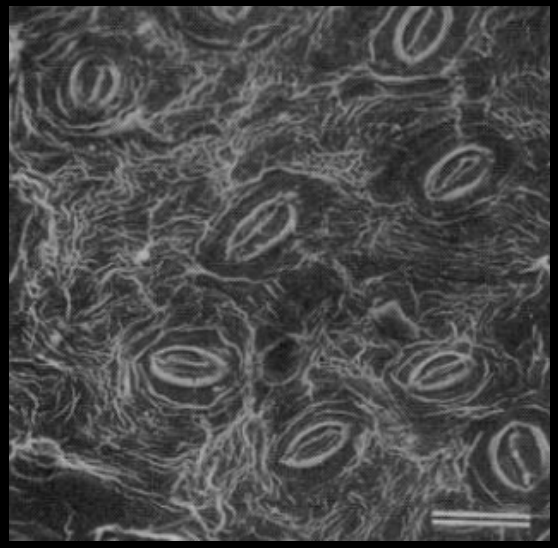






Fossil Estimates

Miocene *Platanus*



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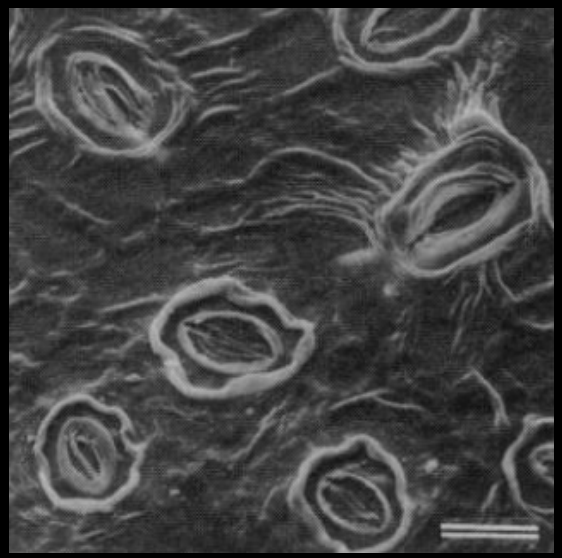
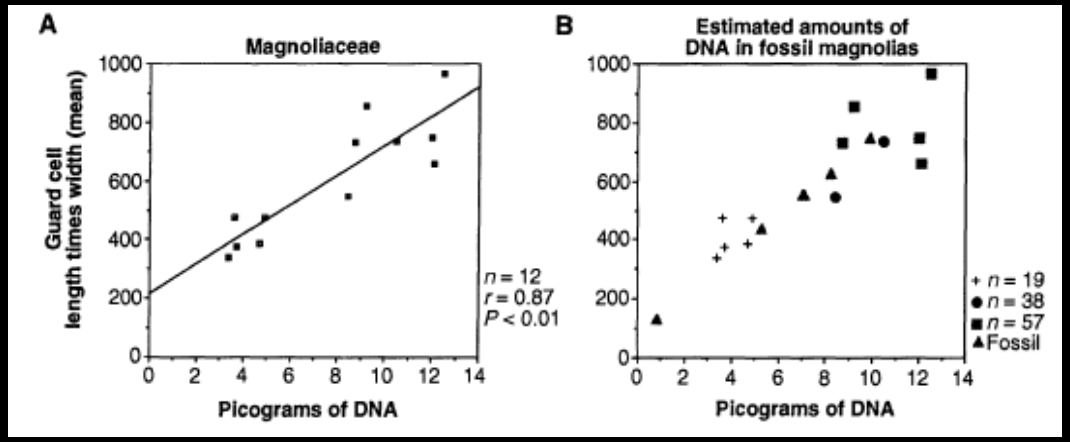
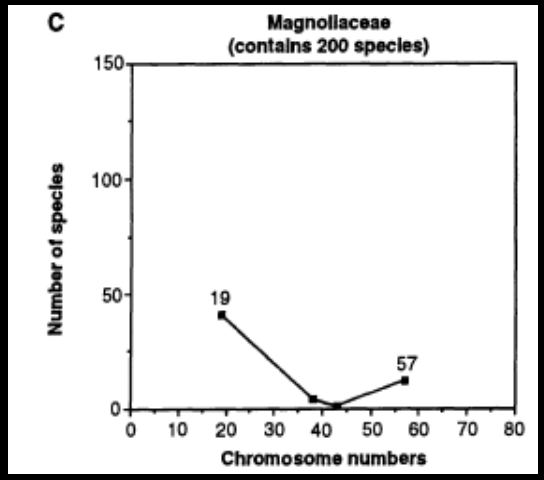


