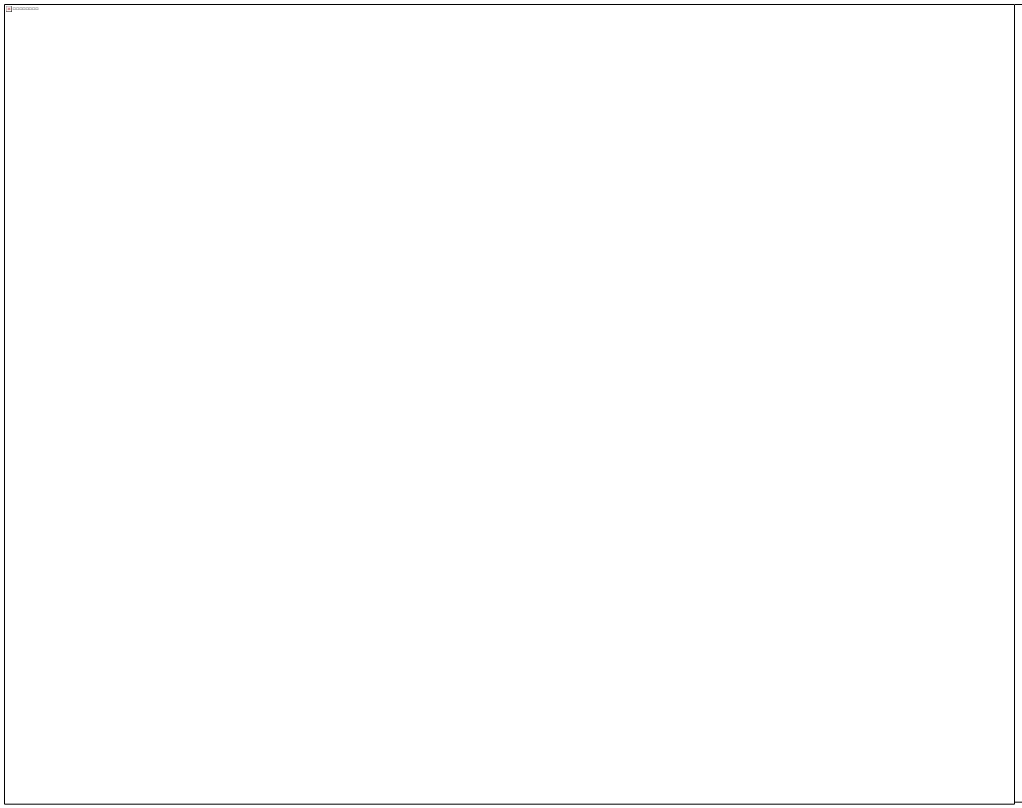
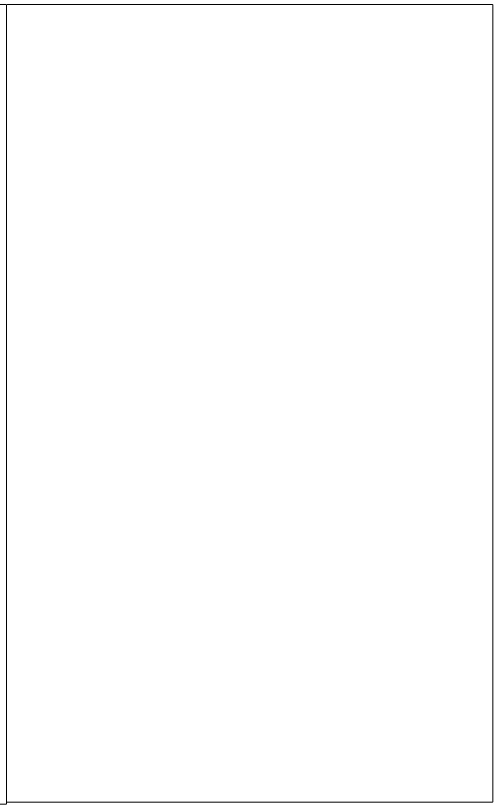
Plant of the Day





Cyperus esculentus - Cyperaceae
Chufa (tigernut)
Top Crop for calory production per square meter
One of the world's worst weeds

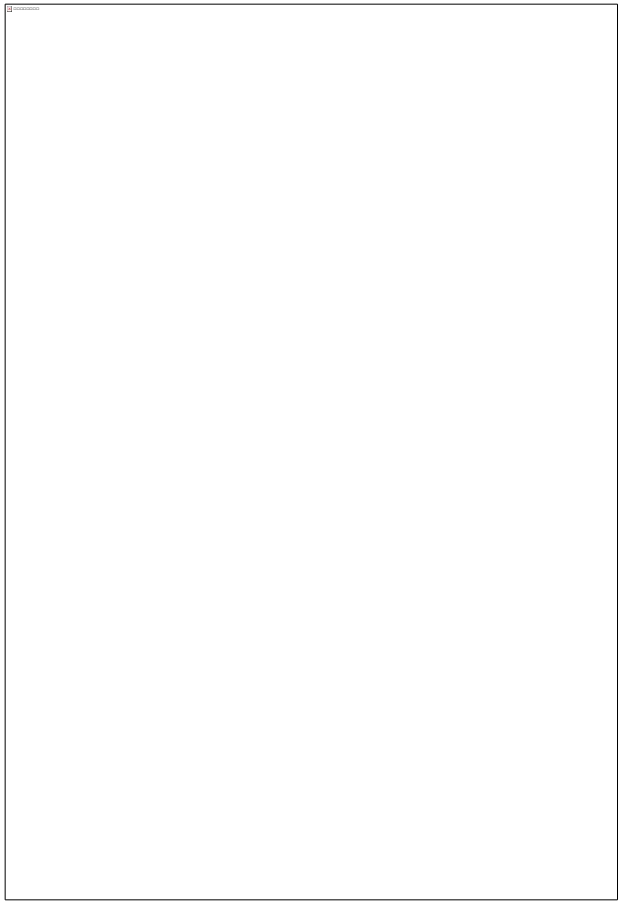
Big Questions

Is polyploidy an evolutionary dead-end?

