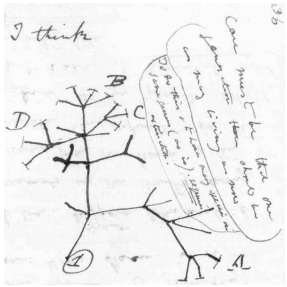
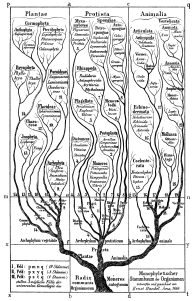
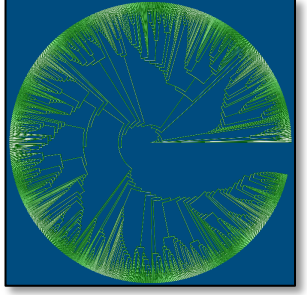
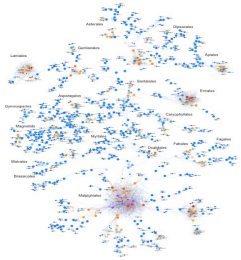
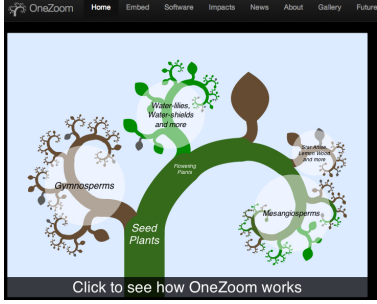