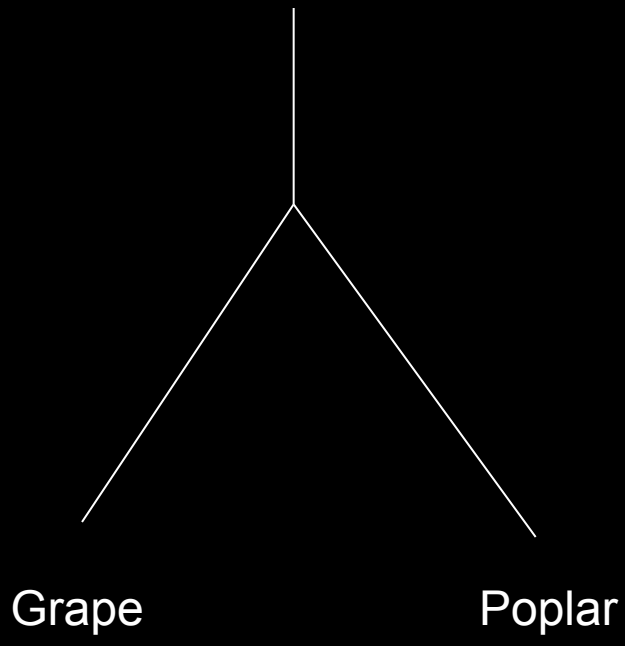




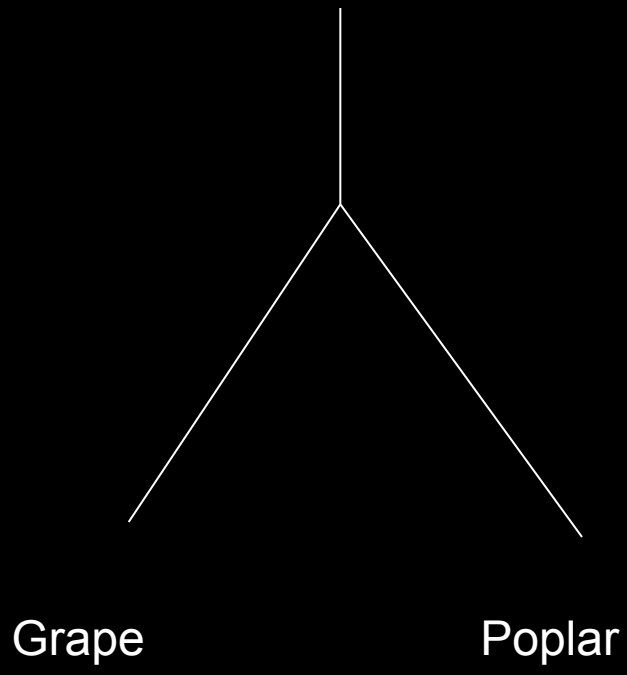
n > 7 – 9

70% angiosperms

Single copy

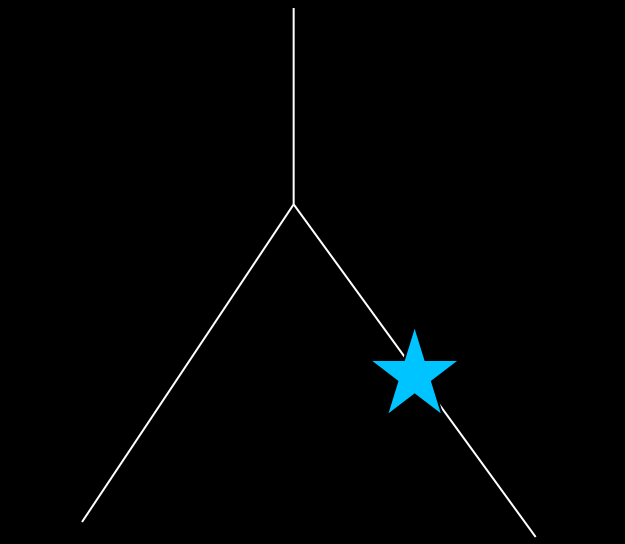


Species Tree

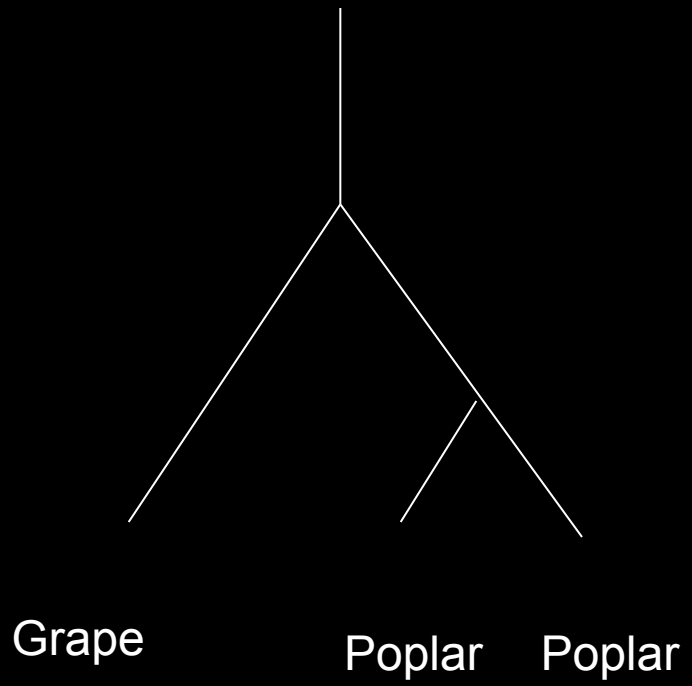


Gene Tree

Paleopolyploidy

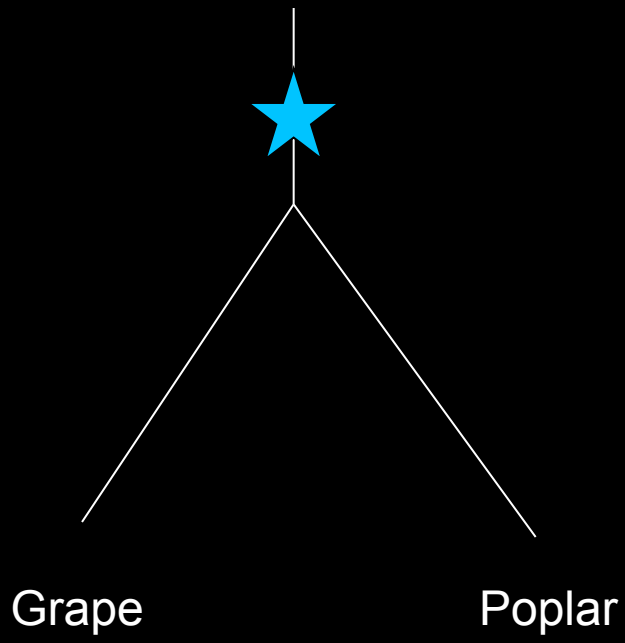


Species Tree

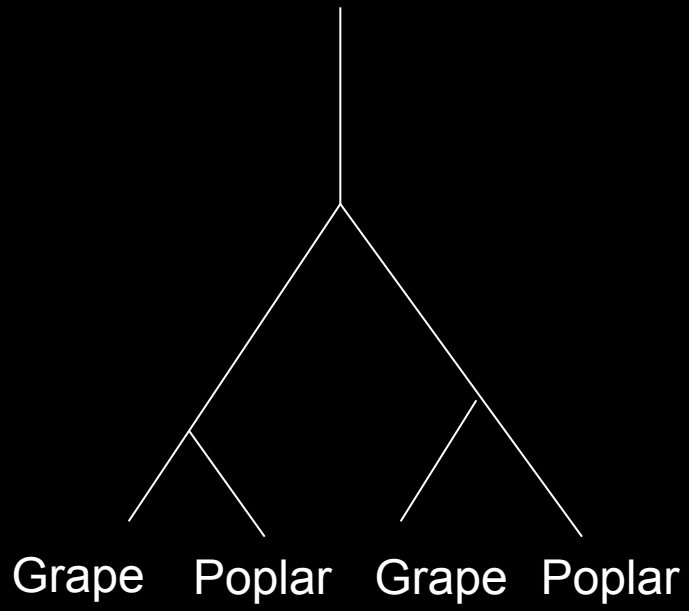


Gene Tree