If so, why are all land plants the products of multiple polyploidization events?

How do polyploid genomes diploidize (i.e., what are the rules)?

Paleopolyploidy



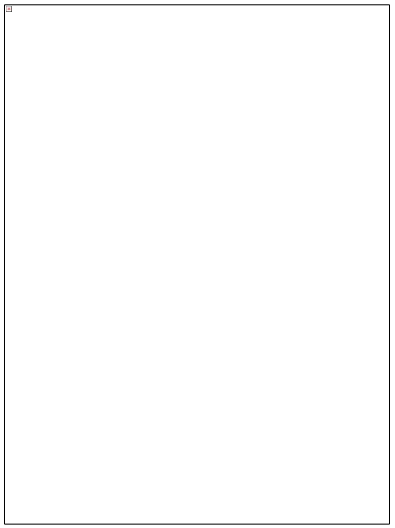
Ancient whole genome duplication

No different from neopolyploidy – except that it happened a long time ago

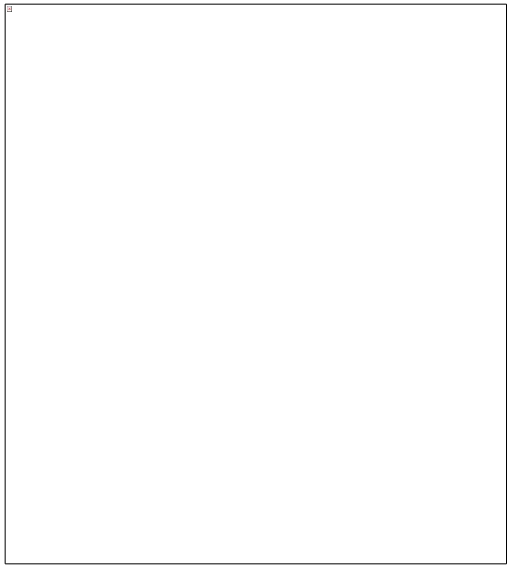
Track the historical contribution of polyploid speciation to evolution

Conventional views about the evolutionary role of polyploidy

Polyploidy = Evolutionary noise (1970)



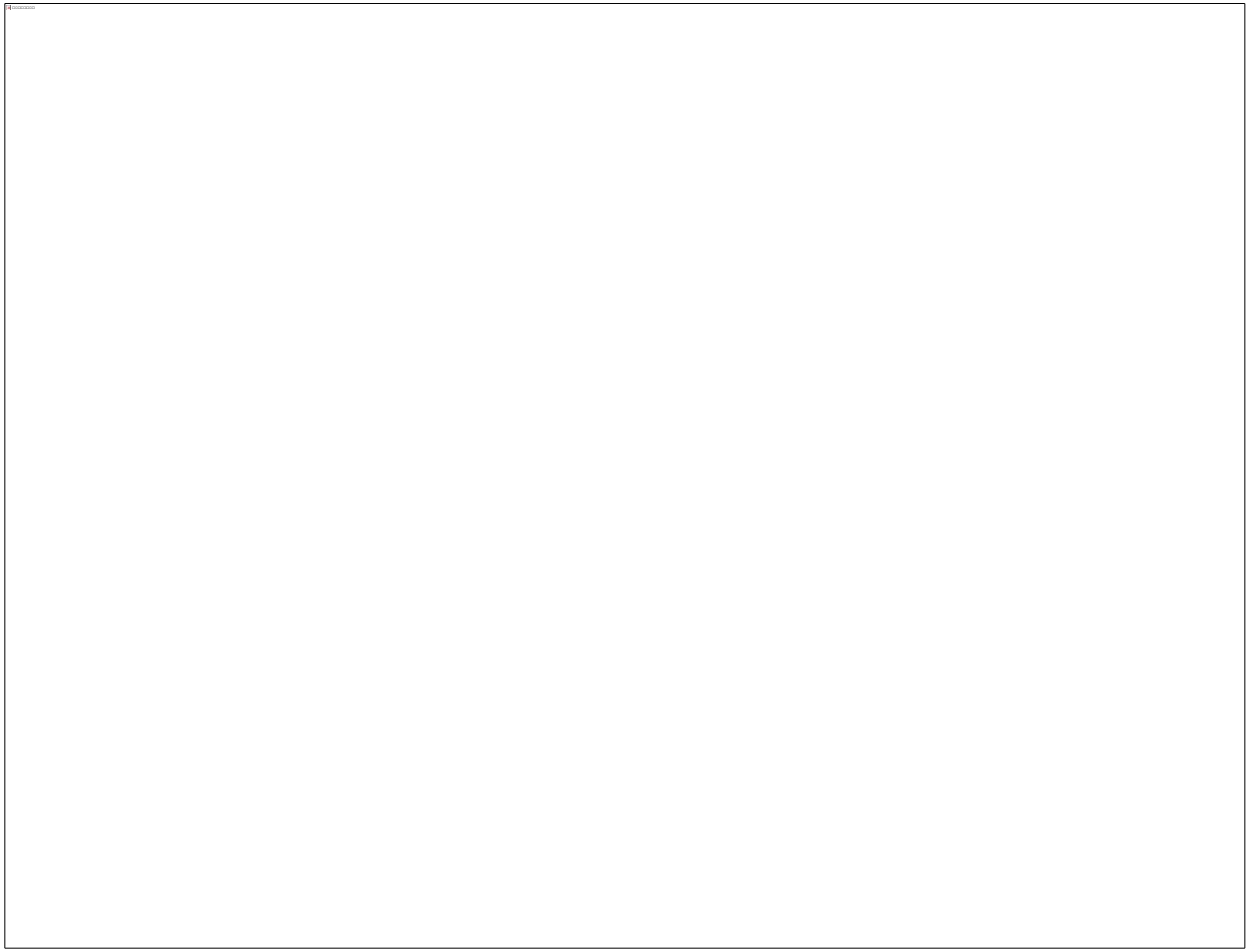
W. H. Wagner, Jr.



G. L. Stebbins

“…polyploidy has contributed little to progressive evolution” (1971)

Diploidization – the process of converting a polyploid genome into a diploid one.