Contemporary Methods in Assembling and Using the Tree of Life

Pamela S. Soltis

Florida Museum of Natural History

University of Florida

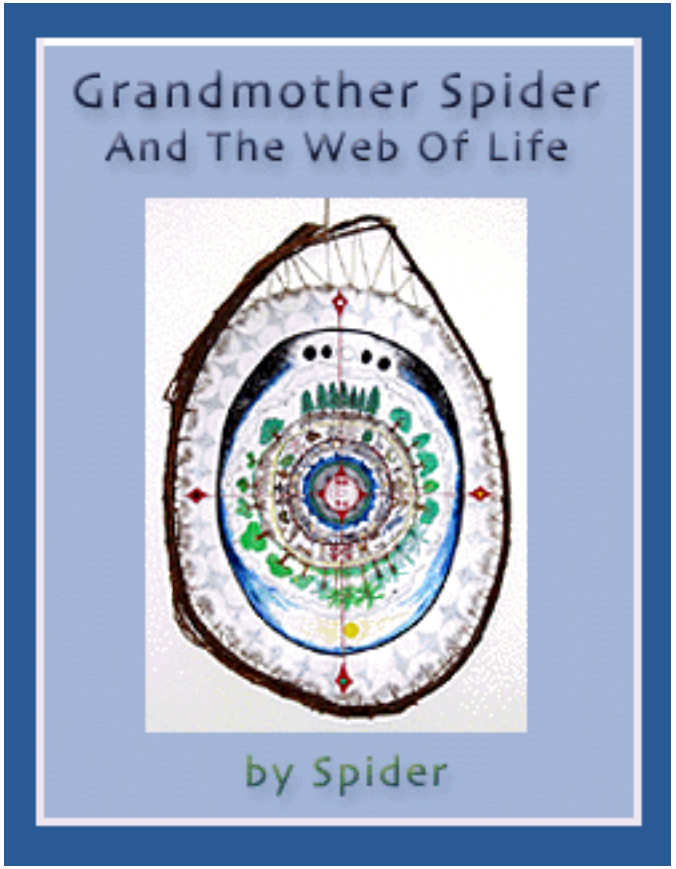
FLORIDA MUSEUM OF NATURAL HISTORY™