Paleopolyploidy

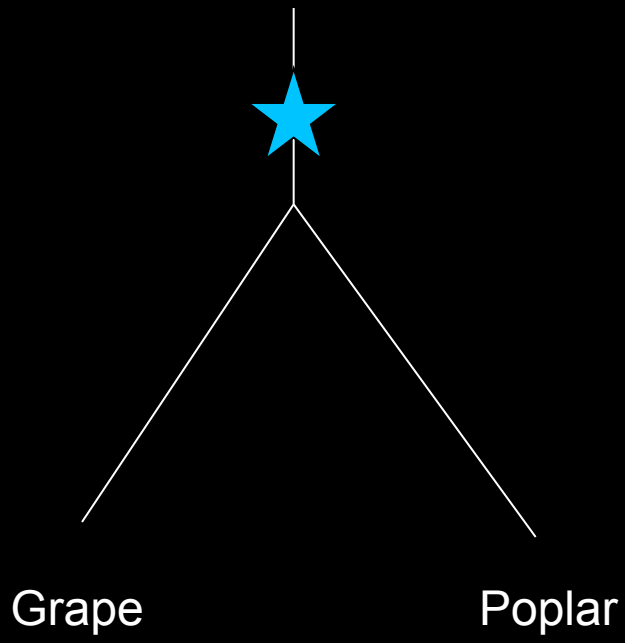


Species Tree

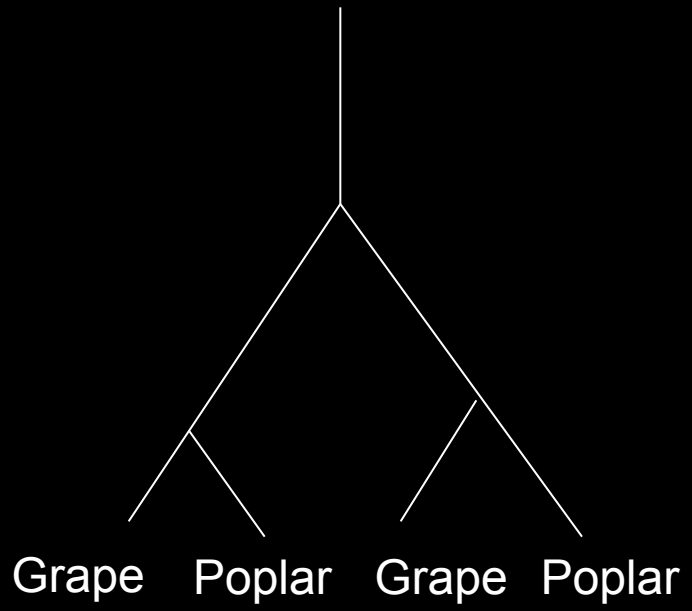


Gene Tree

Paleopolyploidy



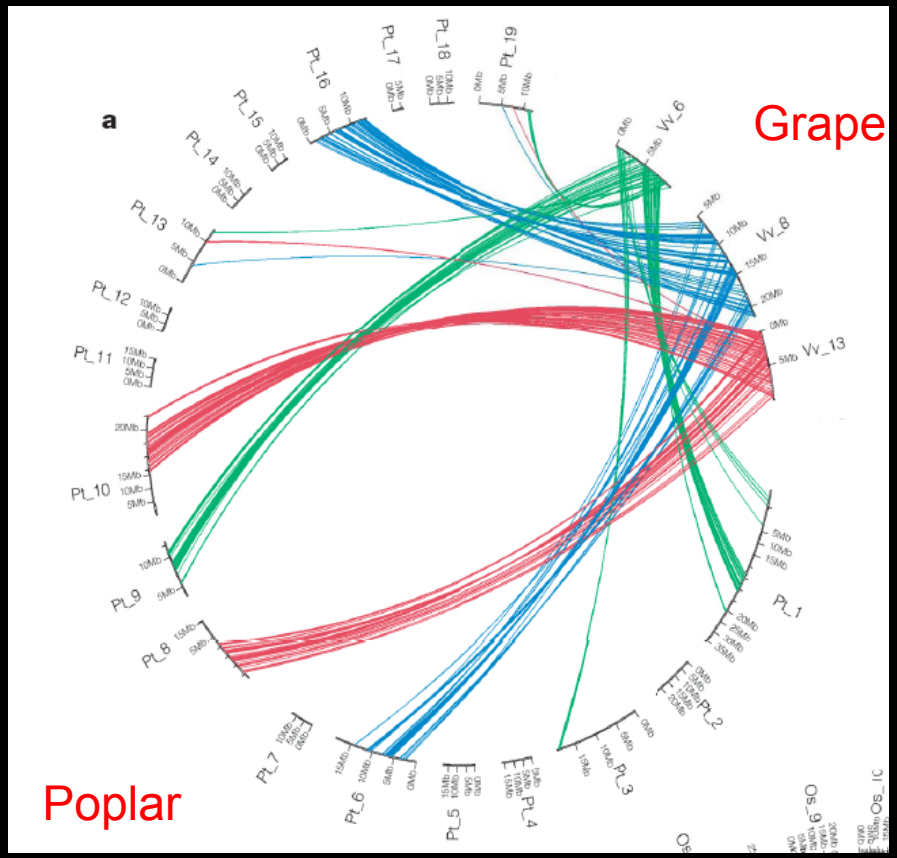
Species Tree



Gene Tree

How do we tell gene duplication from paleopolyploidy?

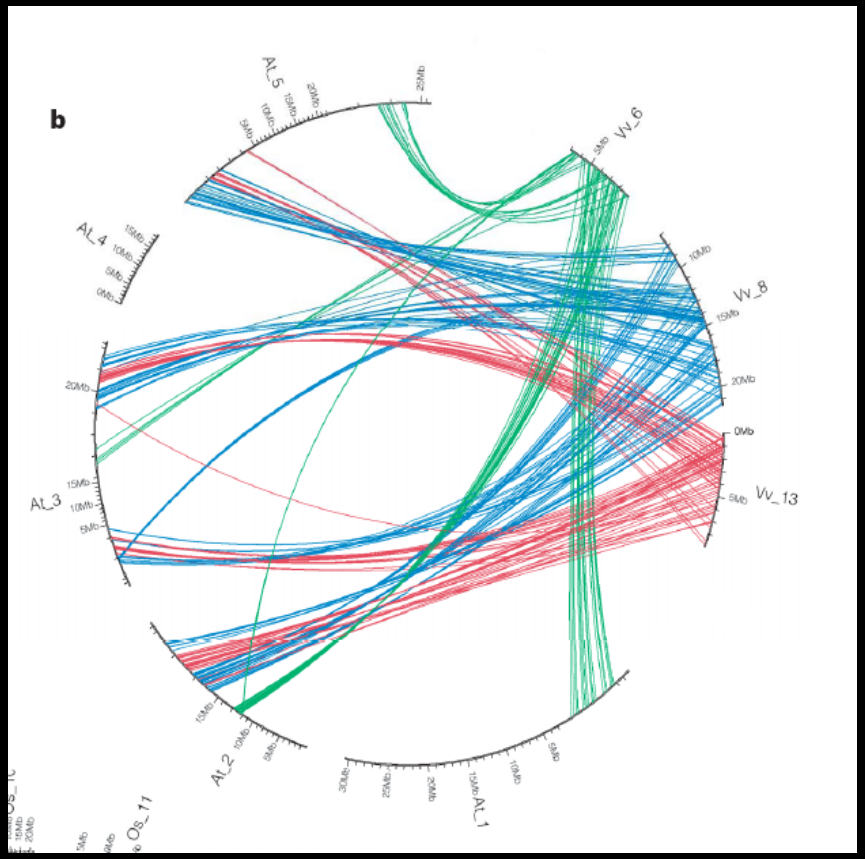
Synteny Analyses



What is the history of paleopolyploidy?