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

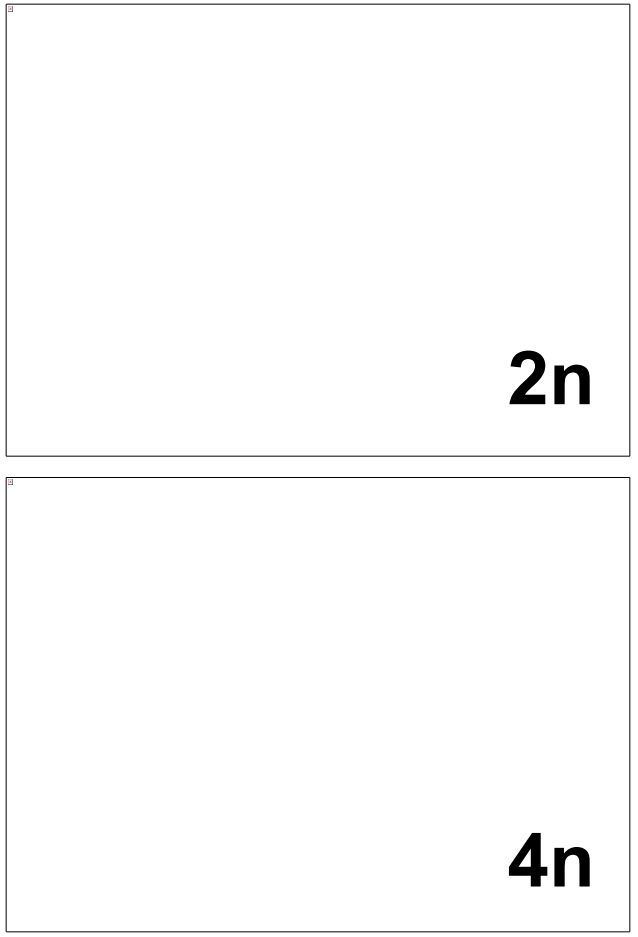
Fossils

Synteny relationships of duplicated genes – conserved gene order

Age estimates of duplicate genes

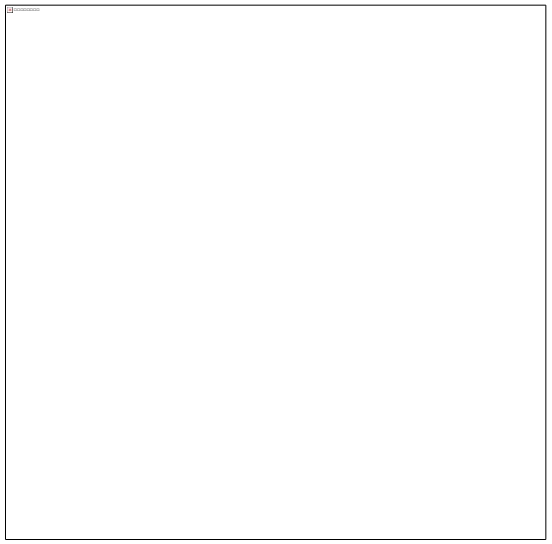
Cell Size Increase

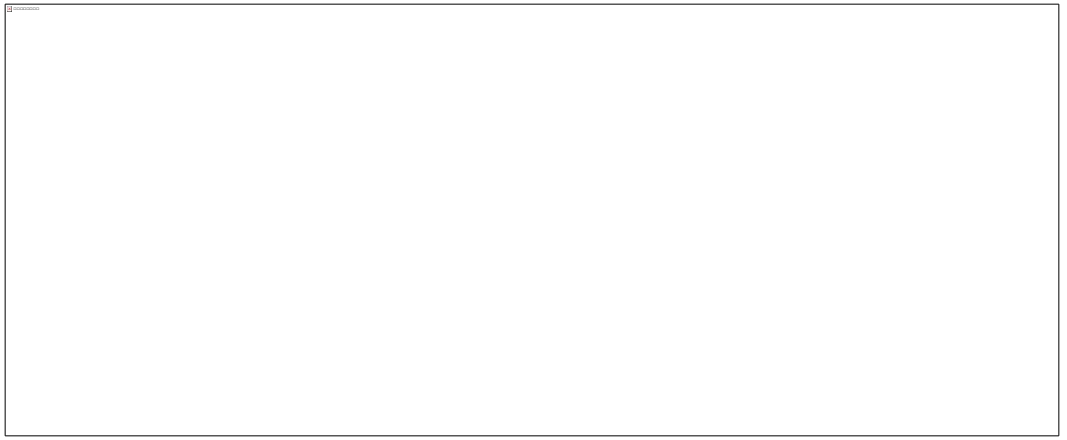
- Consequence of genome size increase
- 2 X increase in cell volume
- 1.58 X increase in cell surface area



