Molecular systematics: a panacea?

What molecular tools can and can't tell us about plant diversity

Richard Olmstead
Department of Biology and Burke Museum

DEPARTMENT OF BIOLOGY
UNIVERSITY of WASHINGTON

BURKE
MUSEUM

Molecular systematics: a panacea?

Panacea: *a solution or remedy for all problems*

Molecular systematics: a panacea?

Panacea: *a solution or remedy for all problems*

To start, we need
to know what problems
need solutions!

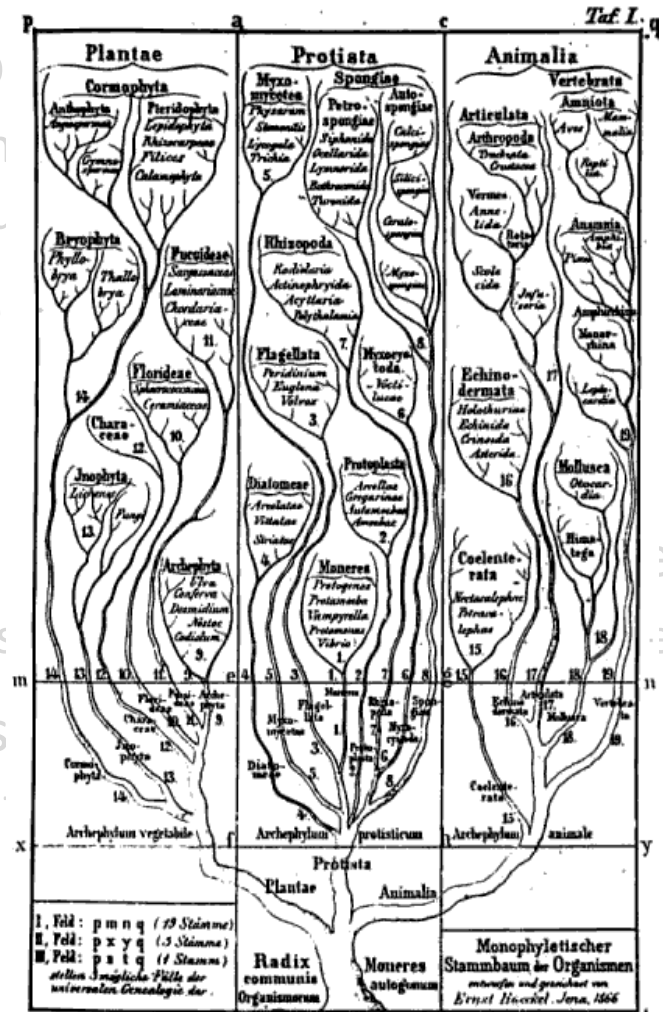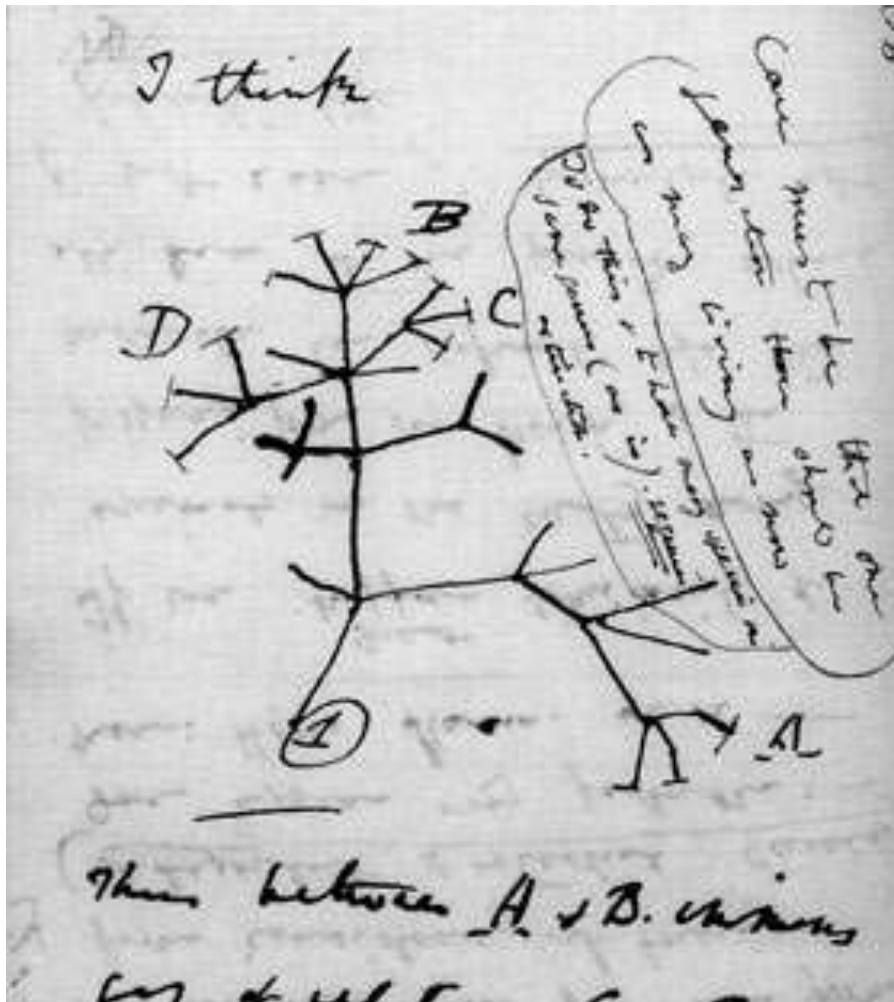DNA in cesium chloride solution; S. Wagstaff photo

Problems in Plant Diversity:

- How do we know what species are related to each other?

- How do we know what species this plant belongs to?

- How do we know what a species even is?

- How do we know what to name and how do we assign a name?