Synteny Analyses

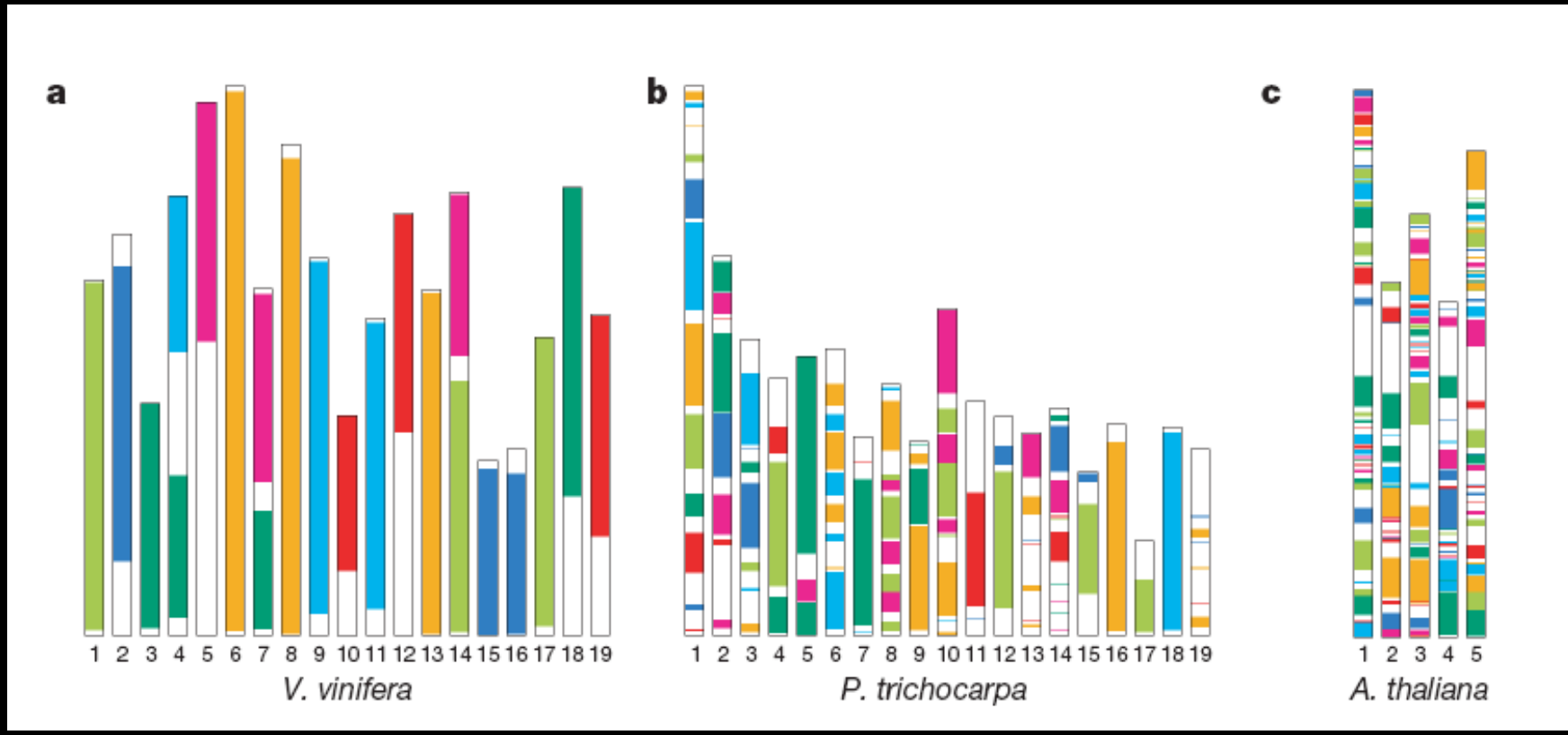
Arabidopsis



Grape

What is the history of paleopolyploidy?