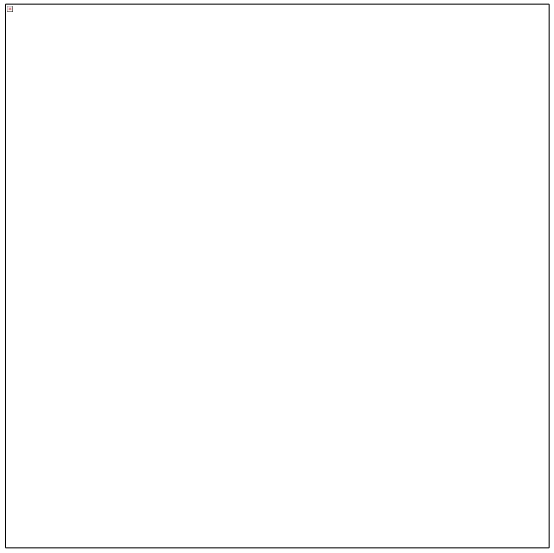
Fossil Estimates

Miocene *Platanus*



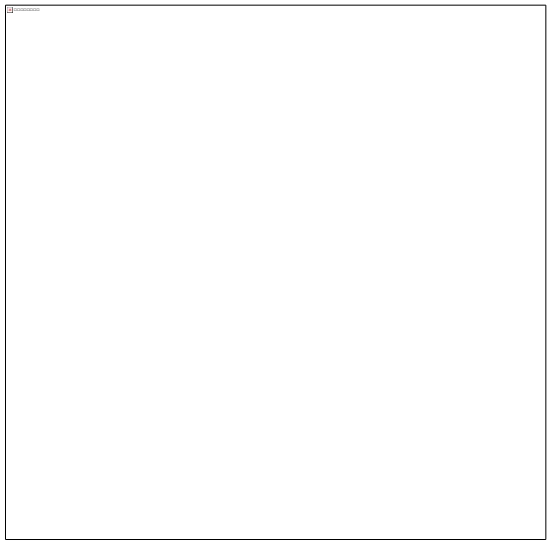


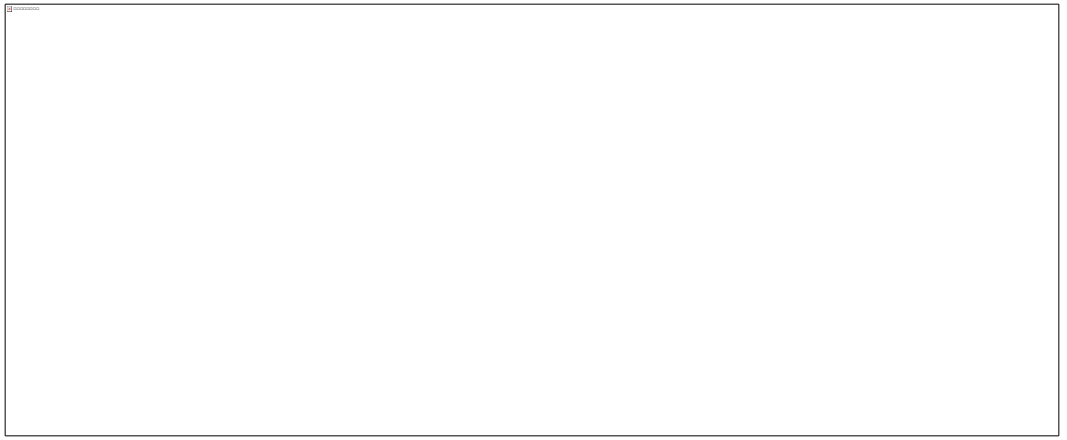
Extant *Platanus*



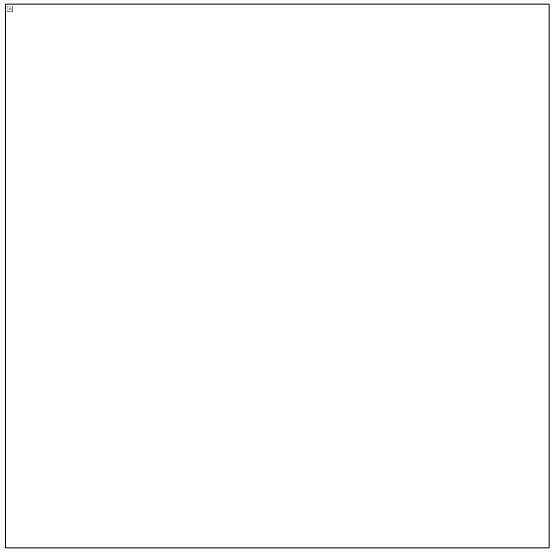
Fossil Estimates

Miocene *Platanus*





Extant *Platanus*



n > 7 – 9

70% angiosperms

Gene trees versus species trees

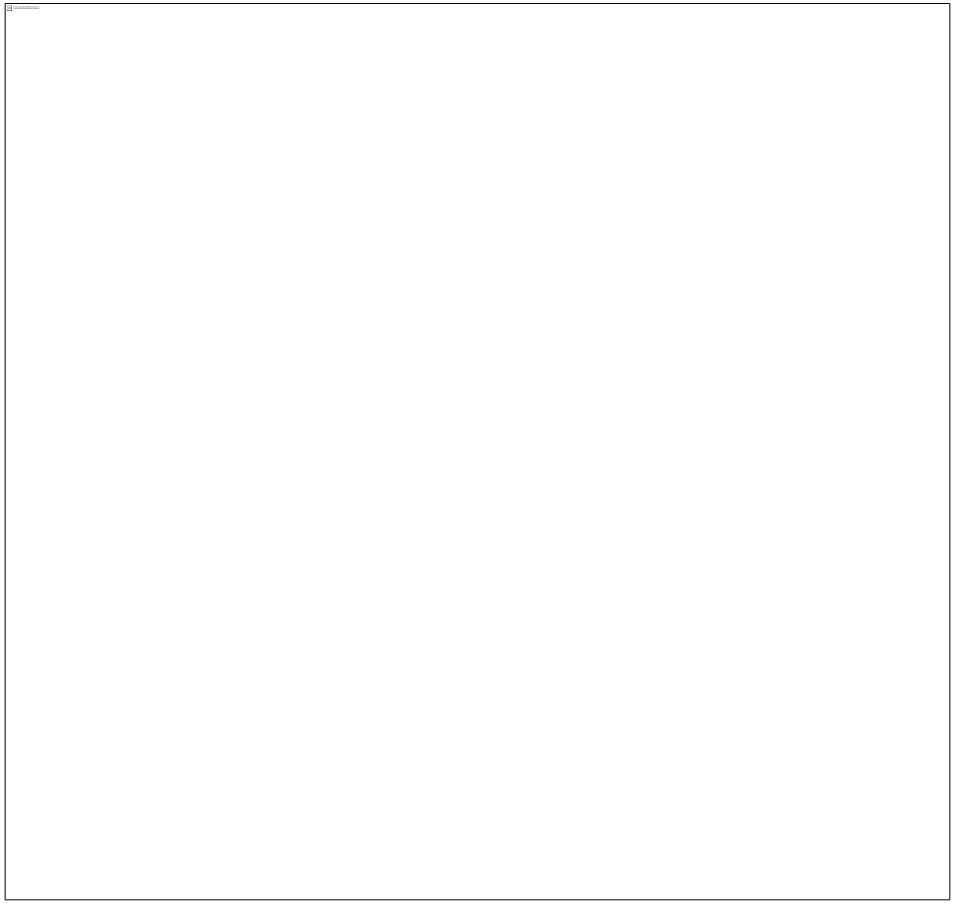
Gene trees versus species trees

Gene trees versus species trees

Gene trees versus species trees

Synteny Analyses

Grape

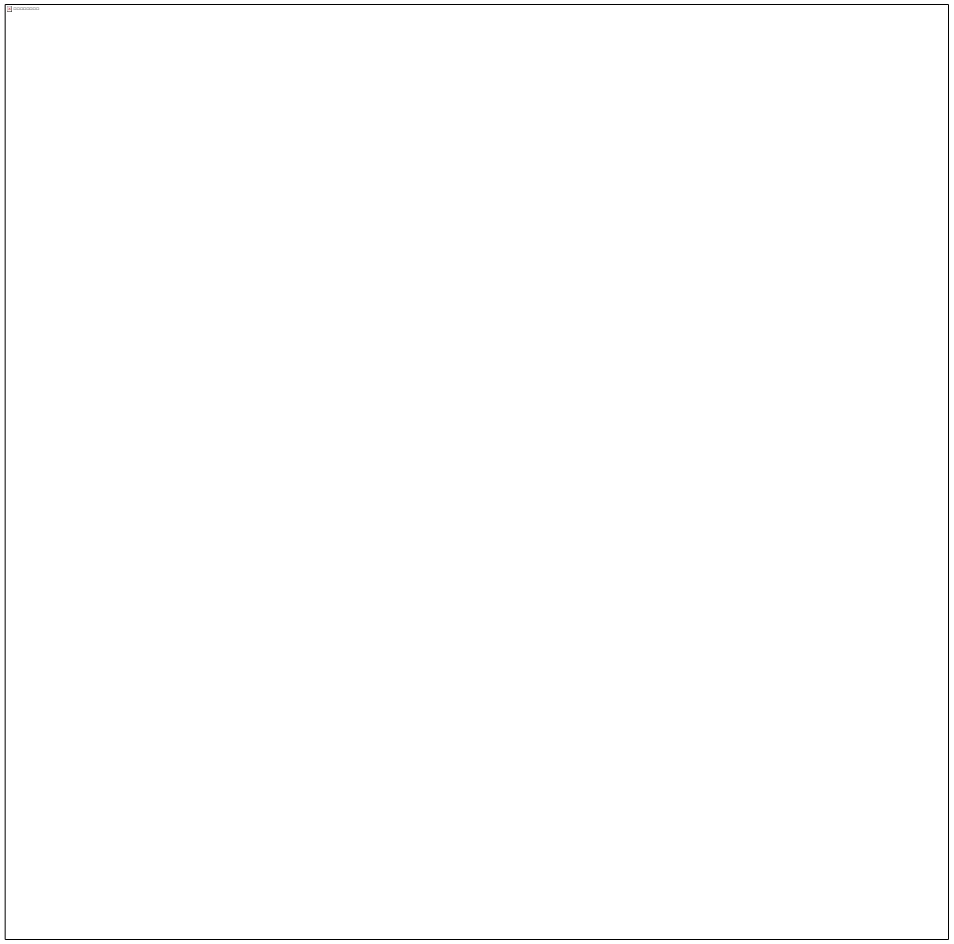


Poplar

What is the history of paleopolyploidy?