- How do we know where these plants came from?
- How do we know how old this group of plants is?
- How do we integrate fossil and living plants?
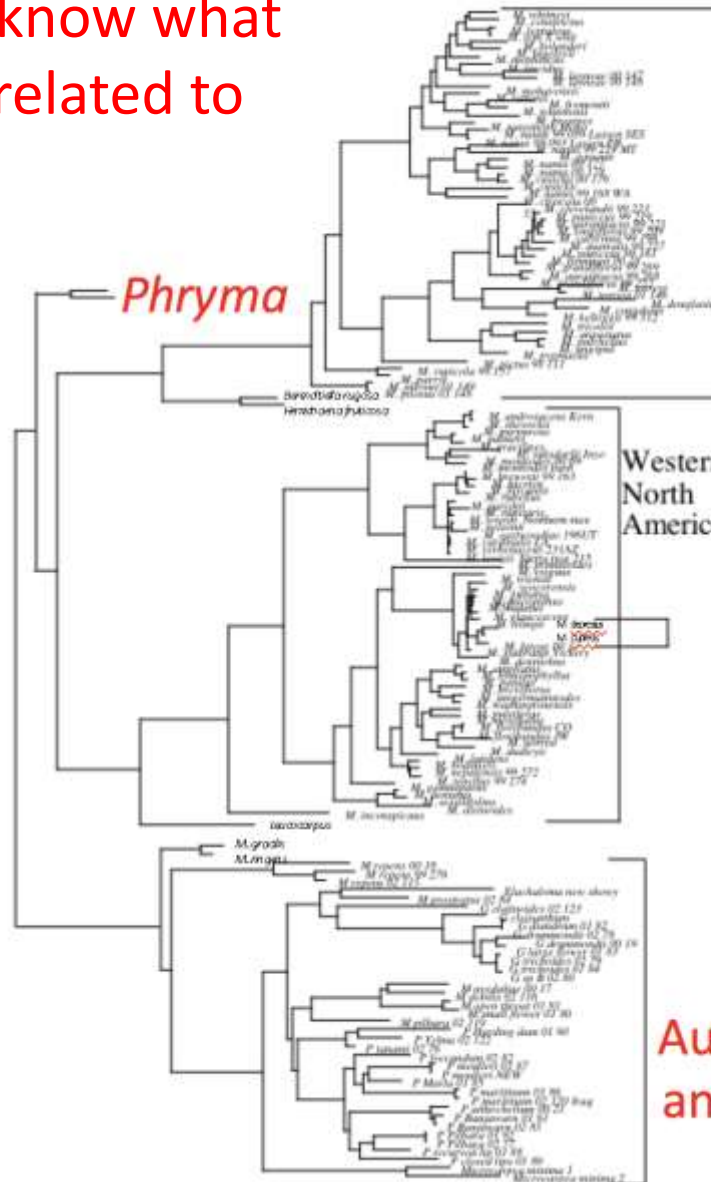- How do we …?

Problems in Plant Diversity:

- How do we know what species are related to each other?

Ever since Darwin, we've expected classifications to reflect evolutionary relationships: "*all true classification is genealogical*"

Problems in Plant Diversity

- How do we know what species are related to each other?

Beardsley & Olmstead, 2002
Am. J. Bot. 89: 1093

Western North America *Mimulus*
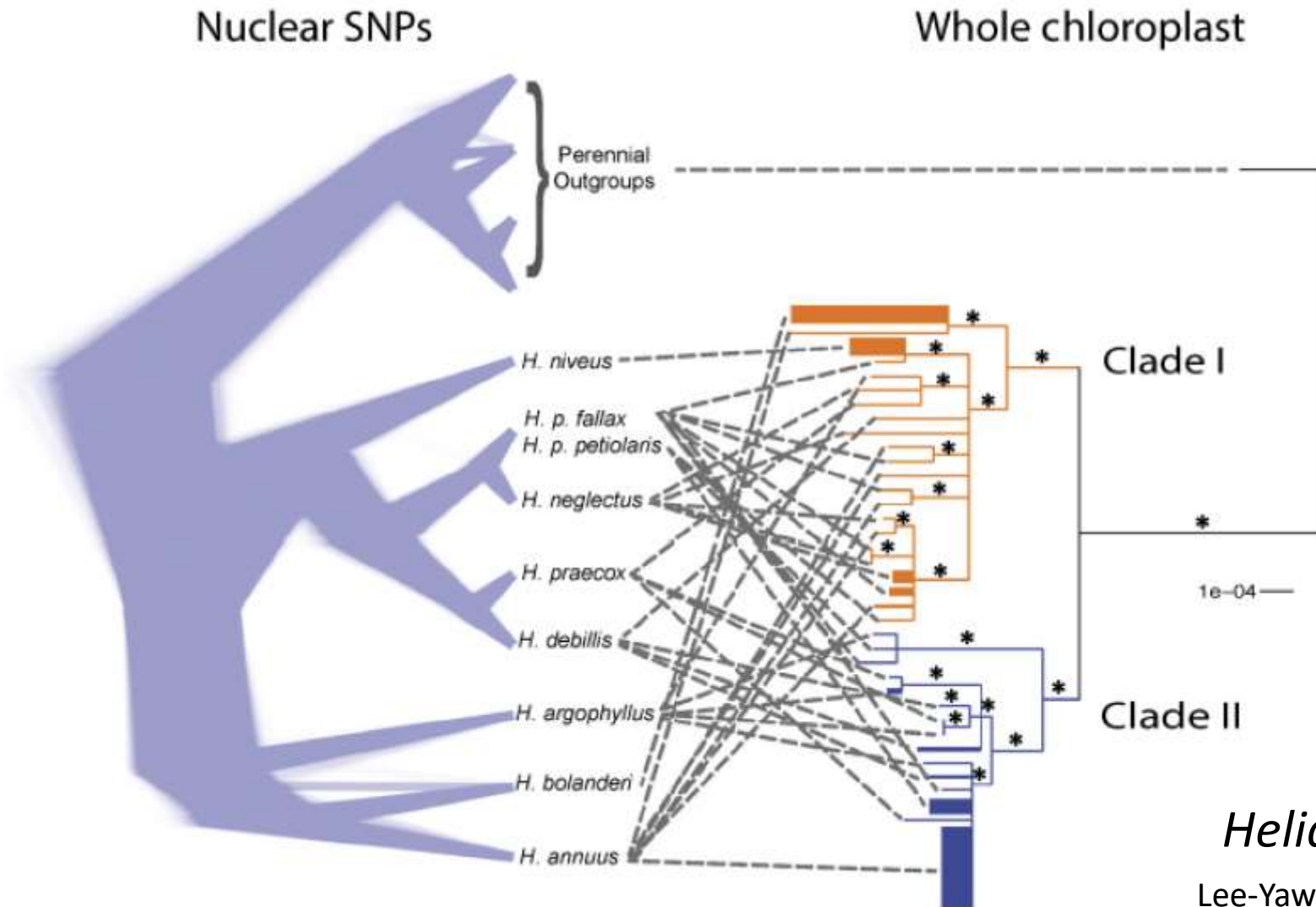
Phryma

Phrymaceae

Western North America *Mimulus*

Australian *Mimulus* and 4 other genera

Photo: G. Smith

Problems in Plant Diversity

- How do we know what species are related to each other?

Helianthus

Lee-Yaw et al., 2019

Problems in Plant Diversity

- How do we know what species are related to each other?

Dipterocarpaceae

28 My

28 My

Whole plastid genome

RADseq; 20,000 nuclear loci
100,000 SNPs

Problems in Plant Diversity

- How do we know what species are related to each other?
  Ever since Darwin, we've expected classifications to reflect evolutionary relationships: "*all true classification is genealogical* "

- **How do we know what species this plant belongs to?**
  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if you are not trained in plant ID?