UF | UNIVERSITY of FLORIDA

The Circle of Life

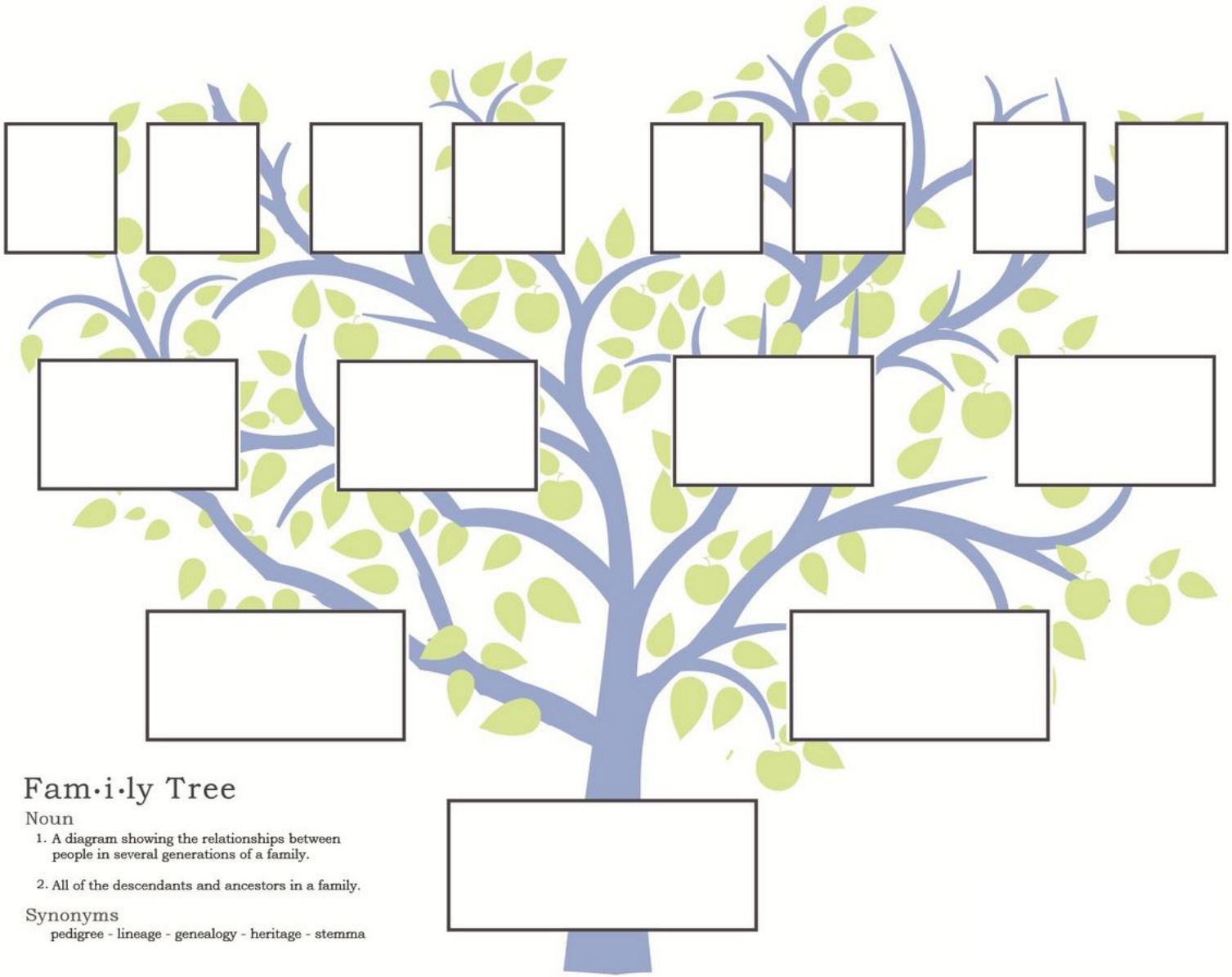
Life is connected…

genealogically



ecologically

Family Tree



Fam·i·ly Tree

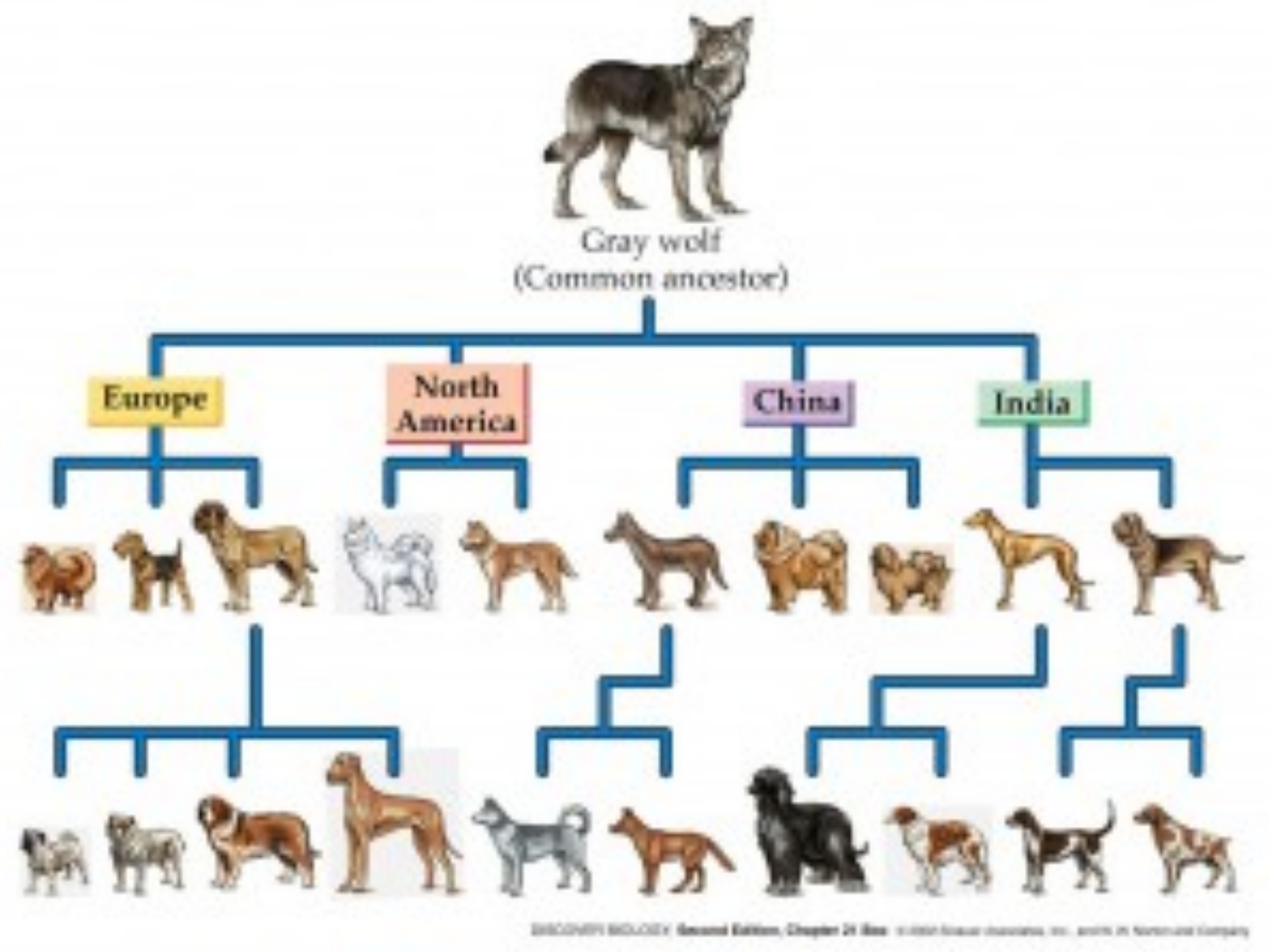