Synteny Analyses

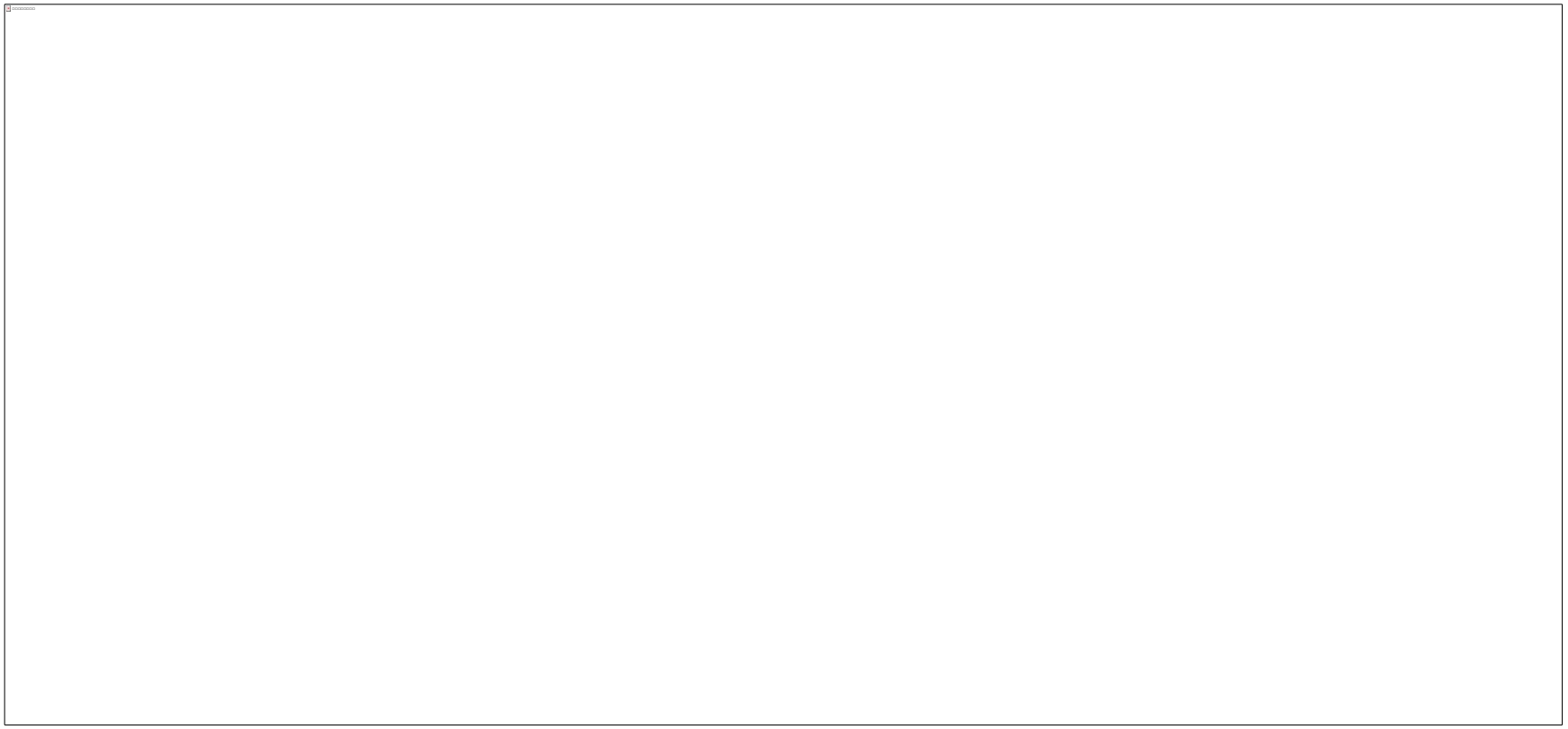
Grape



Arabidopsis

What is the history of paleopolyploidy?