- How do we know what a species even is?
  Species concepts are many and varied, but fall into two main categories
  1) mechanism based, or 2) lineage based

- How do we know what to name and how do we assign a name?
  'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

Problems in Plant Diversity

- How do we know what species are related to each other?

  Ever since Darwin, we've expected classifications to reflect evolutionary relationships: *"all true classification is genealogical "*

- **How do we know what species this plant belongs to?**

  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if you are not trained in plant ID?

1a Fls in elongate racemes in the axils or terminating ordinary brs (the main st also terminating in a raceme); corolla 6–8 mm, blue; lvs gen 3–8 × 1.5–5 cm, ovate or lance-ovate, with broadly rounded or subcordate base; sts 2–8 dm, arising singly from slender rhizomes; moist bottomlands; transcontinental, mostly w Cas in our area, occ e to n ID; mad-dog s., blue s., madweed, hoodwort   1 **S. lateriflora** L.
1b Fls paired at the nodes (solitary in the axils); corolla (12–)15 mm or more
  2a Lvs mostly truncate-cordate at base, the larger ones gen (2–)2.5–5 cm; palate or corolla merely papillate; sts 2–8 dm, arising singly from slender rhizomes; wet meadows and riparian zones; circumboreal, s on both sides Cas to CA, e in much of N Am to Atl; marsh s., willow-weed s.   2 **S. galericulata** L.

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

Problems in Plant Diversity

- How do we know what species this plant belongs to?

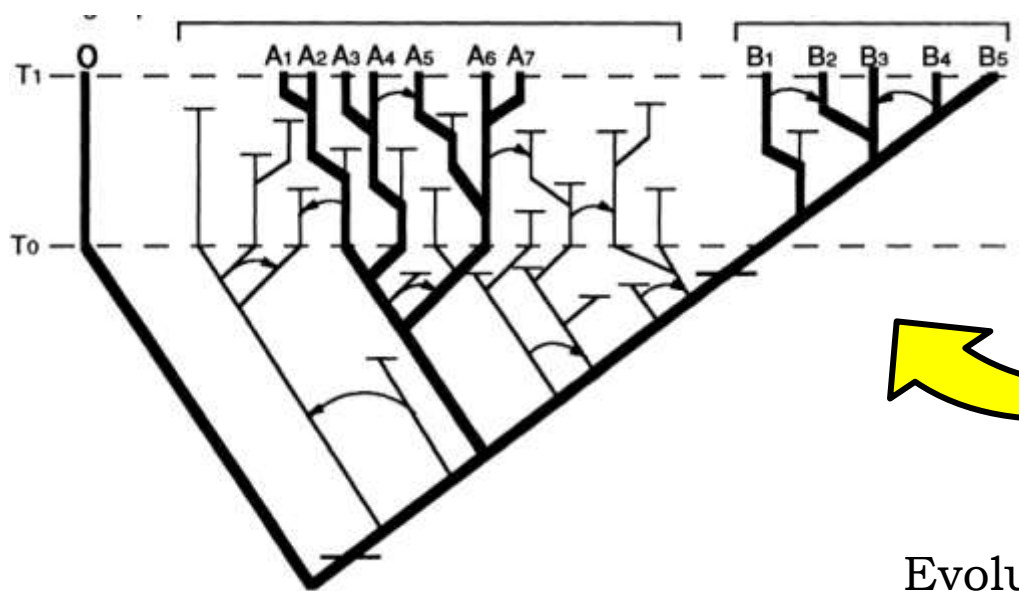## DNA barcoding
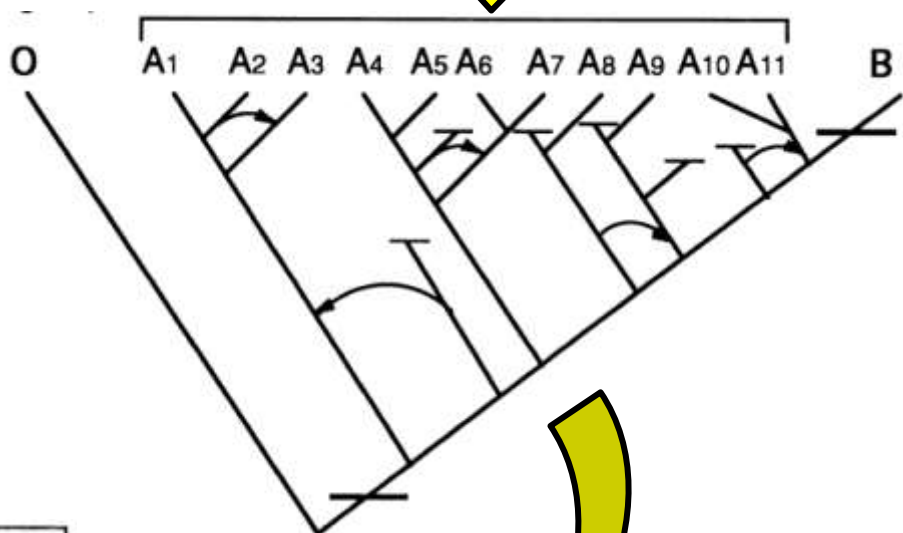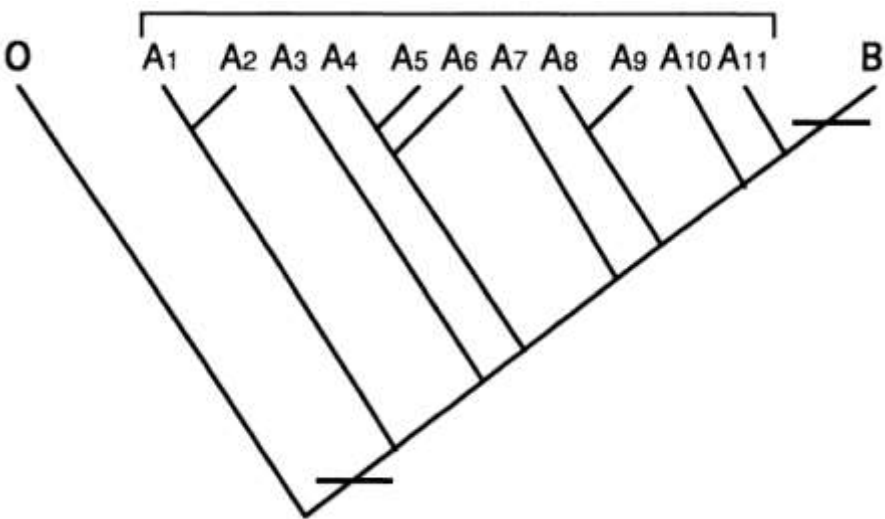
Problems in Plant Diversity

- How do we know what species are related to each other?
  Ever since Darwin, we've expected classifications to reflect
  evolutionary relationships: "*all true classification is genealogical* "

- How do we know what species this plant belongs to?
  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?