Noun

1. A diagram showing the relationships between people in several generations of a family.

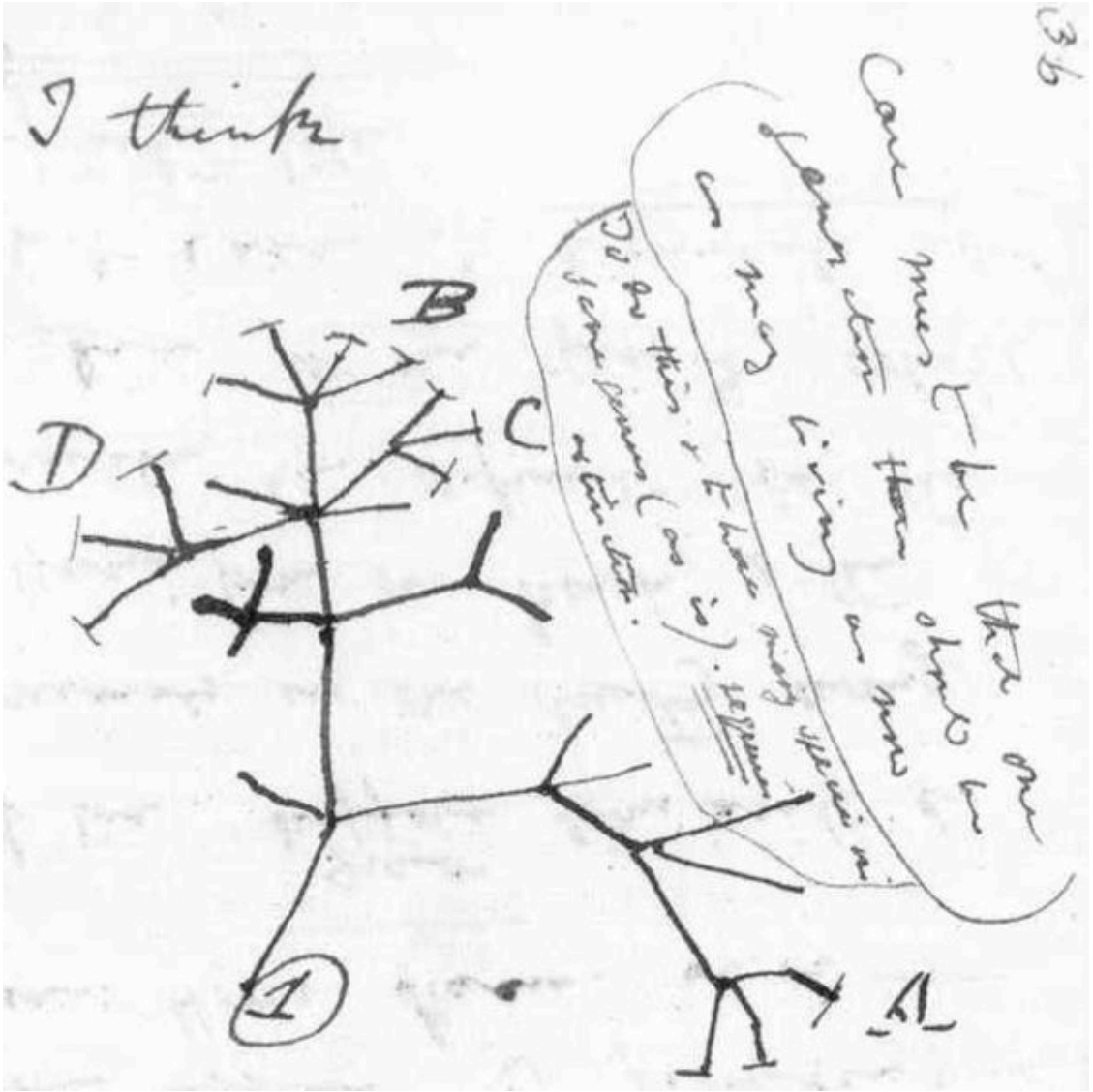
2. All of the descendants and ancestors in a family.

