# Green Tree of Life: Resolving green plant phylogeny, from morphology to genomics

*Presented by:*

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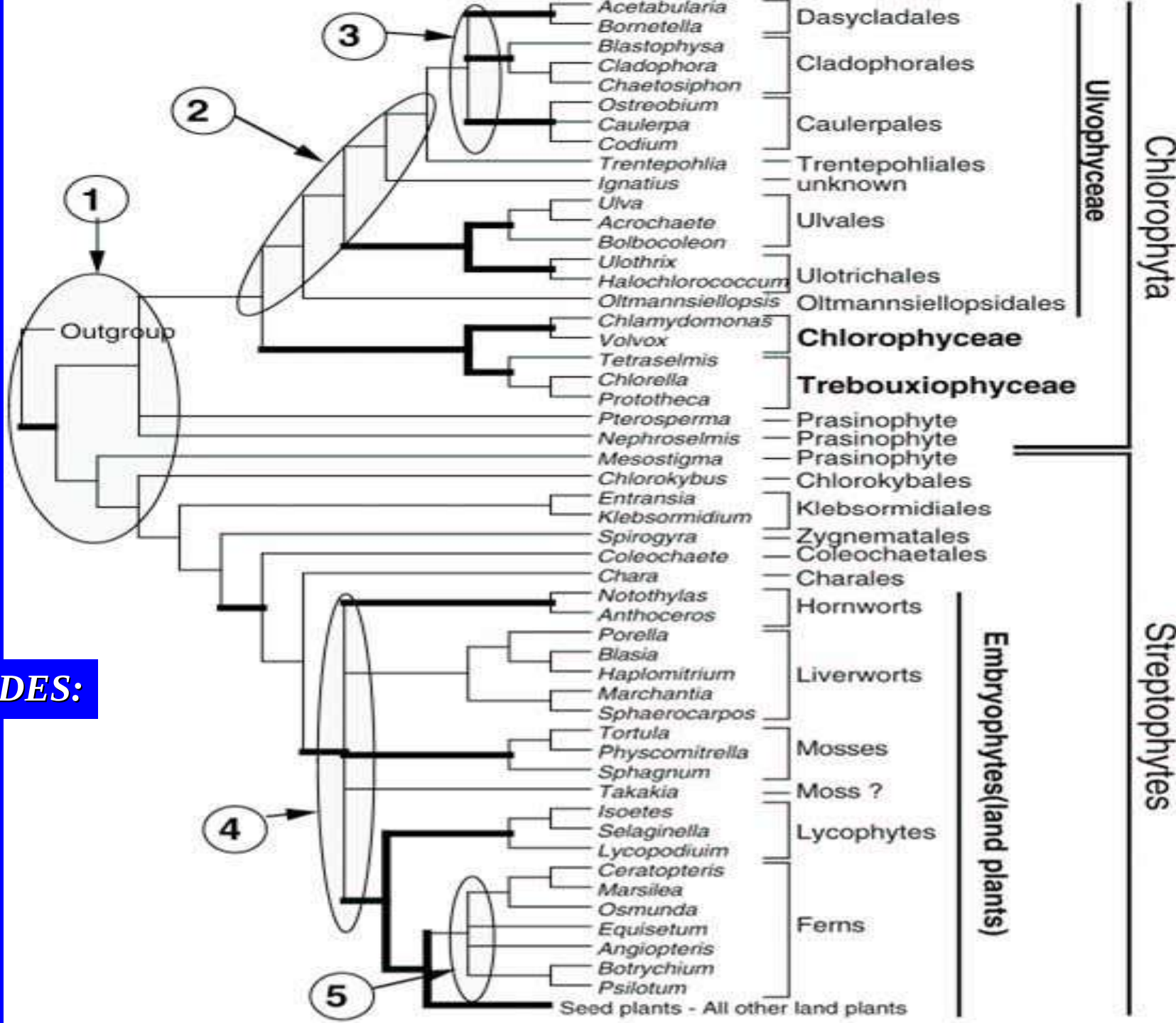
West Boothbay Harbor, Maine

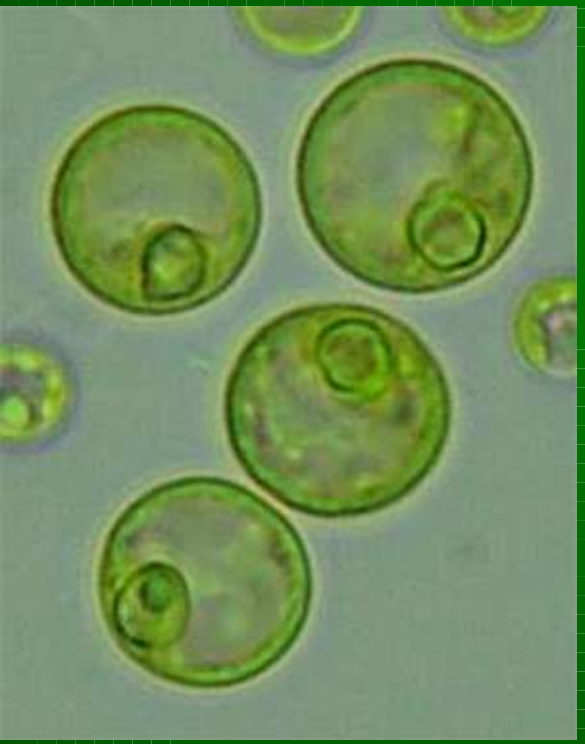
the green tree of life

***UNRESOLVED NODES:***



# Ulvophyceae: One class or two?

- CCMP 1293
  - Coccoidal morphology, resembles *Chlorocystis*
  - Ulotrichales ultrastructure
  - Disjunct gene sequences (18s rRNA, *tufA*)