  Species concepts are many and varied, but fall into three main categories
  1) morphology based, 2) mechanism based, or 3) lineage based

- How do we know what to name and how do we assign a name?
  'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

Problems in Plant Diversity

- How do we know what a species even is?

Species concepts are many and varied, but fall into three main categories

1) morphology based: Who cares if they represent anything 'real' in nature, we can tell 'em apart!

2) mechanism based: Can they interbreed?
Do they share some ecological attribute?
Is there a mate recognition system?

3) lineage based: Do they represent a distinct evolutionary lineage?
Species delimitation analysis

Evolution of a species over time

Problems in Plant Diversity

- How do we know what species are related to each other?

  Ever since Darwin, we've expected classifications to reflect evolutionary relationships: *"all true classification is genealogical "*

- How do we know what species this plant belongs to?

  Visual morphological traits are nice, but what if its not in flower? what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?

  Species concepts are many and varied, but fall into three main categories 1) morphology, 2) mechanism based, or 3) lineage based

- How do we know what to name and how do we assign a name?

  'Grouping' and 'naming' are distinct processes. Shouldn't they be linked?

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

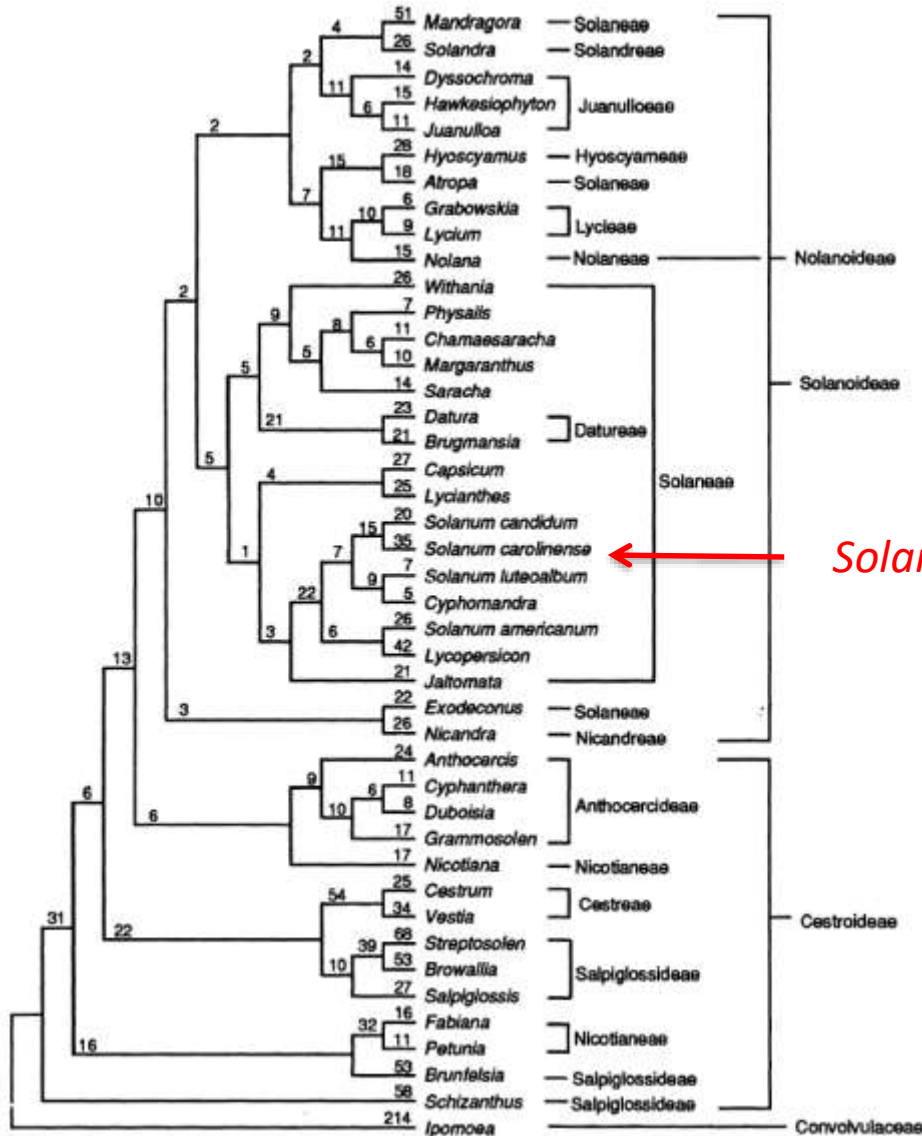- How do we …?