Synteny Analyses



Whole Genome Sequences

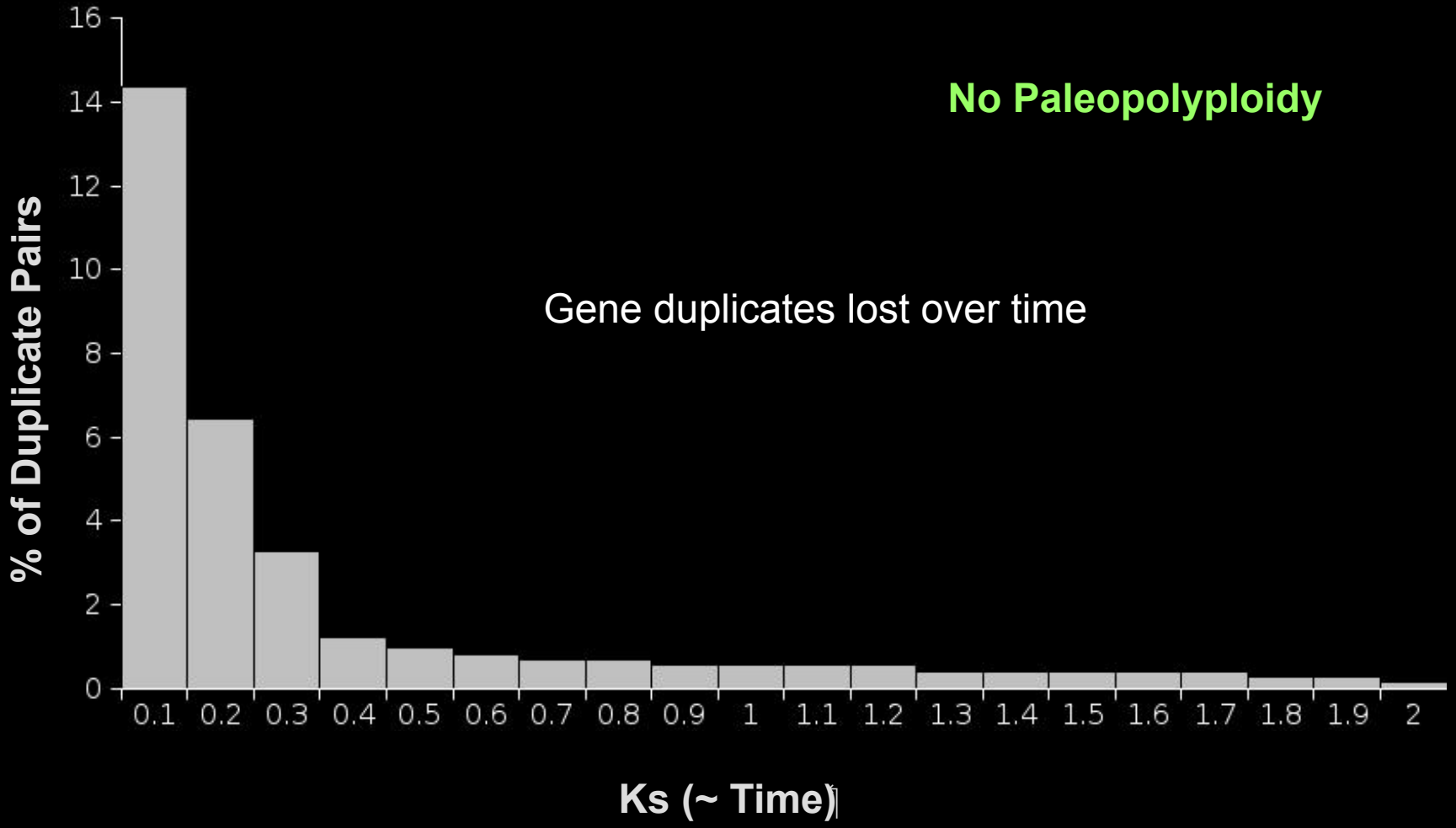
Duplicate Gene Age Distributions

Find duplicate genes in the genome.

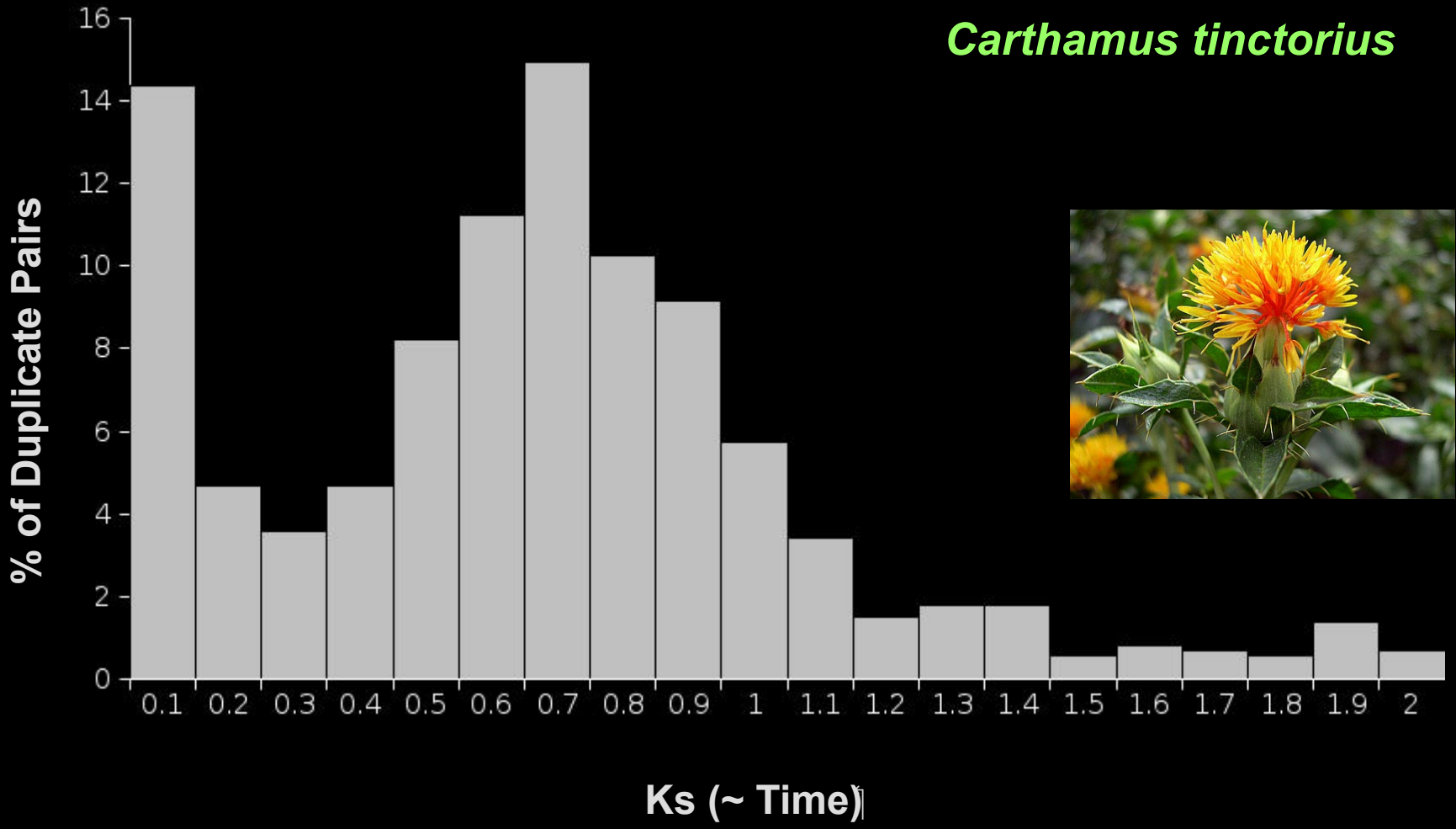
What is the sequence divergence between duplicates?

This is a measure of when the duplication event occurred.