- *Blastophysa* spp.
  - Cladophorales morphology
  - Cladophorales ultrastructure
  - Disjunct 18s sequence
    1. Sister to 1293
    2. Basal to Cladophorales

- Discontinuous morphological/molecular evolution

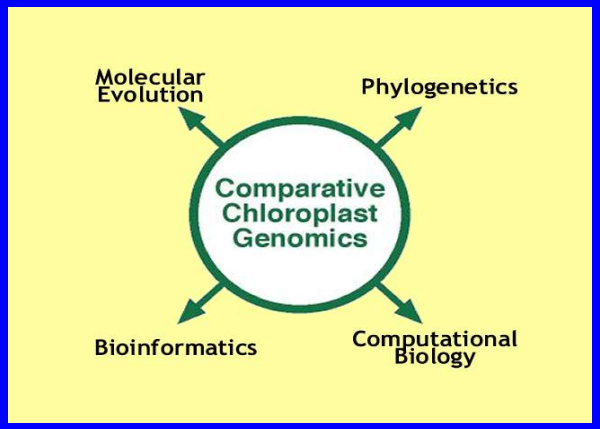
# The Deep Green "family"

Some of the projects that have been funded as part of the "Deep Green" tradition of research cooperation.

GREEN PLANT BAC LIBRARY PROJECT

THE GREEN PLANT BAC LIBRARY PROJECT

DEEP TIME



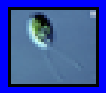
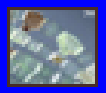

DEEP GENE

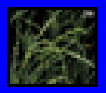
the green tree of life

deepestgreen

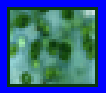
The Floral Genome Project









# The Green Tree of Life (GToL):

## "Deep Green Plant Phylogenetics: Novel Analytical Methods for Scaling from Genomics to Morphology"

***TOWARD RESOLUTION OF GREEN PLANT PHYLOGENY***



| | | |
|---|---|---|
| O'Kelly | 0228655 | Bigelow Lab for Ocean Sciences |
| Donoghue | 0228576 | Yale University |
| Mandoli, Olmstead | 0228660 | University of Washington |
| Mishler, Smith, Boore | 0228729 | University of California, Berkeley |
| Renzaglia | 0228679 | Southern Illinois University, Carbondale |
| Wolf | 0228432 | Utah State Univ. |

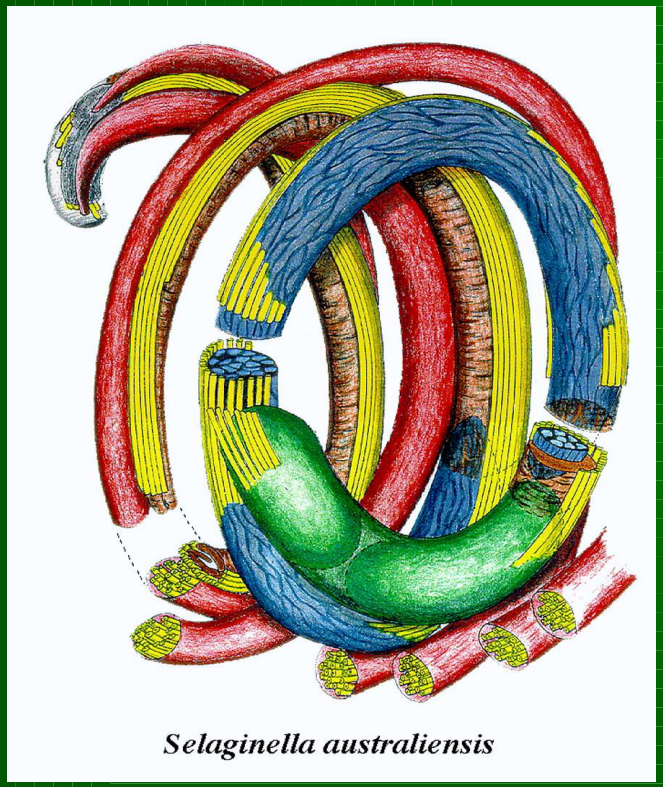

## Goals:

* complete a matrix of whole genome sequences for chloroplasts and mitochondria and develop Bacterial Artificial Chromosome (BAC) nuclear genome libraries (where feasible given genome size) for ca. 50 representatives of the critical deep-branching lineages of green plants.

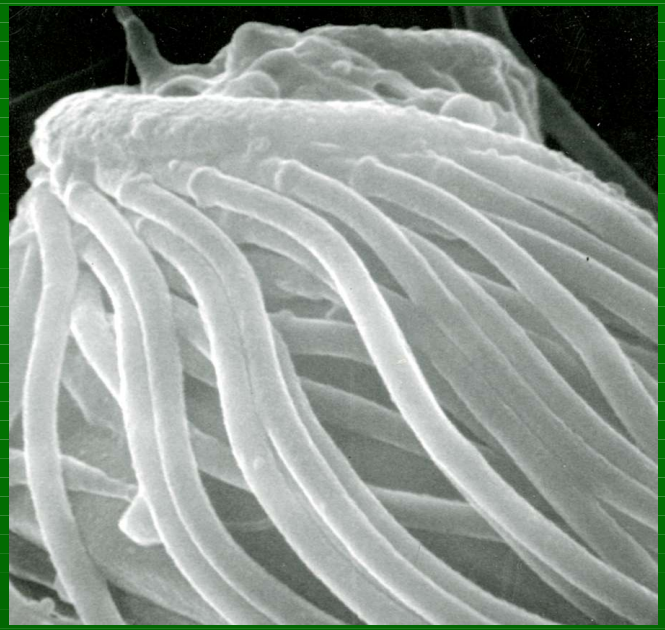
* produce a comprehensive set of comparable morphological and ultrastructural data for these same taxa;