Problems in Plant Diversity

- How do we know what to name and how do we assign a name?
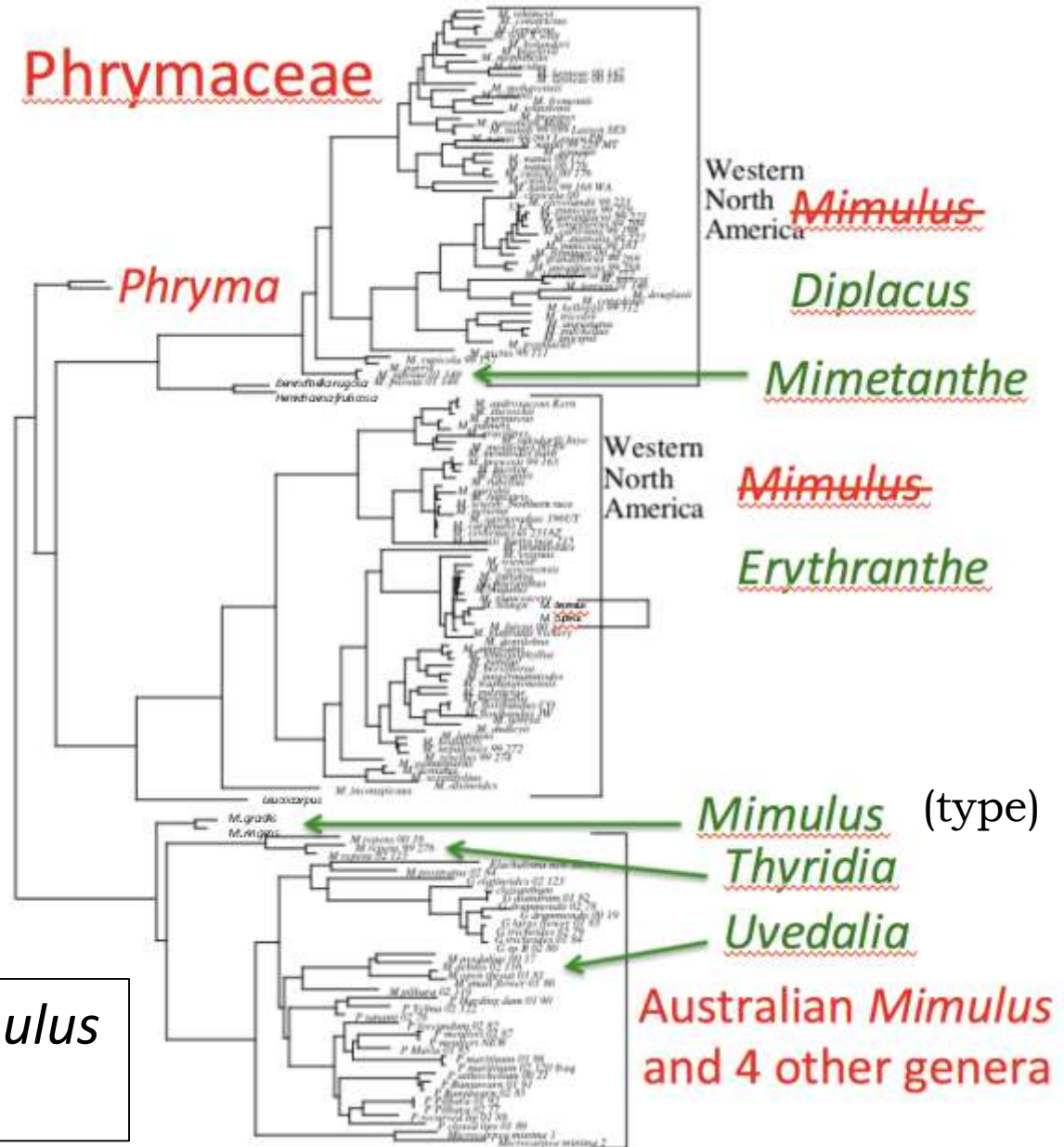
New classification for *Mimulus*
Barker et al., 2012

Problems in Plant Diversity

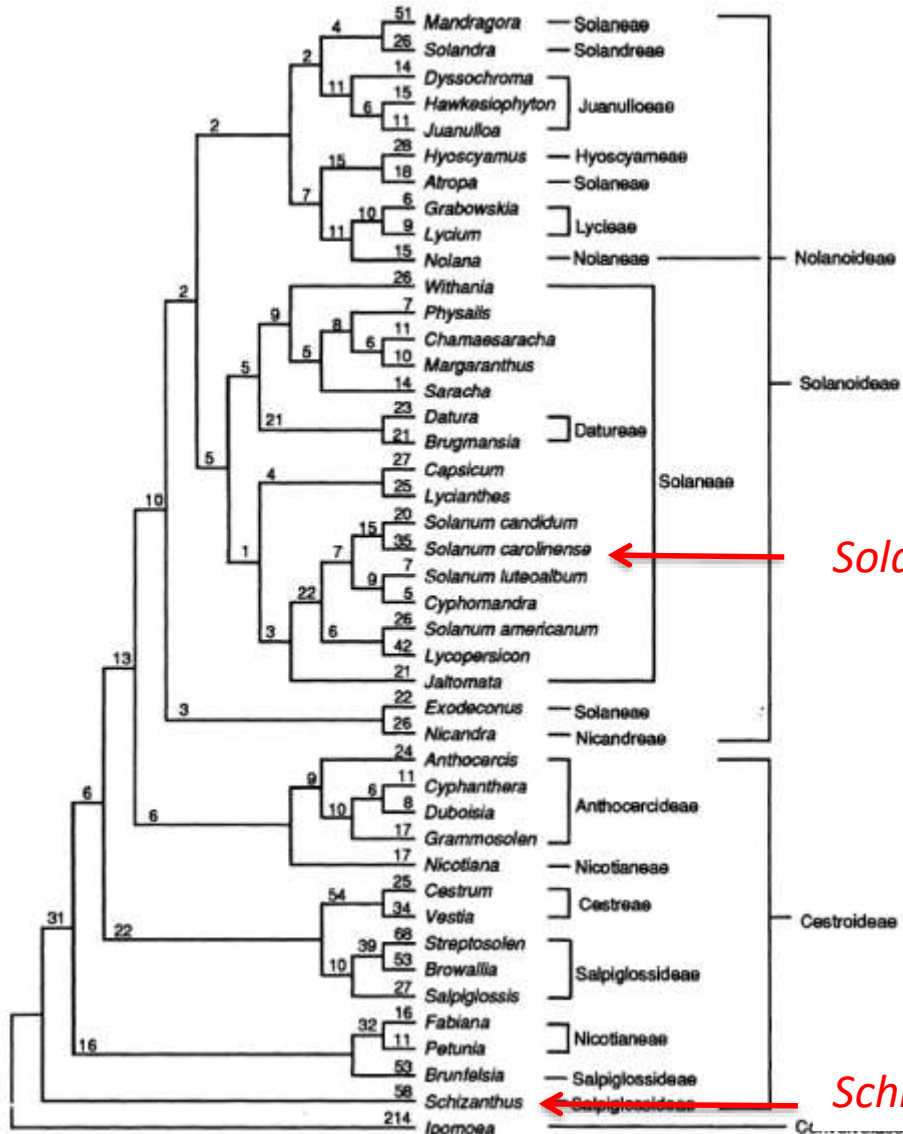- How do we know what to name and how do we assign a name?

ICN: Solanaceae is the group of species at the family rank containing the type species *Solanum nigrum*.

Solanum nigrum

Problems in Plant Diversity

- How do we know what to name and how do we assign a name?

ICN: ~~Solanaceae~~ is the group of species at the family ~~rank~~ containing the ~~type~~ species *Solanum nigrum*.