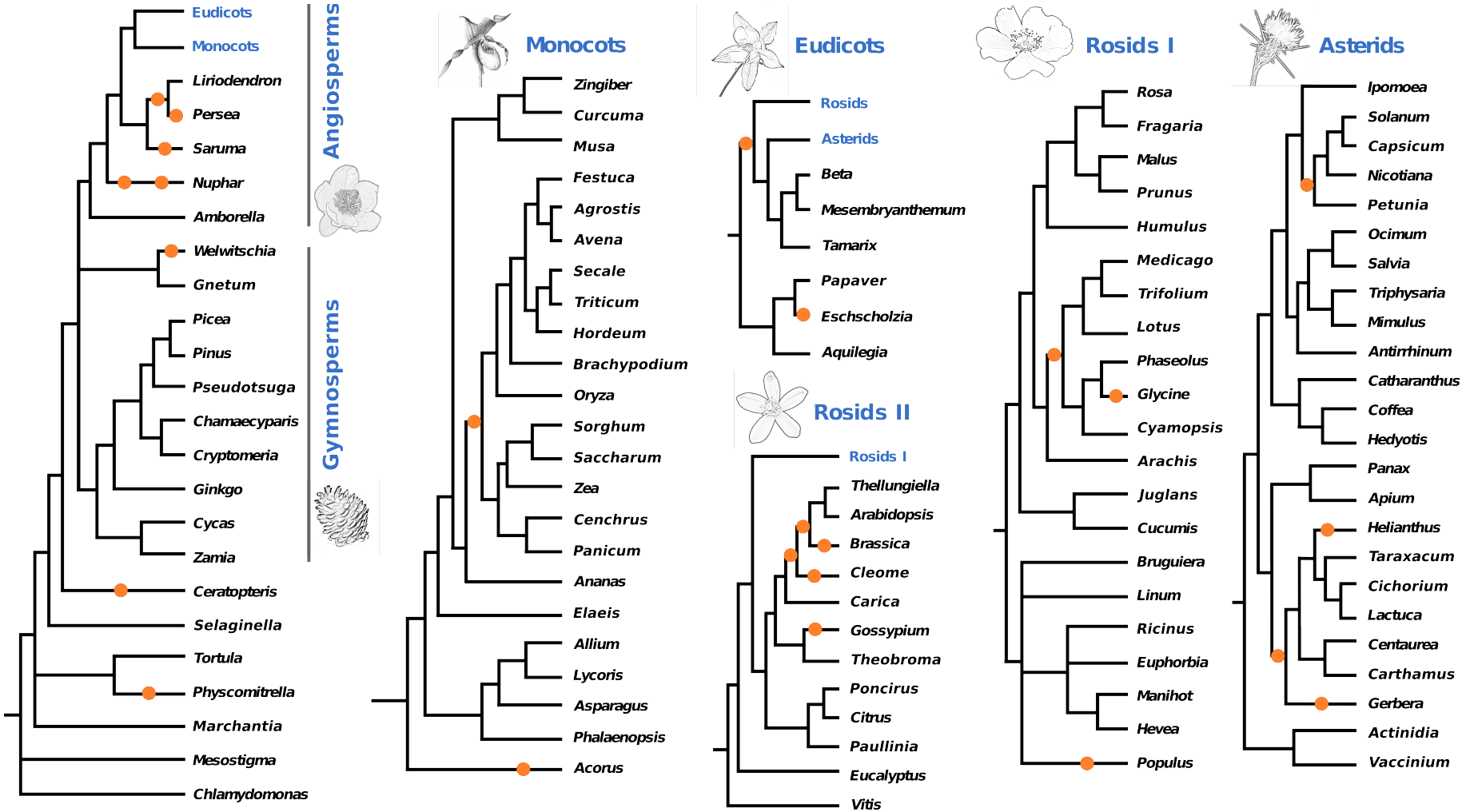
Duplicate Gene Age Distributions



Duplicate Gene Age Distributions

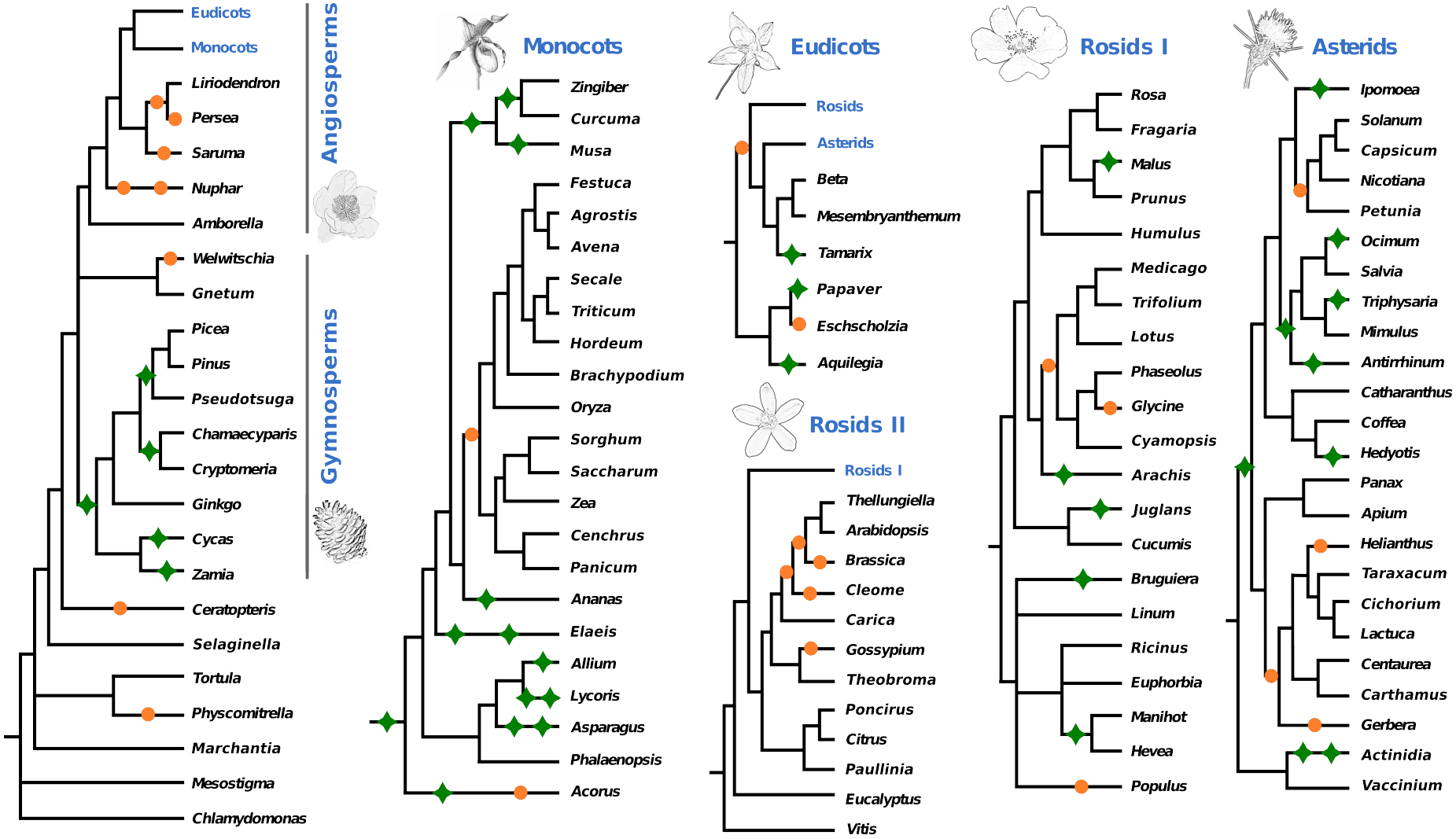


Previously Known Genome Duplications



Barker *et al.*, in prep

Newly Recognized Genome Duplications



Barker *et al.*, in prep

Newly Recognized Genome Duplications

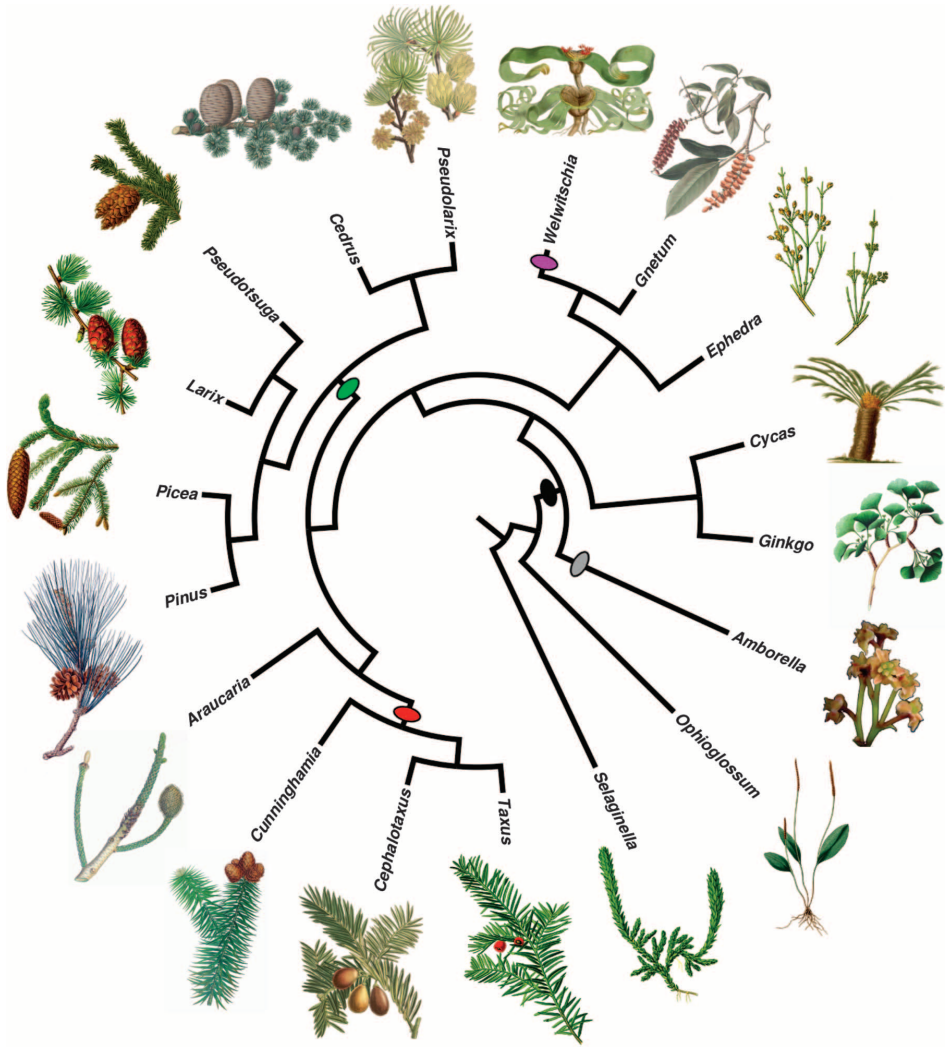
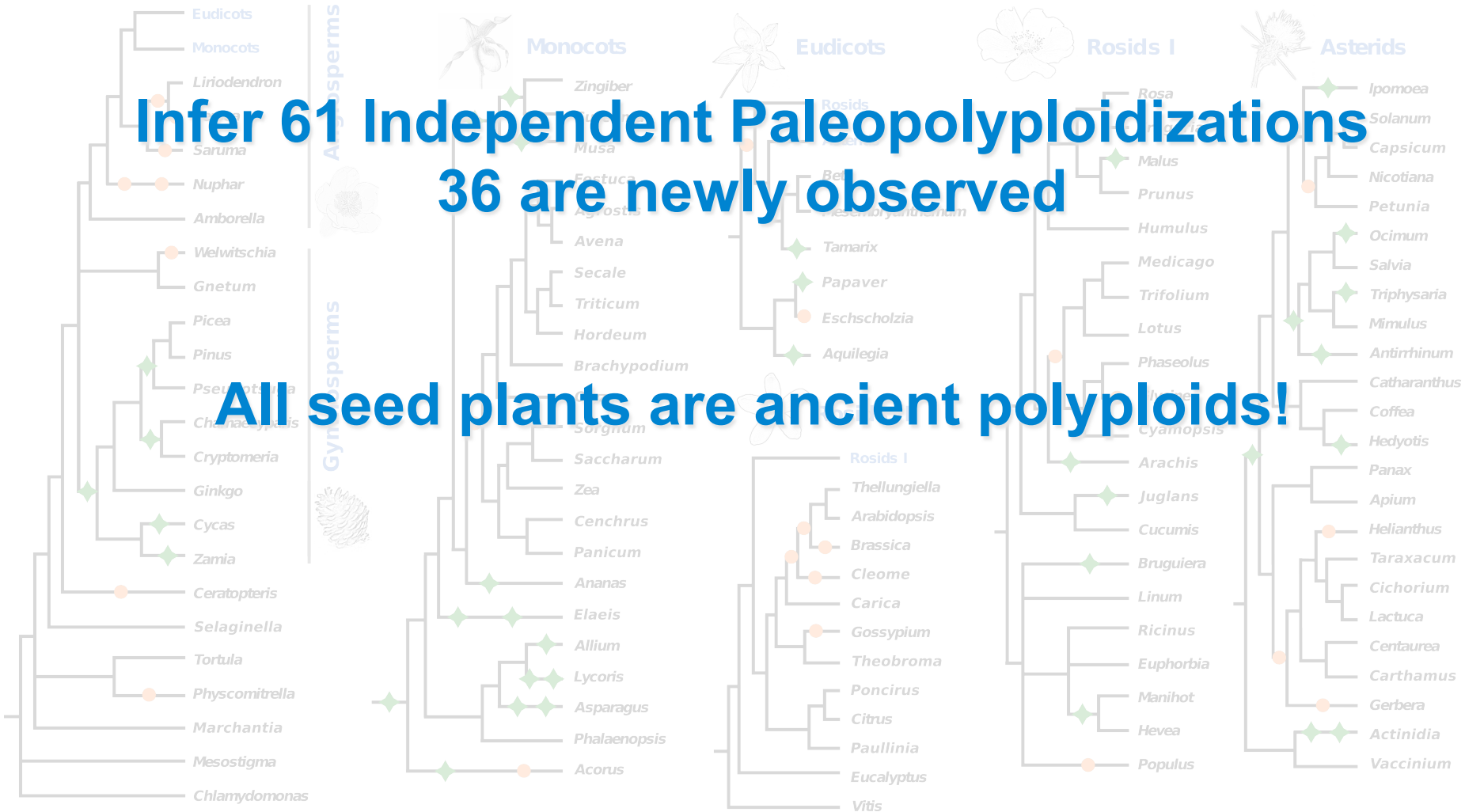


Fig. 2. Phylogenetic placement of WGDs in seed plant and gymnosperm history. Ovals correspond to inferred locations of WGD events; black, seed plant WGD; gray, angiosperm WGD; purple, *Welwitschia* WGD; green, Pinaceae WGD; red, cupressophyte WGD. All botanical illustrations are in the public domain. *Amborella* image adopted from *Amborella* Genome Project, 2013 (*46*). Other botanical illustrations are in the public domain (*59*–*75*).