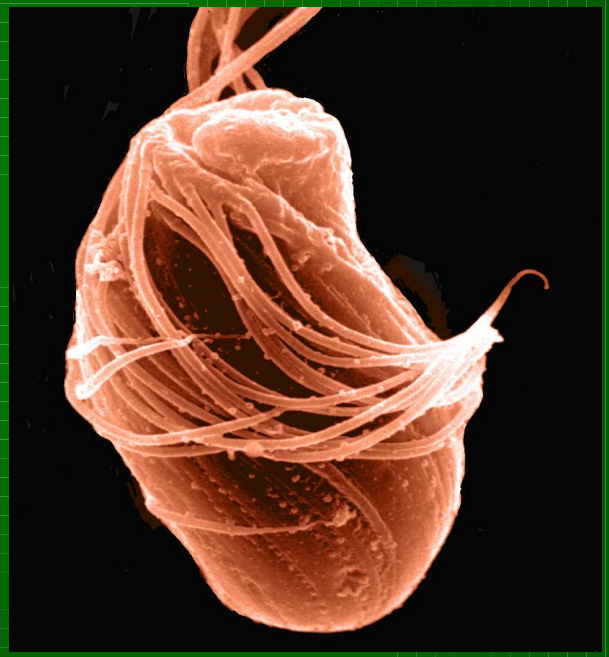
•incorporate inferences from across the phylogenetic hierarchy in green plants using methods designed to permit scaling across studies.

# Morphological/ Ultrastructural Data: Spermatozoid Structure and Development in Embryophytes




Renzaglia





Bryophyte morphology: Teacher Workshop (2003 BSA) and Teaching Materials development.

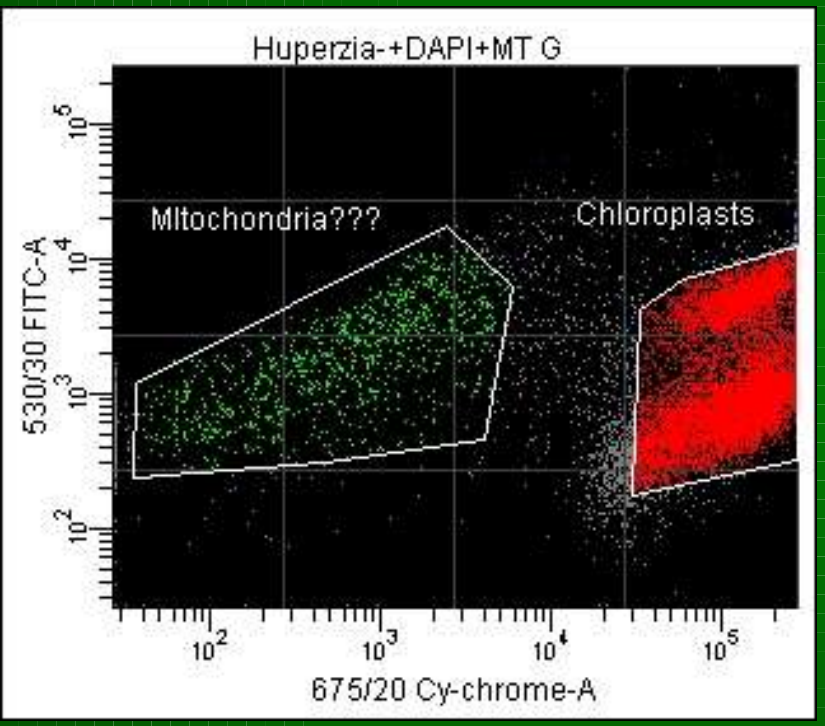

Huperzia lucidula (Lycopodium lucidulum)