Solanum nigrum

PhyloCode: Solanaceae is the smallest clade containing *Solanum nigrum* and *Schizanthus pinnatus* (specifiers).
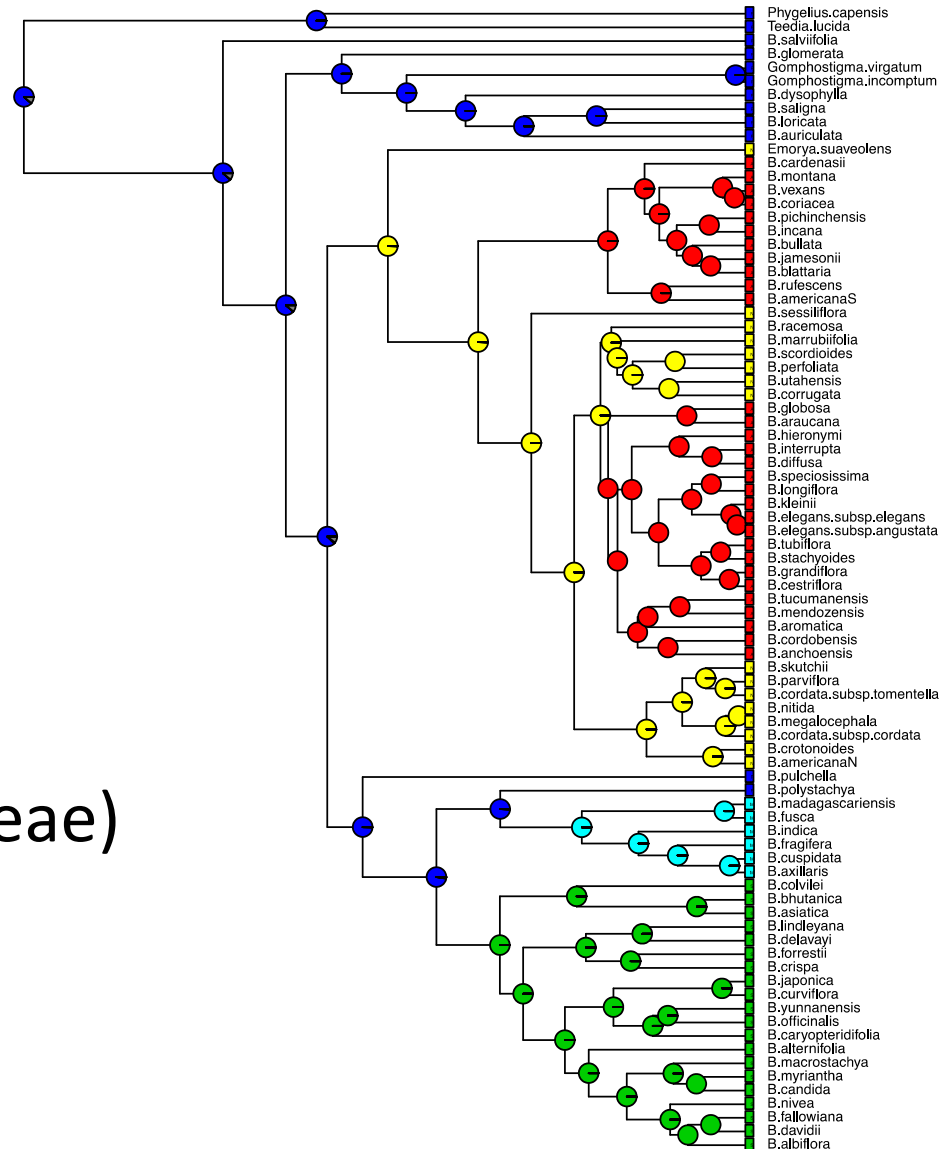
Clade definition

Schizanthus pinnatus

Problems in Plant Diversity

- How do we know what species are related to each other?
  Ever since Darwin, we've expected classifications to reflect
  evolutionary relationships: "*all true classification is genealogical* "

- How do we know what species this plant belongs to?
  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?
  Species concepts are many and varied, but fall into two main categories
  1) mechanism based, or 2) lineage based

- How do we know what to name and how do we assign a name?
  'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?
- How do we know how old this group of plants is?
- How do we Integrate fossil and living plants?
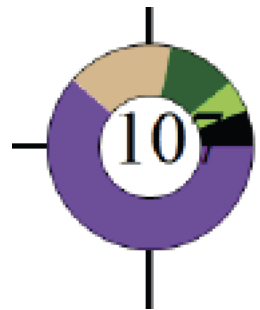- How do we …?

Problems in Plant Diversity

- How do we know where these plants came from?
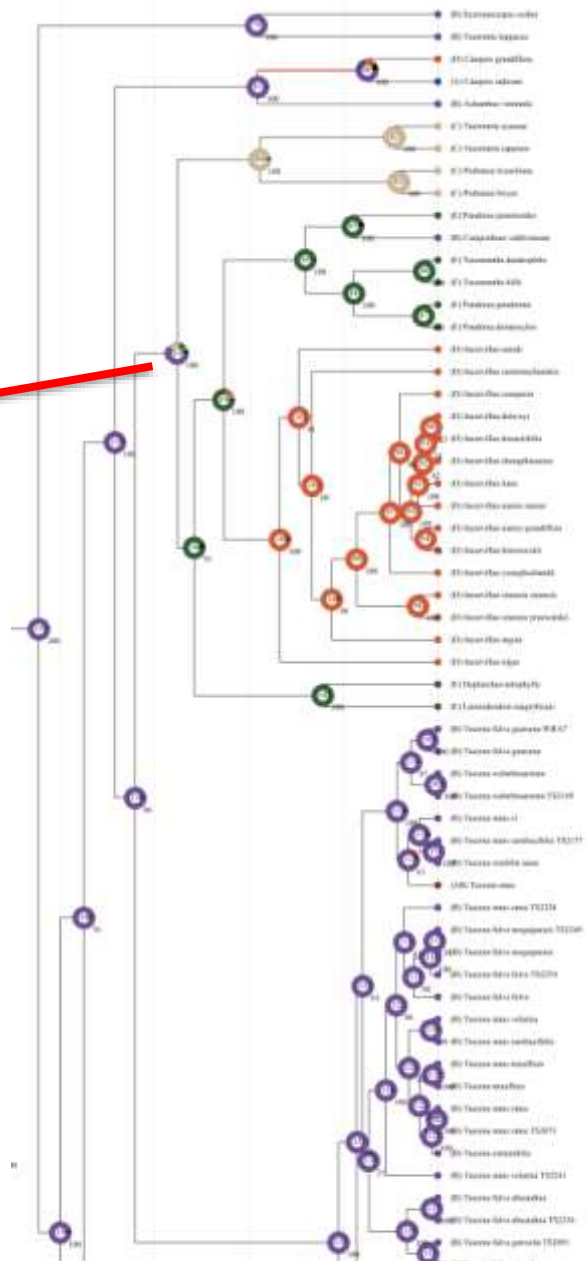

Buddleja
(Scrophulariaceae)

Africa

North America

South America

Madagascar

Asia

Problems in Plant Diversity

- How do we know where these plants came from?