Li *et al.*, 2015

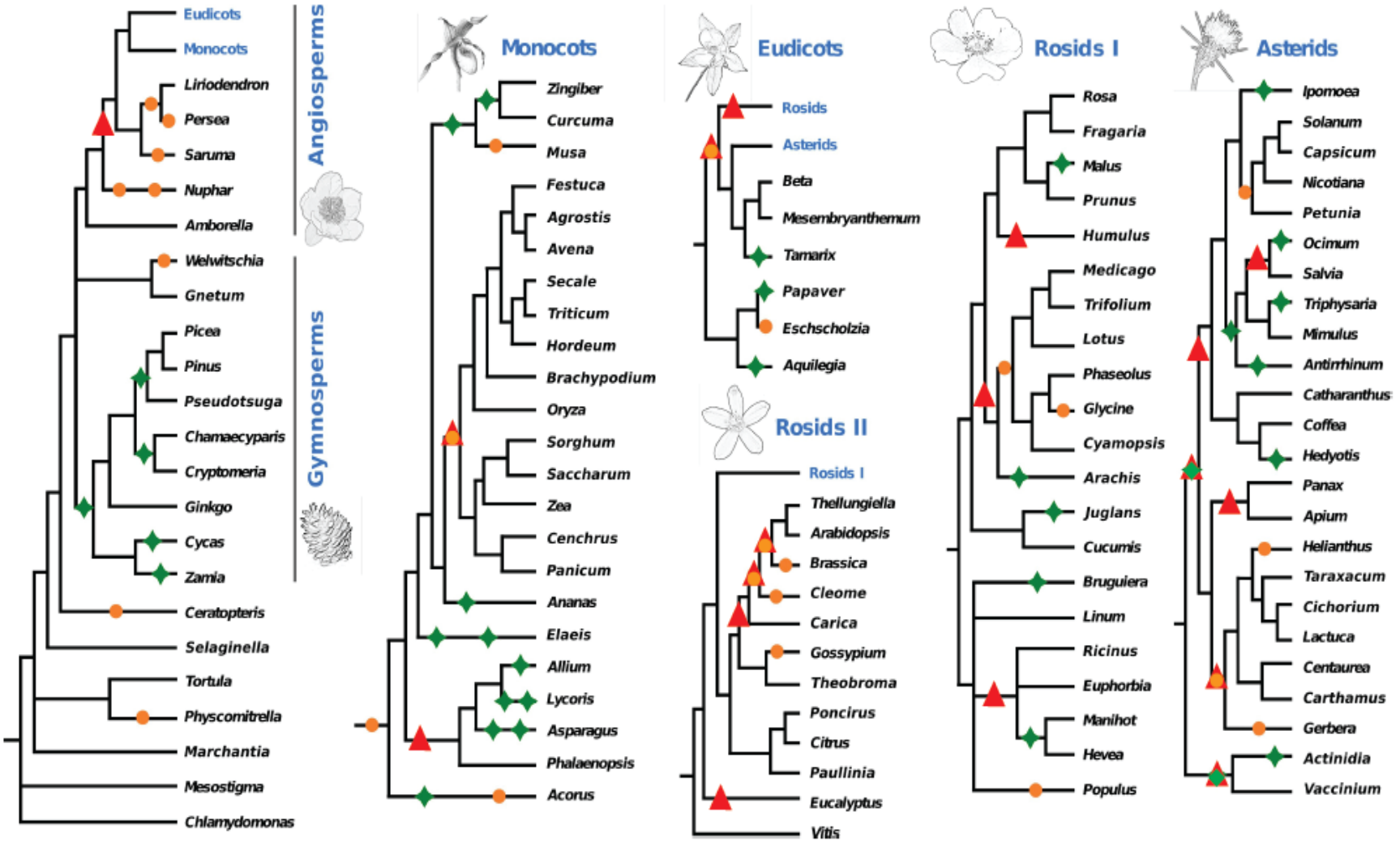
Newly Recognized Genome Duplications



Infer 61 Independent Paleopolyploidizations
36 are newly observed

All seed plants are ancient polyploids!

Barker *et al.*, in prep



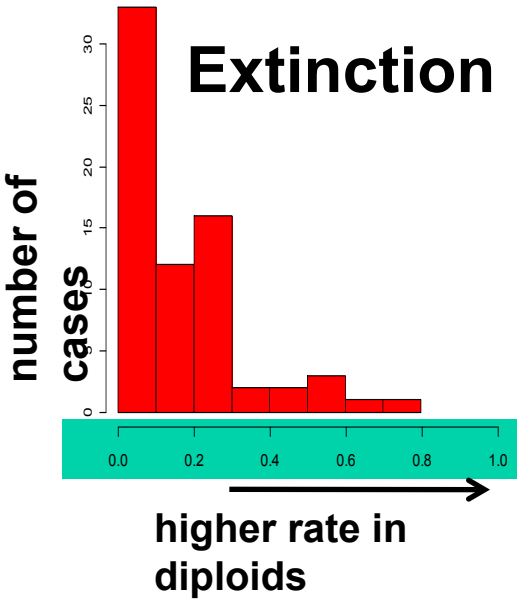
▲ Significant increases in diversification rates in flowering plants

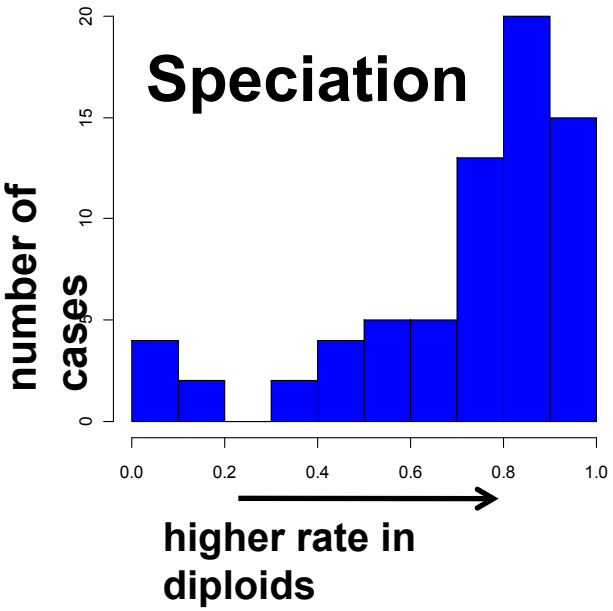
- Half are associated with paleopolyploidy (p = 0.005)

What about neo-polyploidy?

Application of BISSE: binary-state speciation and extinction (likelihood method developed by Maddison et al. 2007)

Polyploidy: ↓ speciation, ↑ extinction (I. Mayrose et al. 2011, Science)





Resolution

Polyploidy is most often an evolutionary dead end, but the expanded genomic potential of those polyploids that do persist drives longer term evolutionary success.

Unanswered questions

Do auto- and allopolyploids differ in their evolutionary success?

What factors control the fate of duplicate genes?

How long must a polyploid lineage persist before it transitions from a trajectory that favors extinction to one that favors diversification?

What evolutionary genetic changes/processes underlie this transition?