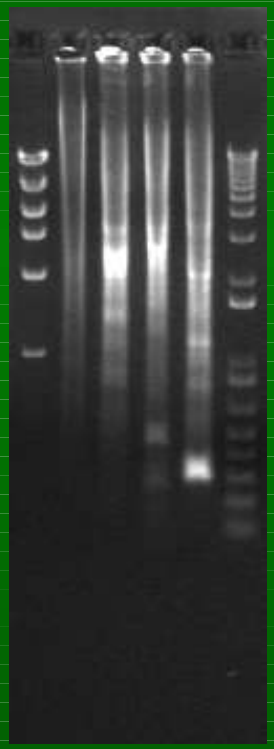
# The dissection of *Huperzia*

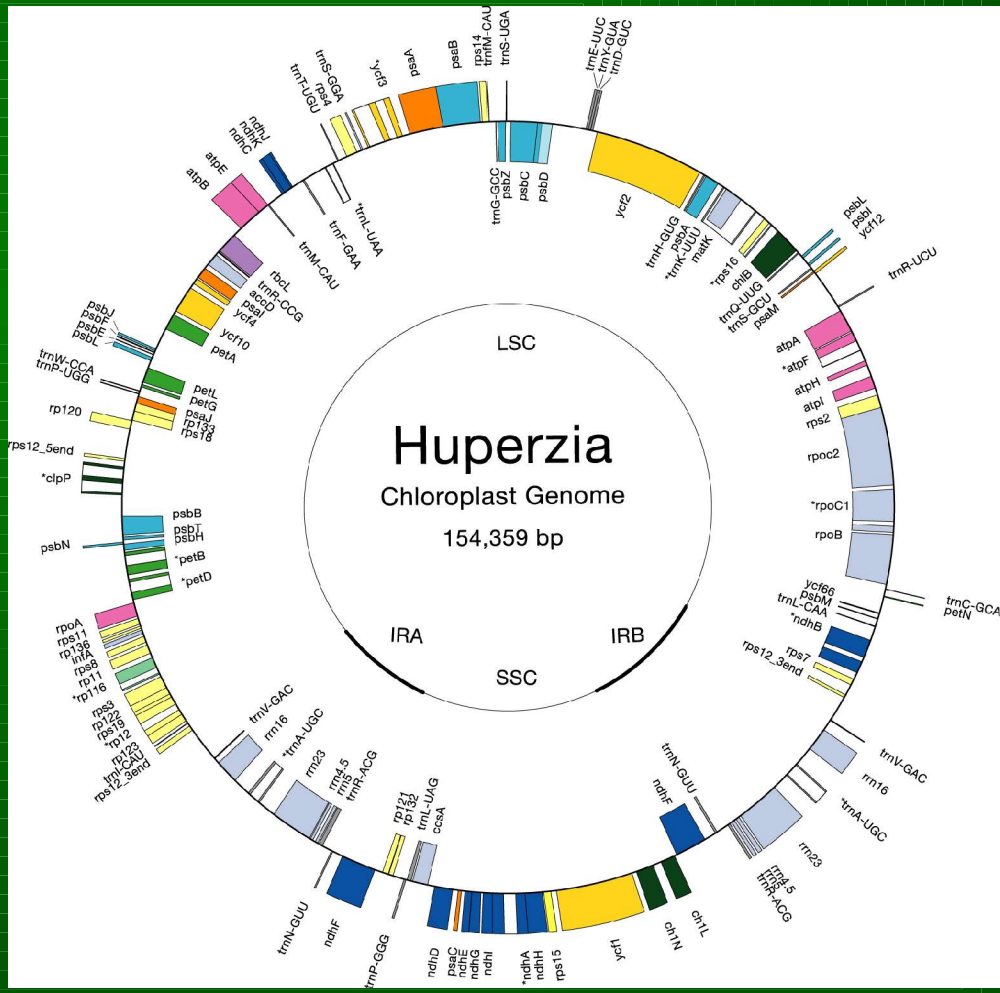
- Specimen collected and identified (Wolf)
- Specimen vouchered (Mishler - Berkeley herbarium)
- Morphological and ultrastructural characterization (Renzaglia)
- Genomic analysis