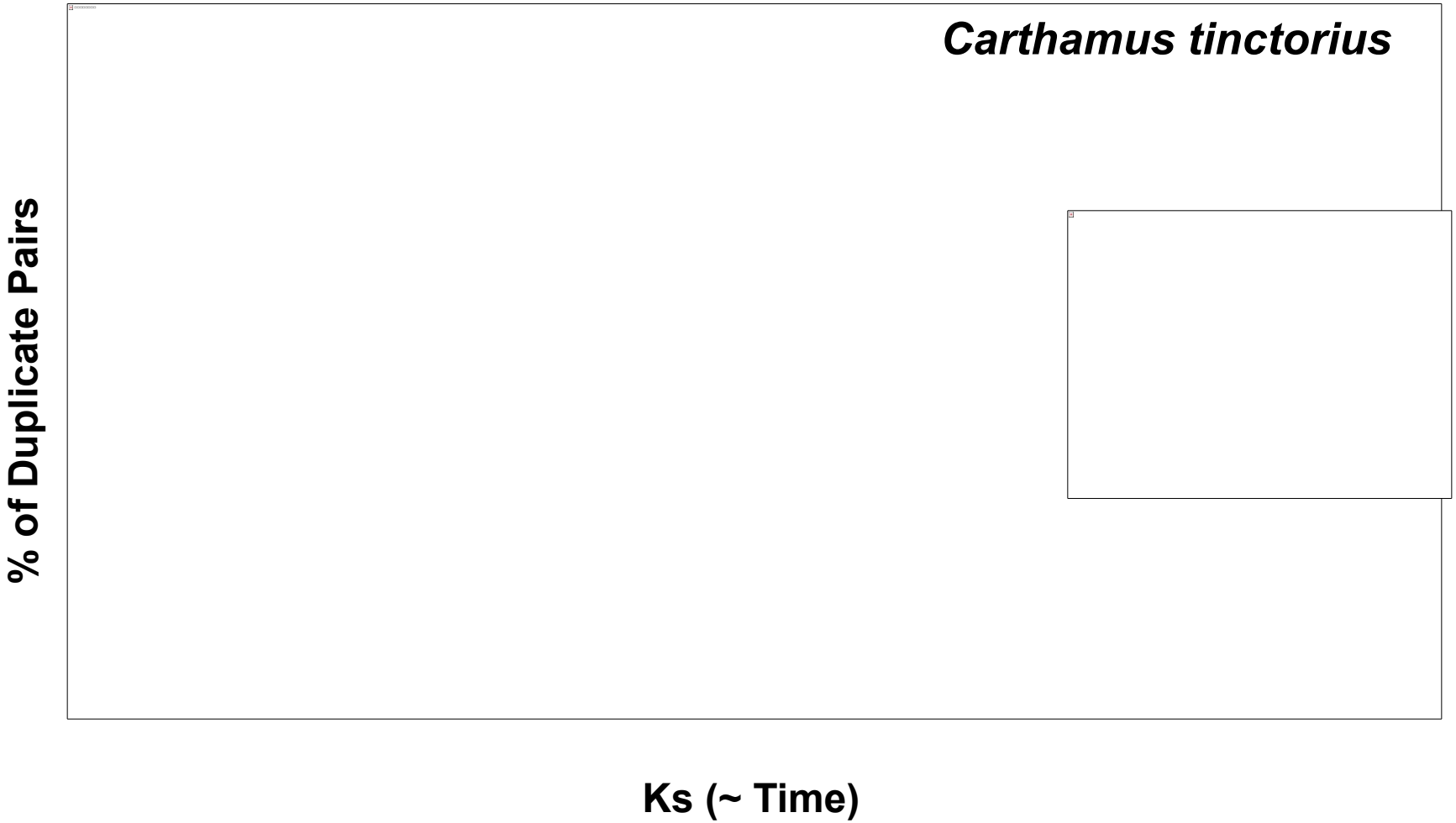
Synteny Analyses



Whole Genome Sequences

Duplicate Gene Age Distributions

Duplicate Gene Age Distributions



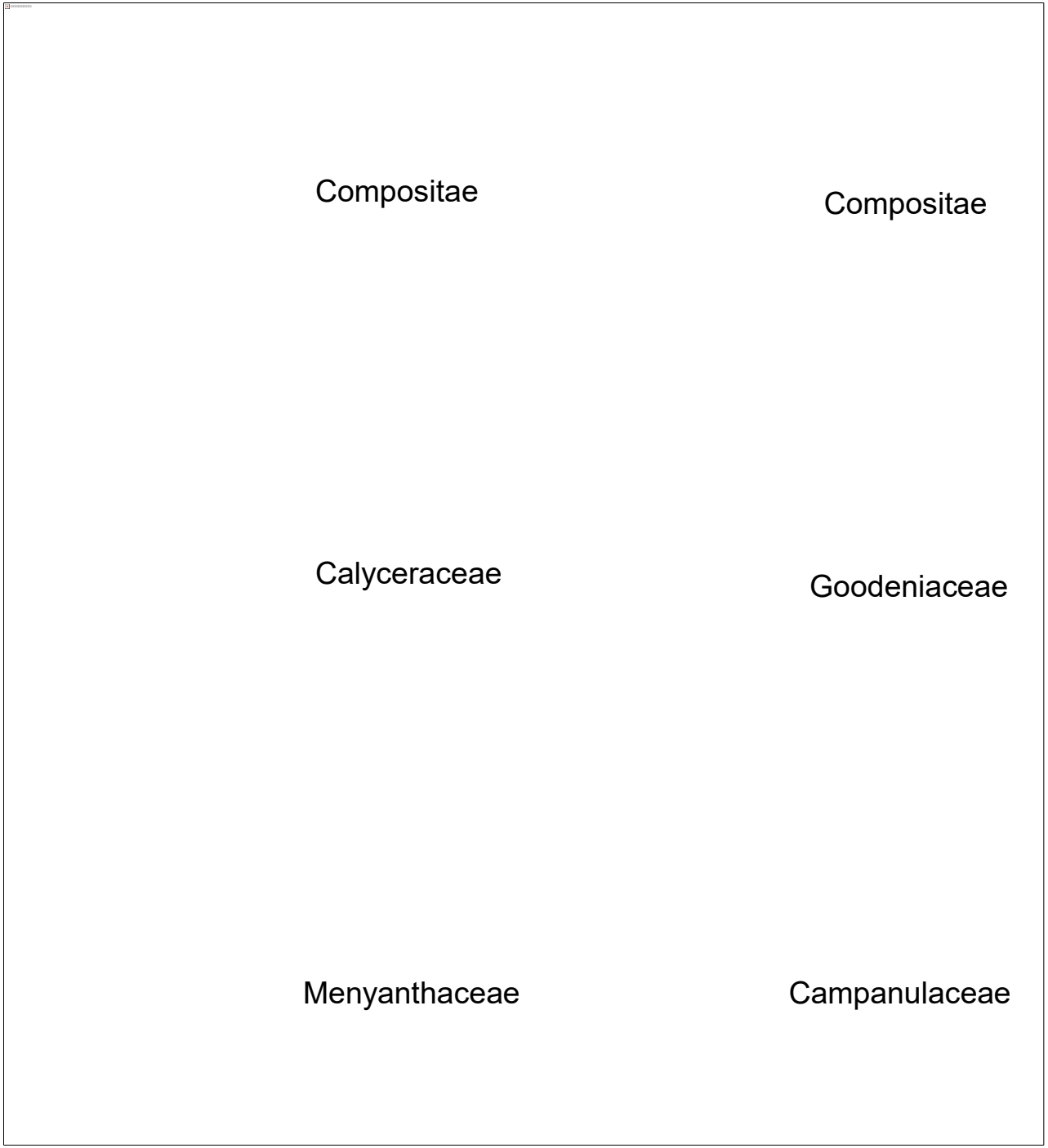
Inferring Paleopolyploidy

Histograms of gene age distributions for six species of Compositae and related families.

The y-axis is the number of gene duplications; the x-axis is synonymous divergence (Ks) of the duplication.