Africa

New World

Australasia

China

Tecomeae
(Bignoniaceae)
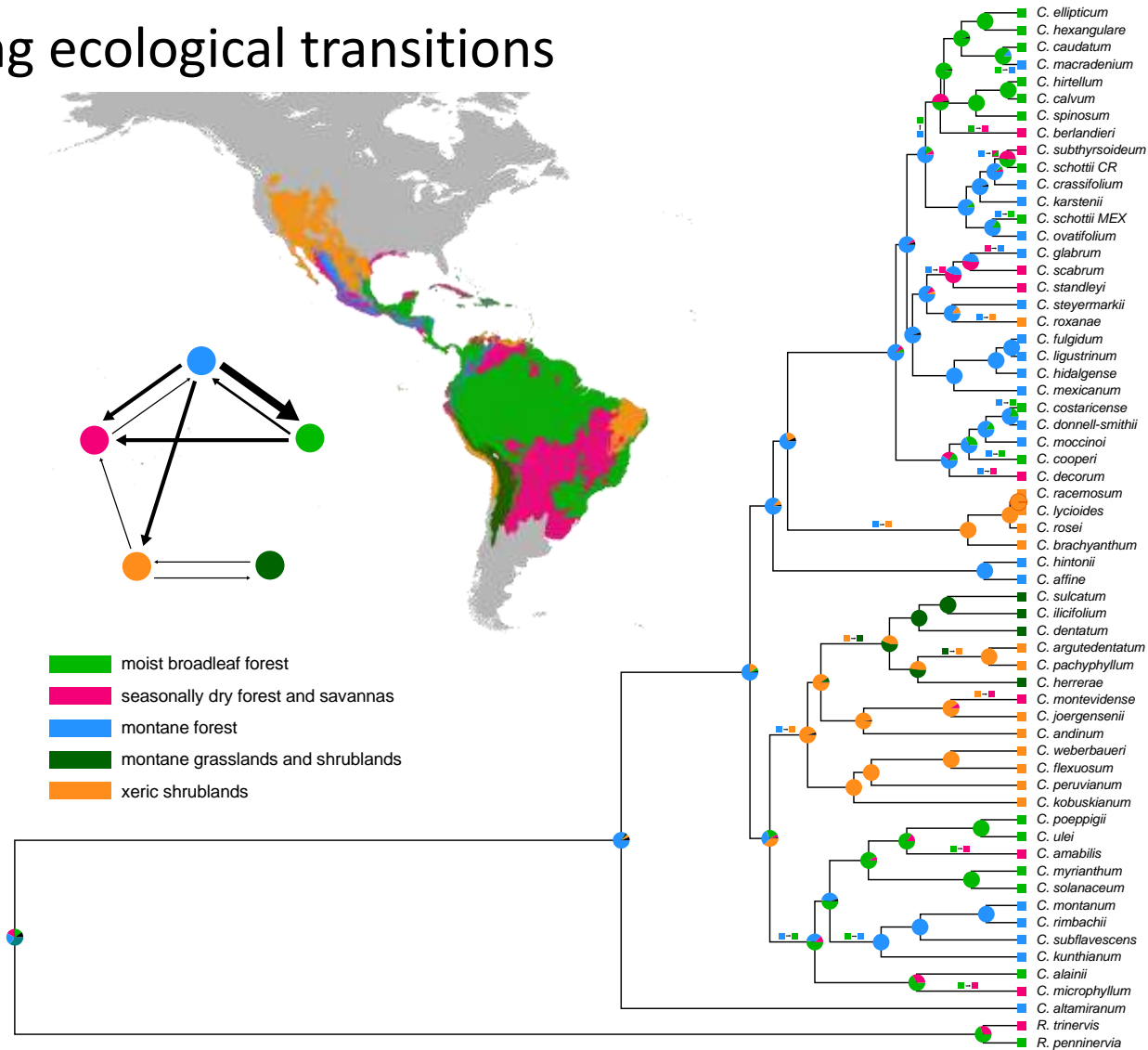
Problems in Plant Diversity

- How do we know where these plants came from?

...including ecological transitions

Citharexylum
(Verbenaceae)