# *Huperzia lucidula* chloroplast genome

Boore / Wolf

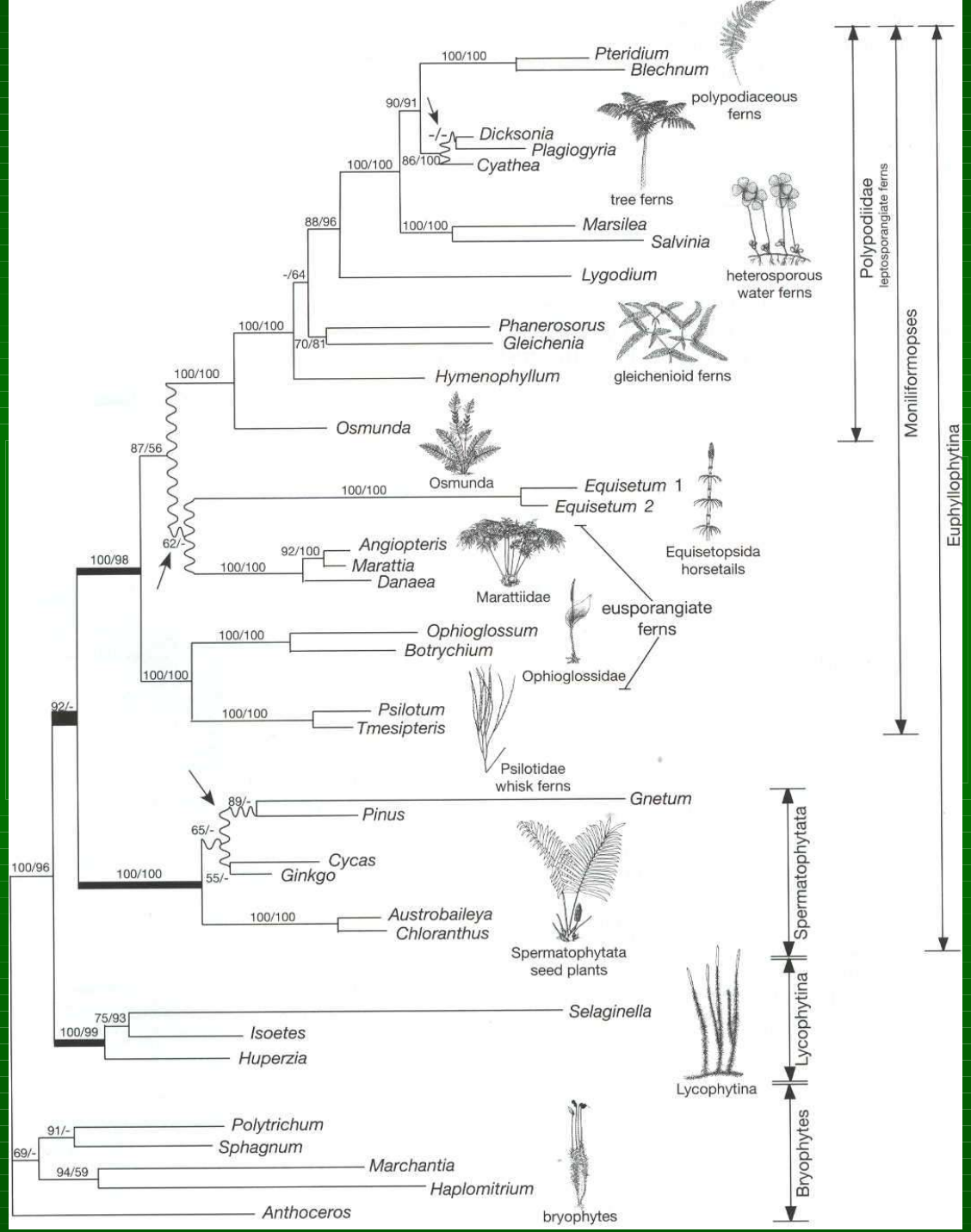


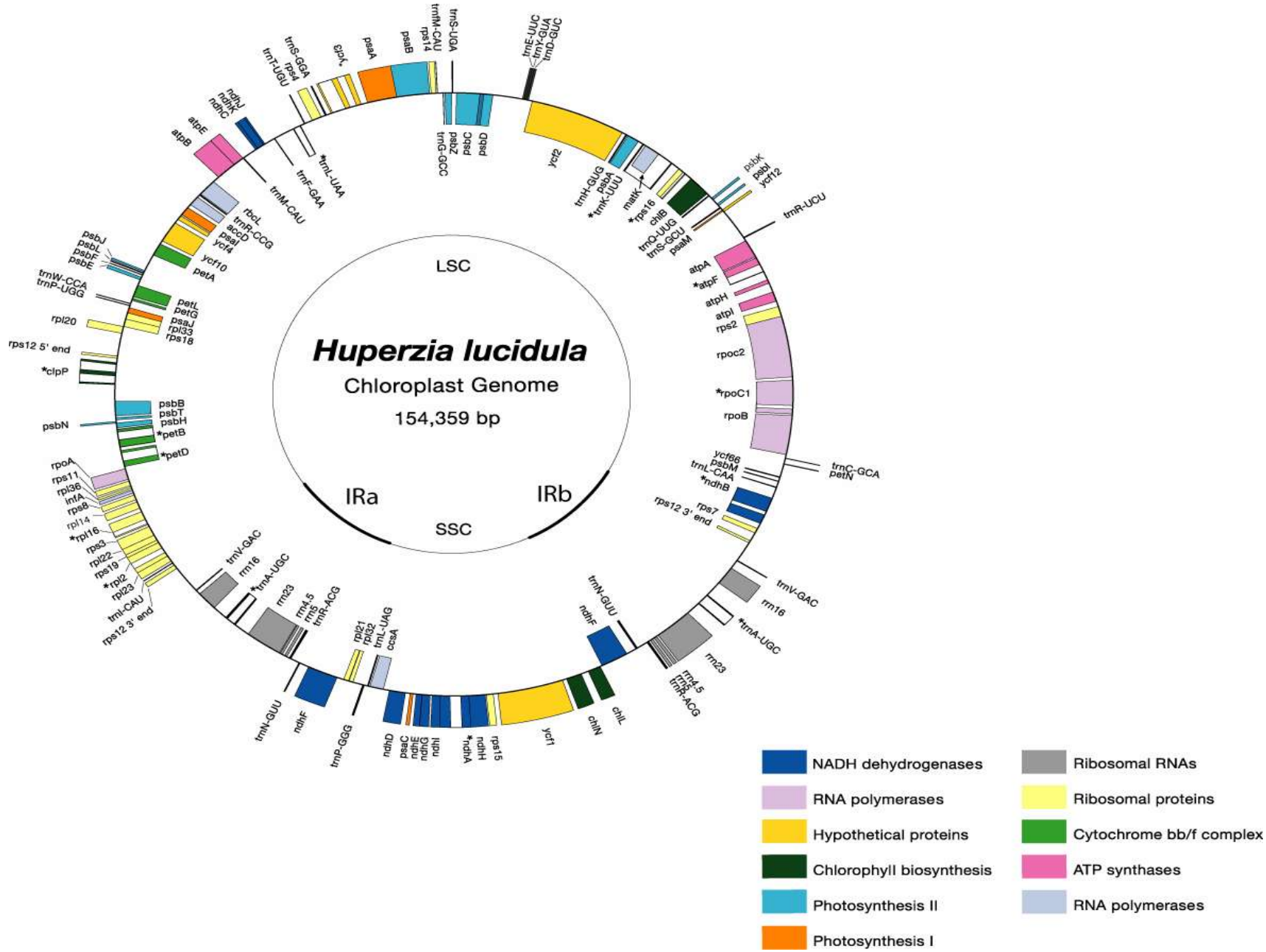



Mandoli / Arumuganathan

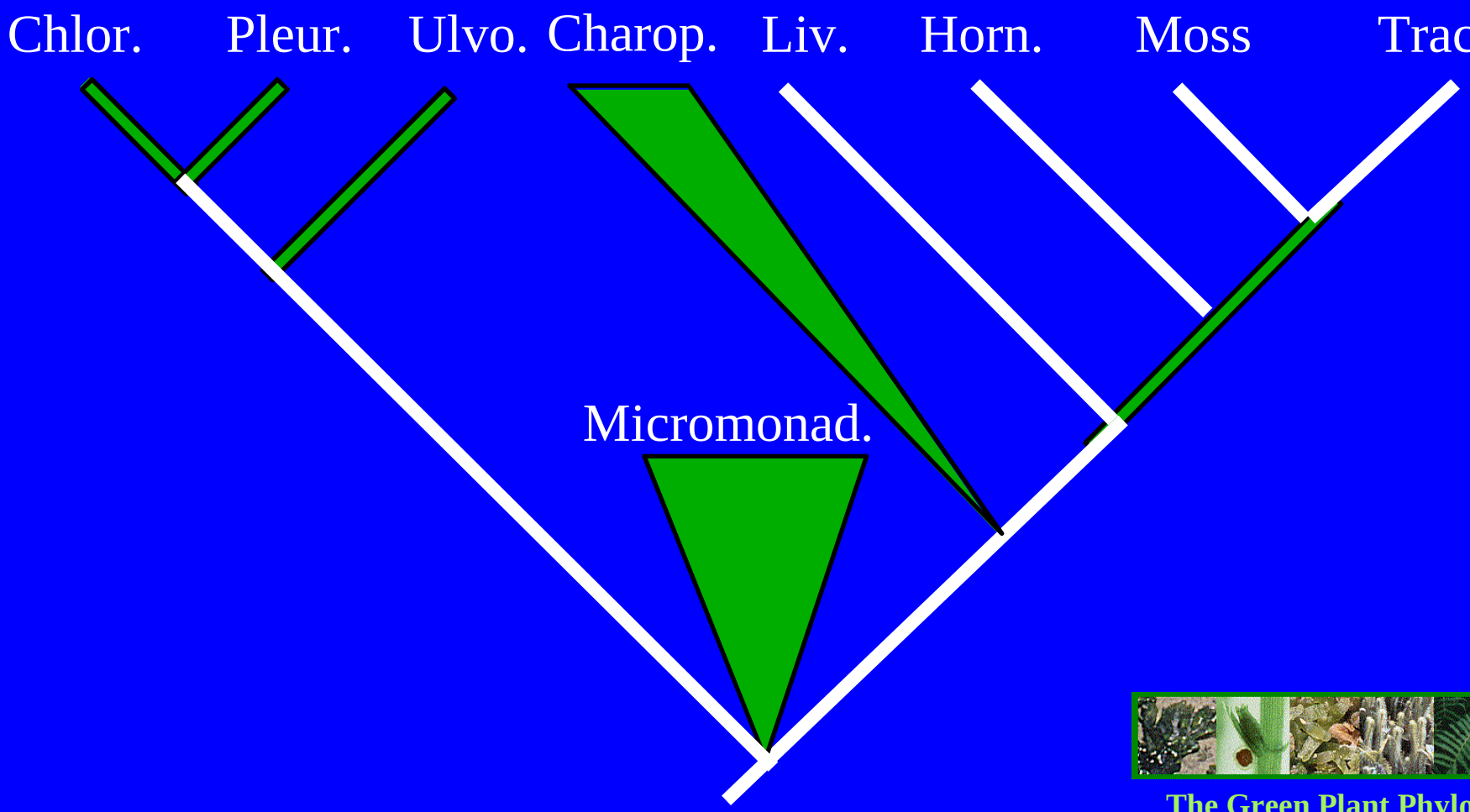
Boore


Pteridium
Blechnum
polypodiaceous ferns
Dicksonia
Plagiogyria
Cyathea
tree ferns
Marsilea
Salvinia
heterosporous water ferns
Lygodium
Phanerosorus
Gleichenia
gleichenioid ferns
Hymenophyllum
Osmunda
Osmunda
Equisetum 1
Equisetum 2
Equisetopsida horsetails
Angiopteris
Marattia
Danaea
Marattiidae
eusporangiate ferns
Ophioglossum
Botrychium
Ophioglossidae
Psilotum
Tmesipteris
Psilotidae whisk ferns
Gnetum
Pinus
Cycas
Ginkgo
Austrobaileya
Chloranthus
Spermatophytata seed plants
Selaginella
Isoetes
Huperzia
Lycophytina
Polytrichum
Sphagnum
Marchantia
Haplomitrium
Anthoceros
bryophytes
Polypodiidae
leptosporangiate ferns
Moniliformopses
Euphyllophytina
Spermatophytata
Lycophytina
Bryophytes


The story continues …


Huperzia lucidula
Chloroplast Genome
154,359 bp
LSC
IRa
IRb
SSC
NADH dehydrogenases
RNA polymerases
Hypothetical proteins
Chlorophyll biosynthesis
Photosynthesis II
Photosynthesis I
Ribosomal RNAs
Ribosomal proteins
Cytochrome bb/f complex
ATP synthases
RNA polymerases