Peaks of gene duplication in panels A, B, and C correspond to whole-genome duplications.

American J of Botany, Volume: 103, Issue: 7, Pages: 1203-1211, First published: 16 June 2016, DOI: (10.3732/ajb.1600113)



Inferring Paleopolyploidy

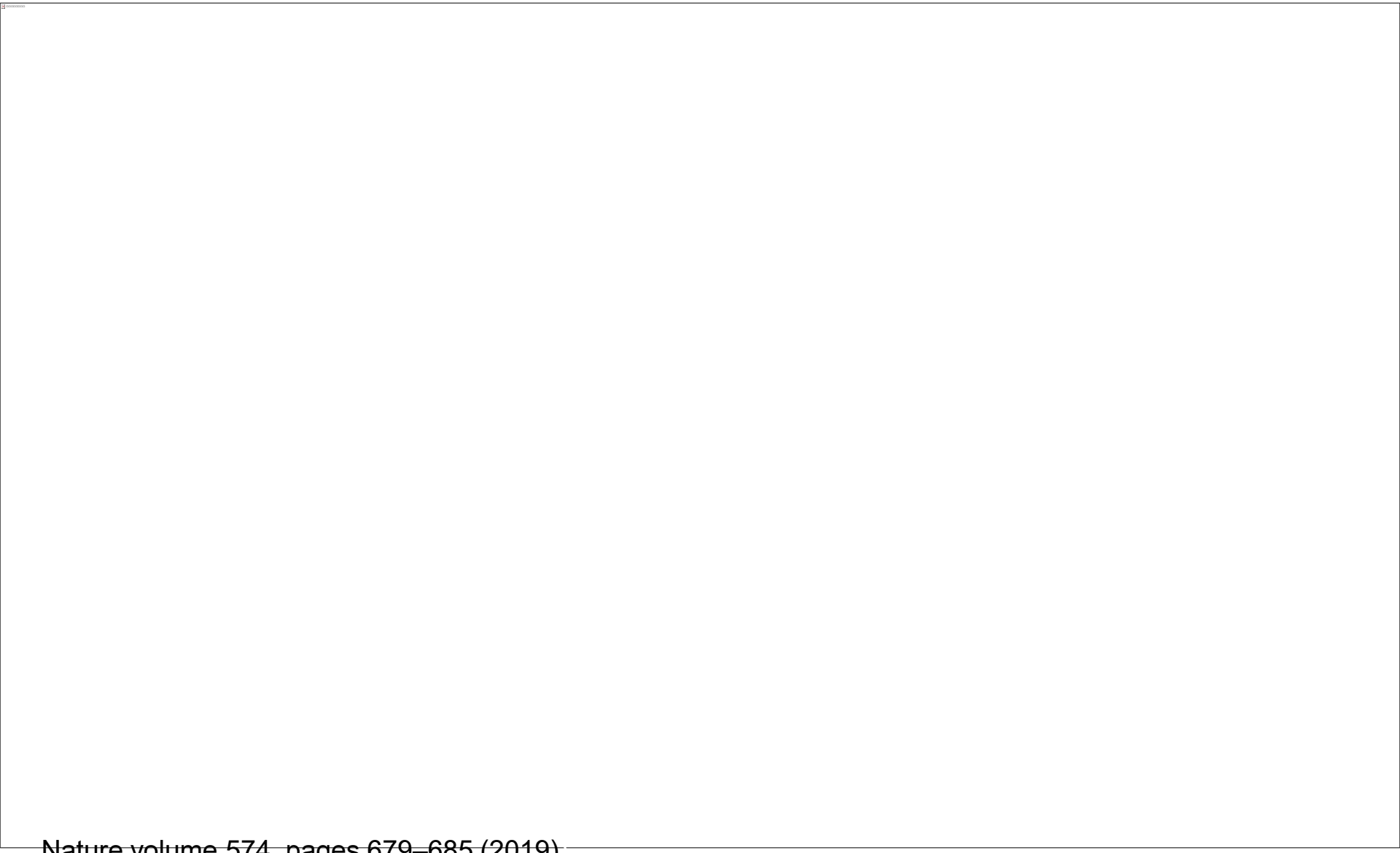
Species tree of Compositae and related families with percentage of gene duplications at each node.