Synonyms

pedigree - lineage - genealogy - heritage - stemma

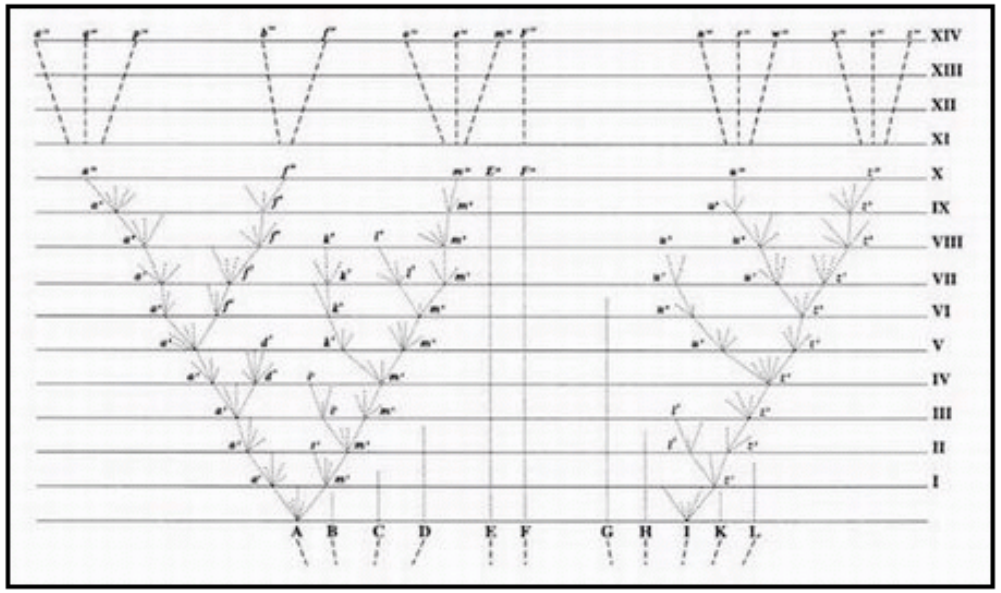

Gray wolf
(Common ancestor)
Europe
North America
China
India

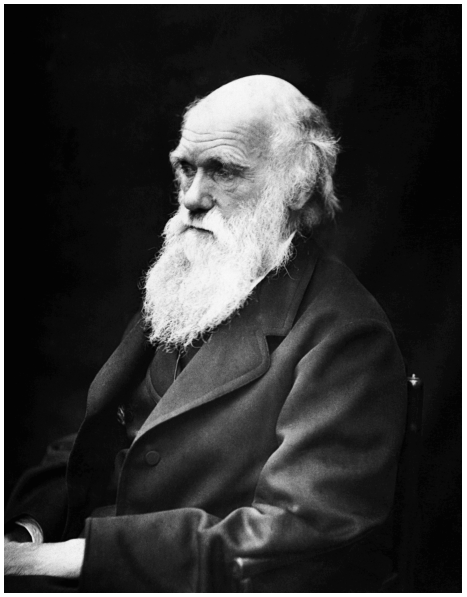
The Tree of Life



Darwin's notebook 1837

Darwin's Great Tree of Life



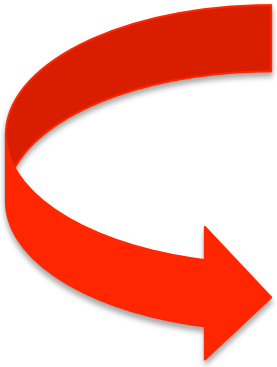


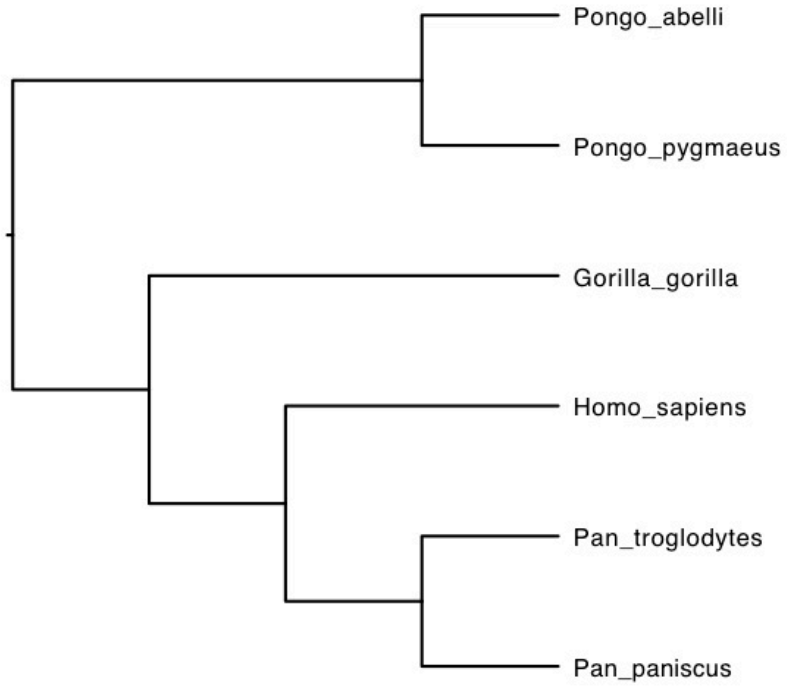
"As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever-branching and beautiful ramifications."