moist broadleaf forest
seasonally dry forest and savannas
montane forest
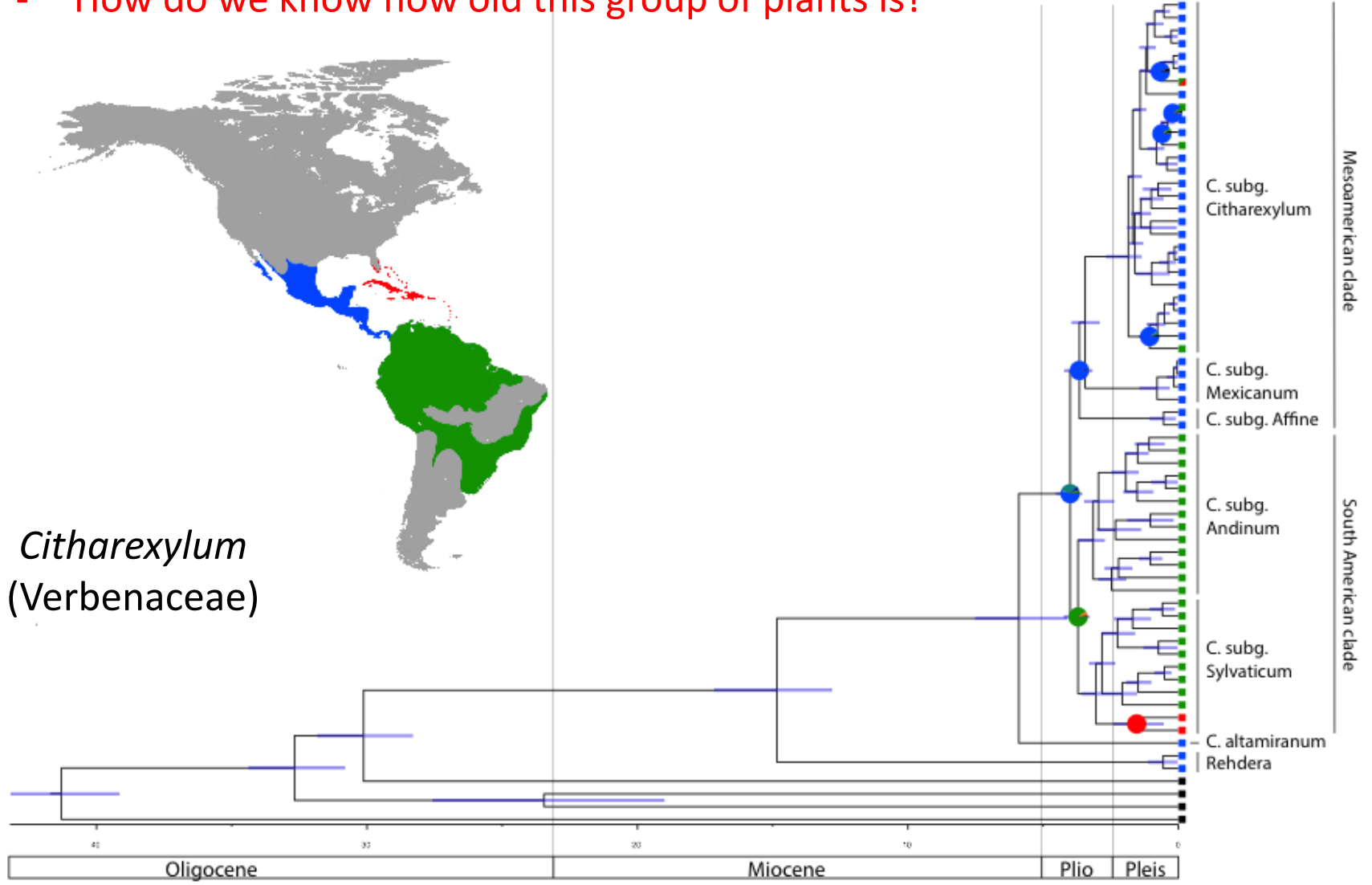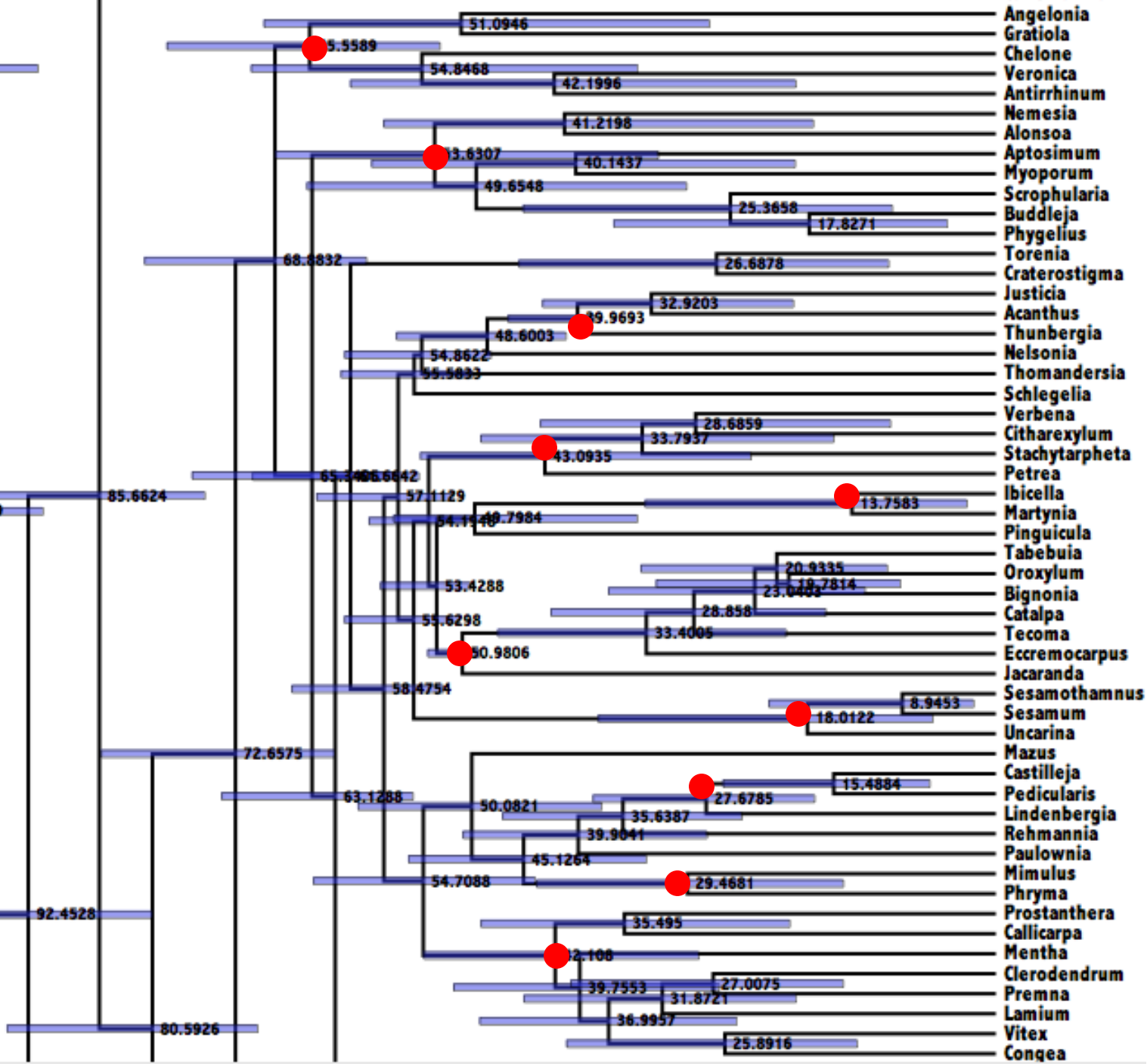montane grasslands and shrublands
xeric shrublands

Problems in Plant Diversity

- How do we know what species are related to each other?

  Ever since Darwin, we've expected classifications to reflect
  evolutionary relationships: *"all true classification is genealogical "*

- How do we know what species this plant belongs to?

  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?

  Species concepts are many and varied, but fall into two main categories
  1) mechanism based, or 2) lineage based

- How do we know what to name and how do we assign a name?

  'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

Problems in Plant Diversity

- How do we know how old this group of plants is?

Citharexylum
(Verbenaceae)

Dated tree of Lamiales

Tank & Olmstead in prep

Problems in Plant Diversity

- How do we know what species are related to each other?

   Ever since Darwin, we've expected classifications to reflect
   evolutionary relationships: *"all true classification is genealogical "*

- How do we know what species this plant belongs to?

   Visual morphological traits are nice, but what if its not in flower?
   what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?

   Species concepts are many and varied, but fall into two main categories
   1) mechanism based, or 2) lineage based

- How do we know what to name and how do we assign a name?

   'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

Problems in Plant Diversity

- How do we know what species are related to each other?
  Ever since Darwin, we've expected classifications to reflect
  evolutionary relationships: *"all true classification is genealogical "*

- How do we know what species this plant belongs to?
  Visual morphological traits are nice, but what if its not in flower?
  what if there is no key? what if there is you are not trained in plant ID?

- How do we know what a species even is?
  Species concepts are many and varied, but fall into two main categories
  1) mechanism based, or 2) lineage based

- How do we know what to name and how do we assign a name?
  'Grouping' and 'naming' are distinct processes. They should they be linked!

- How do we know where these plants came from?

- How do we know how old this group of plants is?

- How do we Integrate fossil and living plants?

- How do we …?

So, what's next?

Isn't DNA just the current fad?
like:
Morphology
Cytology
2° chemistry
Electron microscopy
Protein biochemistry
etc.