American J of Botany, Volume: 103, Issue: 7, Pages: 1203-1211, First published: 16 June 2016, DOI: (10.3732/ajb.1600113)

Whole Genome Duplications WGDs in Seed Plant and Gymnosperm History

Li *et al.*, 2015

Whole Genome Duplications across Green Plants

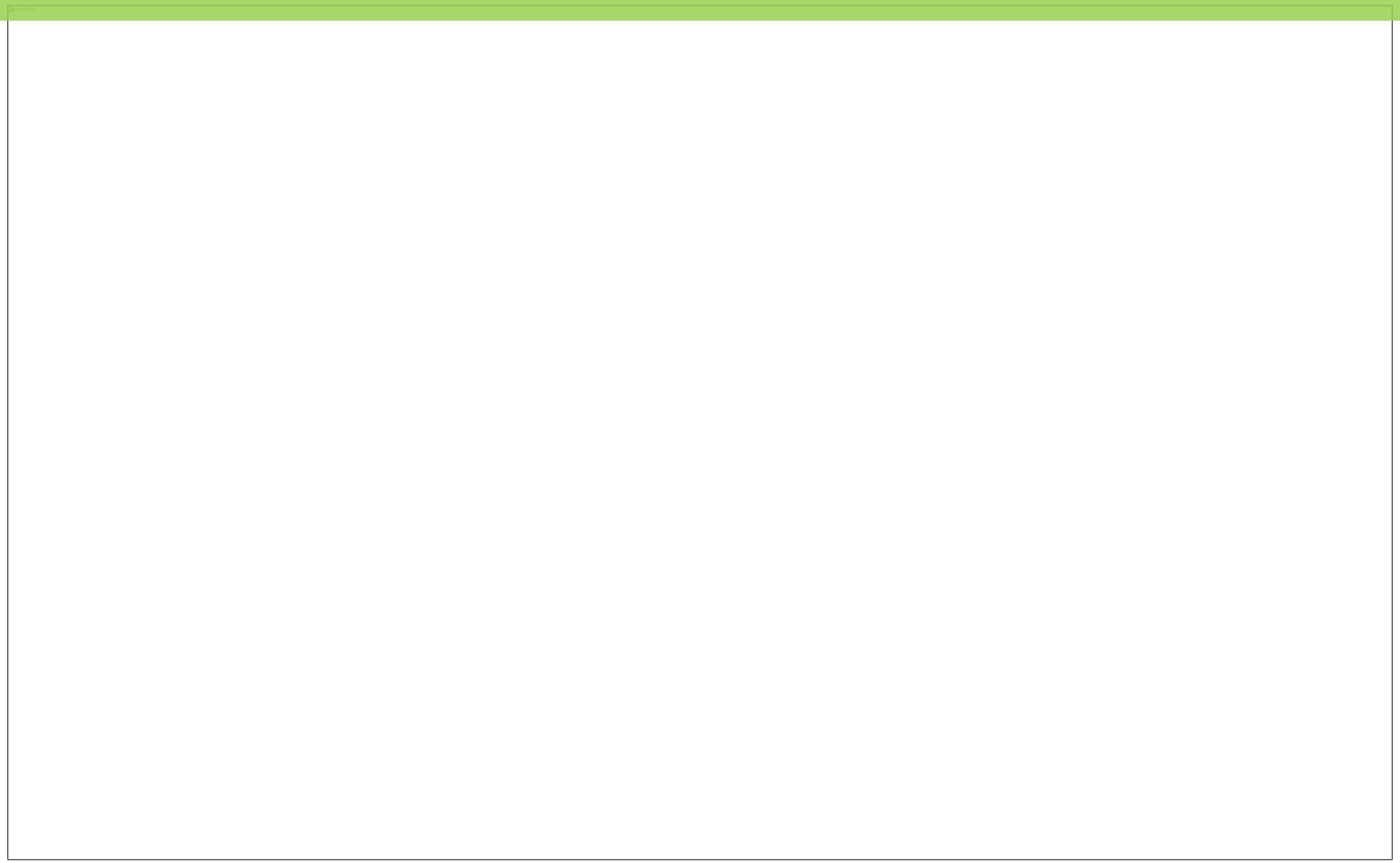


Nature volume 574, pages 679–685 (2019)

Whole Genome Duplications across Green plants

- 244 Independent Paleopolyploidizations
- Most algal lineages show no evidence of WGDs
- All land plants except Selaginella & some liverworts are ancient polyploids
- All seed plants are ancient polyploids
- All flowering plants characterized by at least two WGDs

Effects of paleopolyploidy on diversification rates in flowering plants



▲ Significant increases in diversification rates in flowering plants

- Half are associated with paleopolyploidy (p = 0.005)

M. Barker et al. (unpublished)

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?

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?