Ernst Haeckel's Tree of Life 1866

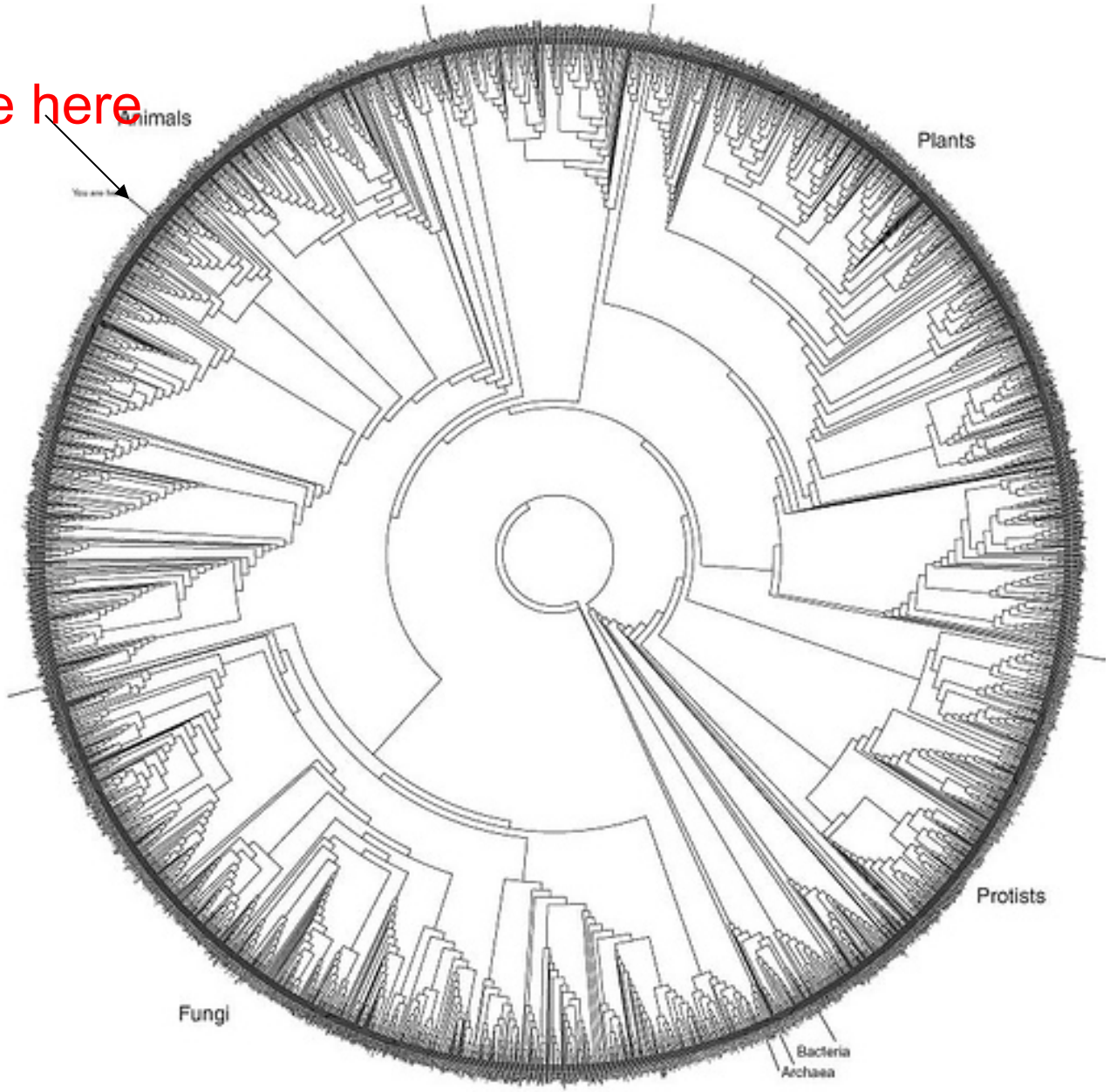
Using DNA Sequences to Build Trees

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Pongo abelli	A	T	G	A	C	C	T	C	A	A	C	A	C	G	T	A	A	A	T	C
Pongo pygmaeus	A	T	G	A	C	C	C	C	A	A	T	A	C	G	C	A	A	A	A	C
Gorilla gorilla	A	T	G	A	C	C	C	C	T	A	T	A	C	G	C	A	A	A	A	C
Homo sapiens	A	T	G	A	C	C	C	C	A	A	T	A	C	G	C	A	A	A	A	T
Pan troglodytes	A	T	G	A	C	C	C	C	A	A	C	A	C	G	C	A	A	A	A	T
Pan paniscus	A	T	G	A	C	C	C	C	A	A	C	A	C	G	C	A	A	A	A	T