# Outline of Green Plant relationships

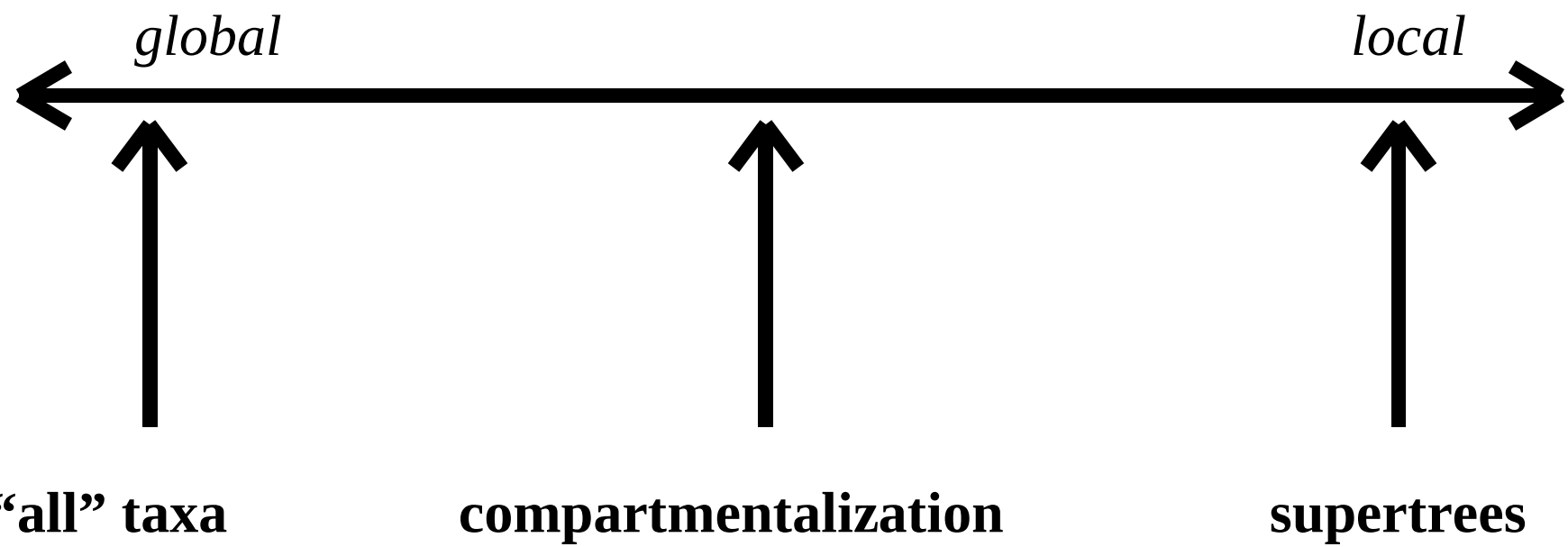


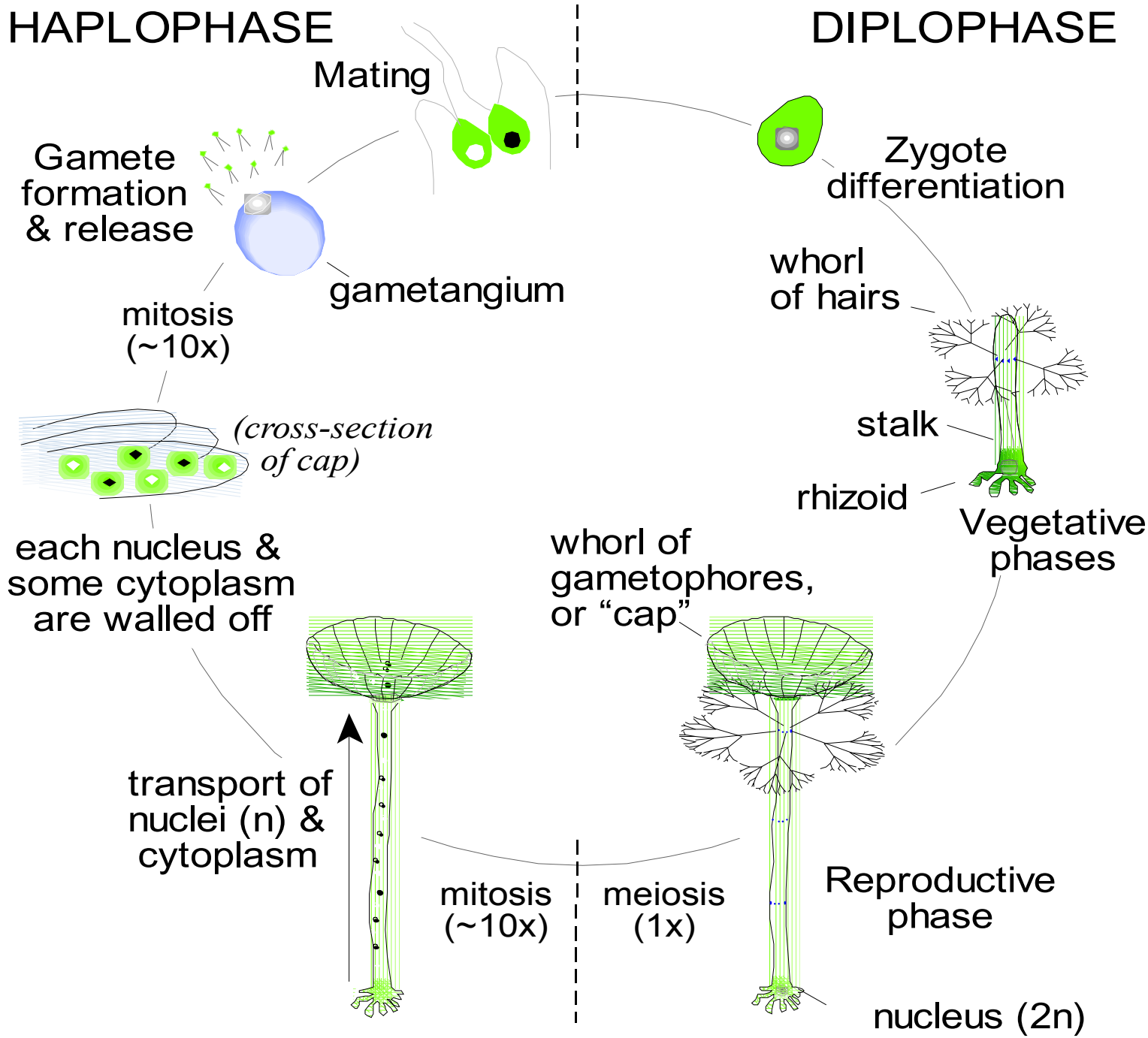

http://ucjeps.berkeley.edu/map2.html

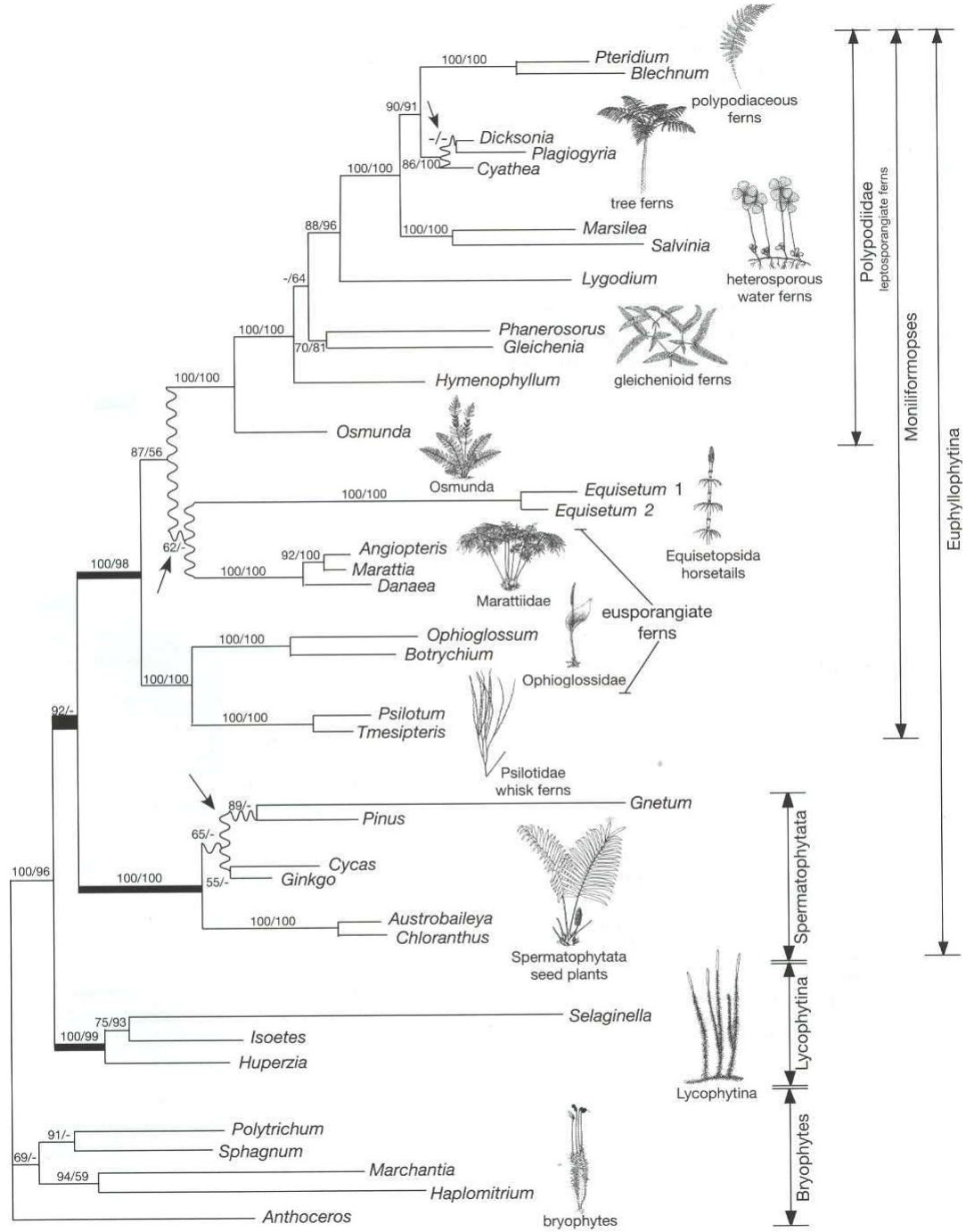


**The Green Plant Phylogeny Research Coordination Group**

# HOW TO CONCATENATE DIFFERENT ANALYSES TO BUILD THE TREE OF LIFE




HAPLOPHASE
DIPLOPHASE
Mating
Gamete formation & release
gametangium
mitosis (~10x)
(cross-section of cap)
each nucleus & some cytoplasm are walled off
transport of nuclei (n) & cytoplasm
mitosis (~10x)
meiosis (1x)
whorl of gametophores, or "cap"
Reproductive phase
nucleus (2n)
Zygote differentiation
whorl of hairs
stalk
rhizoid
Vegetative phases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Hymenophyllum
Osmunda
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Equisetum 2
Equisetopsida horsetails
Angiopteris
Marattia
Danaea
Marattiidae
eusporangiate ferns
Ophioglossum
Botrychium
Ophioglossidae
Psilotum
Tmesipteris
Psilotidae whisk ferns
Gnetum
Pinus
Cycas
Ginkgo
Austrobaileya
Chloranthus
Spermatophytata seed plants
Selaginella
Isoetes
Huperzia
Lycophytina
Polytrichum
Sphagnum
Marchantia
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Anthoceros
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Euphyllophytina
Spermatophytata
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