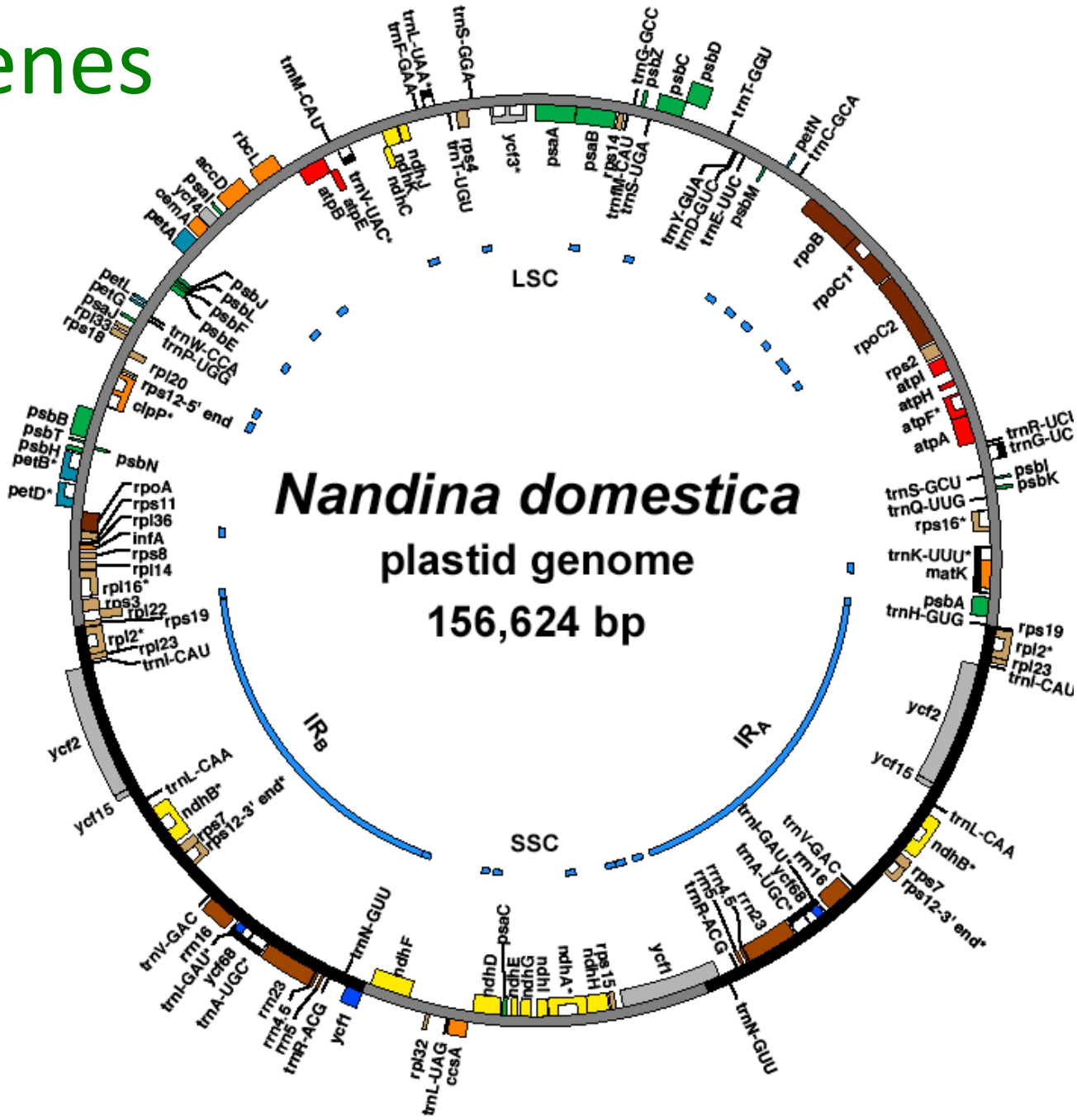


We are Just One Twig on the Tree of Life

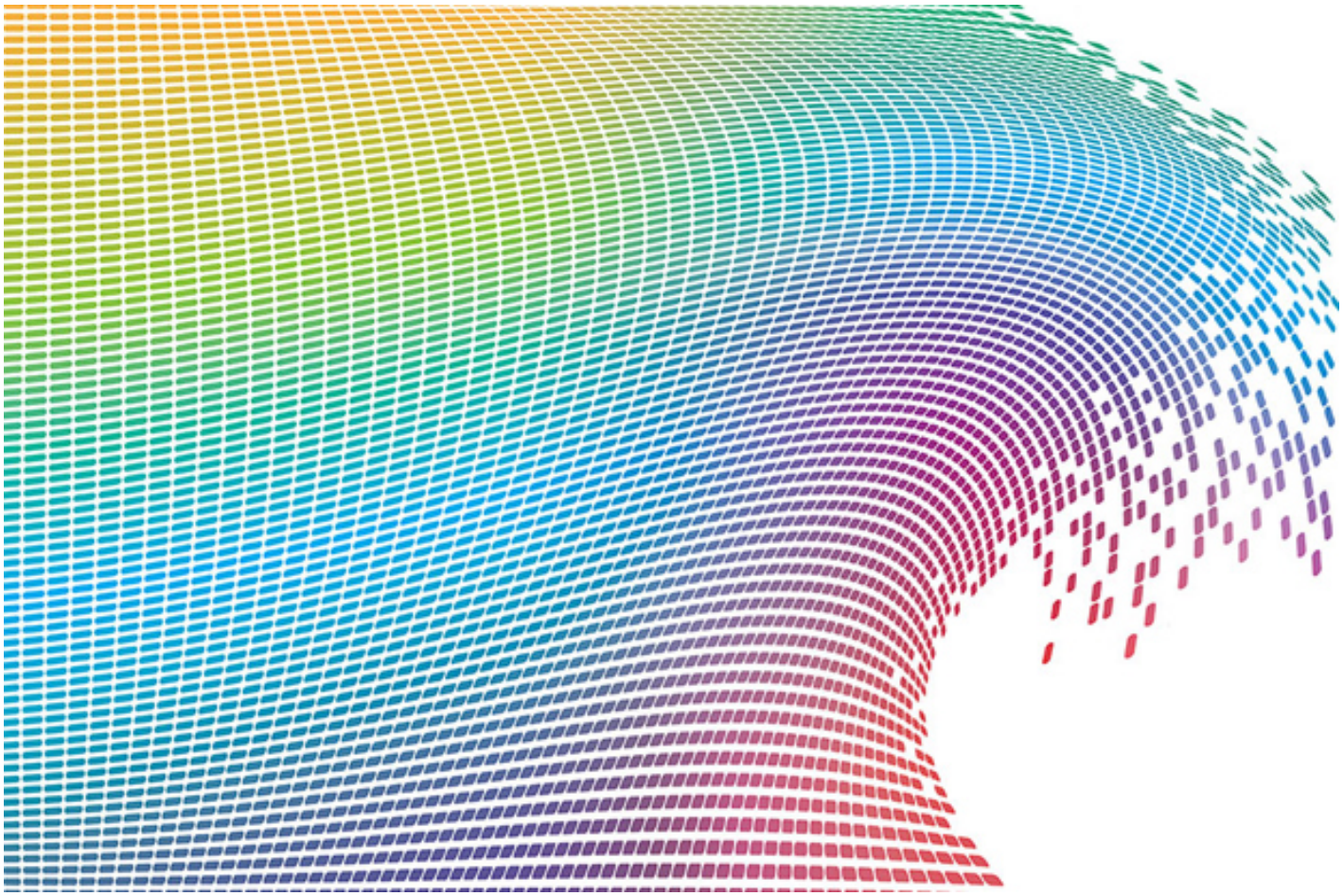


D. Hillis

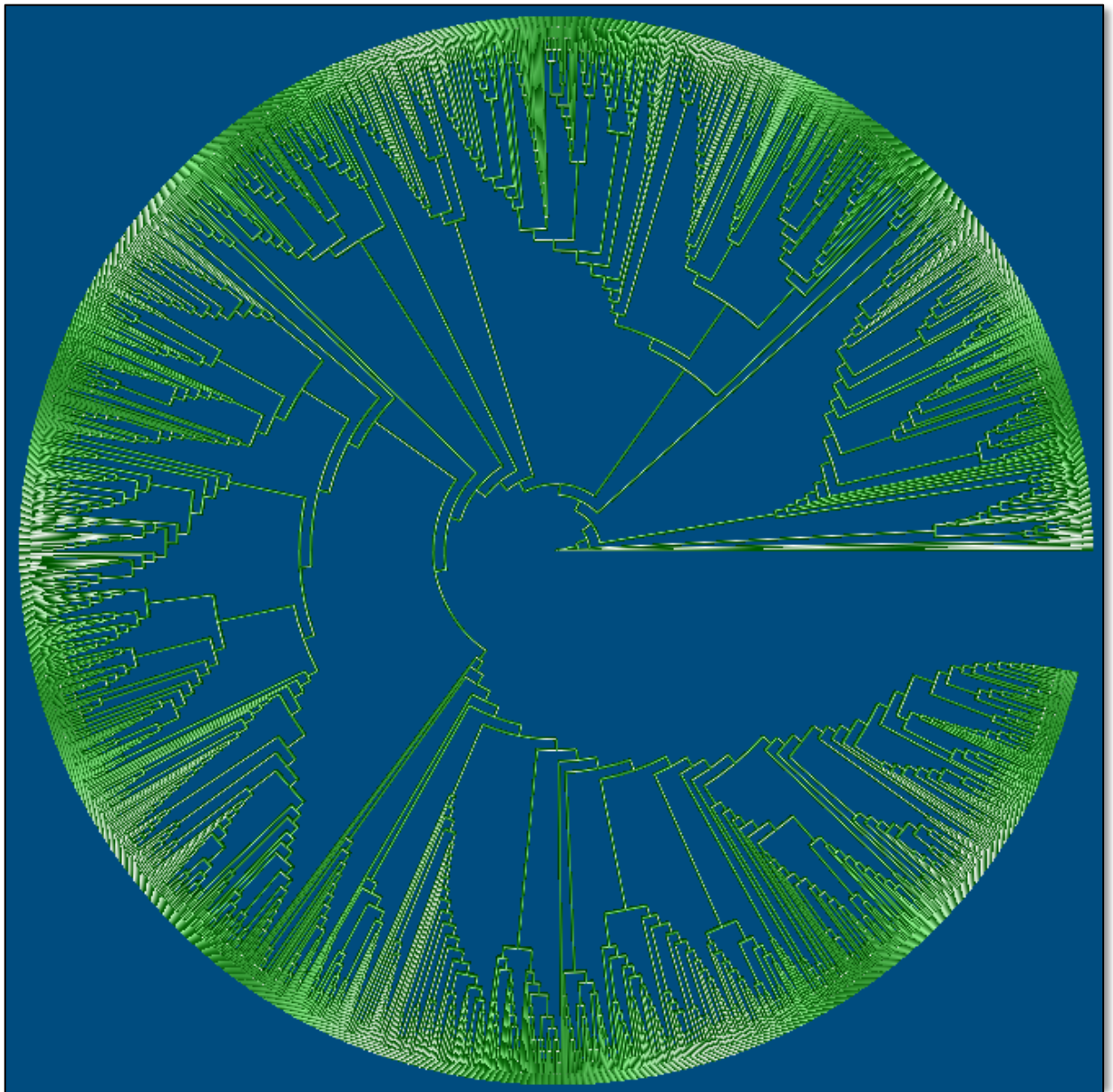
Many Genes


Nandina domestica
plastid genome
156,624 bp
LSC
IRB
SSC
IRA
trnM-CAU
trnL-UAA*
trnF-GAA
trnS-GGA
trnT-UGU
rps4
ycf3*
psaA
psaB
trnG-GCC
psbZ
psbC
psbD
trnT-GGU
petN
trnC-GCA
rpoB
rpoC1*
rpoC2
rps2
atpI
atpH
atpF*
atpA
trnR-UCU
trnG-UCC
psbI
psbK
trnS-GCU
trnQ-UUG
rps16*
trnK-UUU*
matK
psbA
trnH-GUG
rps19
rpl2*
rpl23
trnI-CAU
ycf2
ycf15
trnL-CAA
ndhB*
rps7
rps12-3' end*
trnV-GAC
rrn16
trnI-GAU*
trnA-UGC*
ycf68
rrn23
rrn4.5
rrn5
trnR-ACG
ycf1
trnN-GUU
ndhF
rpl32
trnL-UAG
ccsA
ndhD
psaC
ndhE
ndhG
ndhI
ndhA*
ndhH
rps15
trnM-CAU
trnS-UGA
trnY-GUA
trnD-GUC
trnE-UUC
psbM
trnP-UGG
trnW-CCA
psbJ
psbL
psbF
psbE
petL
petG
psaJ
rpl33
rps18
rpl20
rps12-5' end
clpP*
psbB
psbT
psbH
petB*
petD*
psbN
rpoA
rps11
rpl36
infA
rps8
rpl14
rpl16*
rps3
rpl22
rps19
rpl2*
rpl23
trnI-CAU
ycf2
ycf15
trnL-CAA
ndhB*
rps7
rps12-3' end*
trnV-GAC
rrn16
trnI-GAU*
trnA-UGC*
ycf68
rrn23
rrn4.5
rrn5
trnR-ACG
ycf1
trnN-GUU
ndhF
rpl32
trnL-UAG
ccsA
ndhD
psaC
ndhE
ndhG
ndhI
ndhA*
ndhH
rps15
trnM-CAU
atpE
atpB
rbcL
accD
psaI
ycf4
cemA
petA

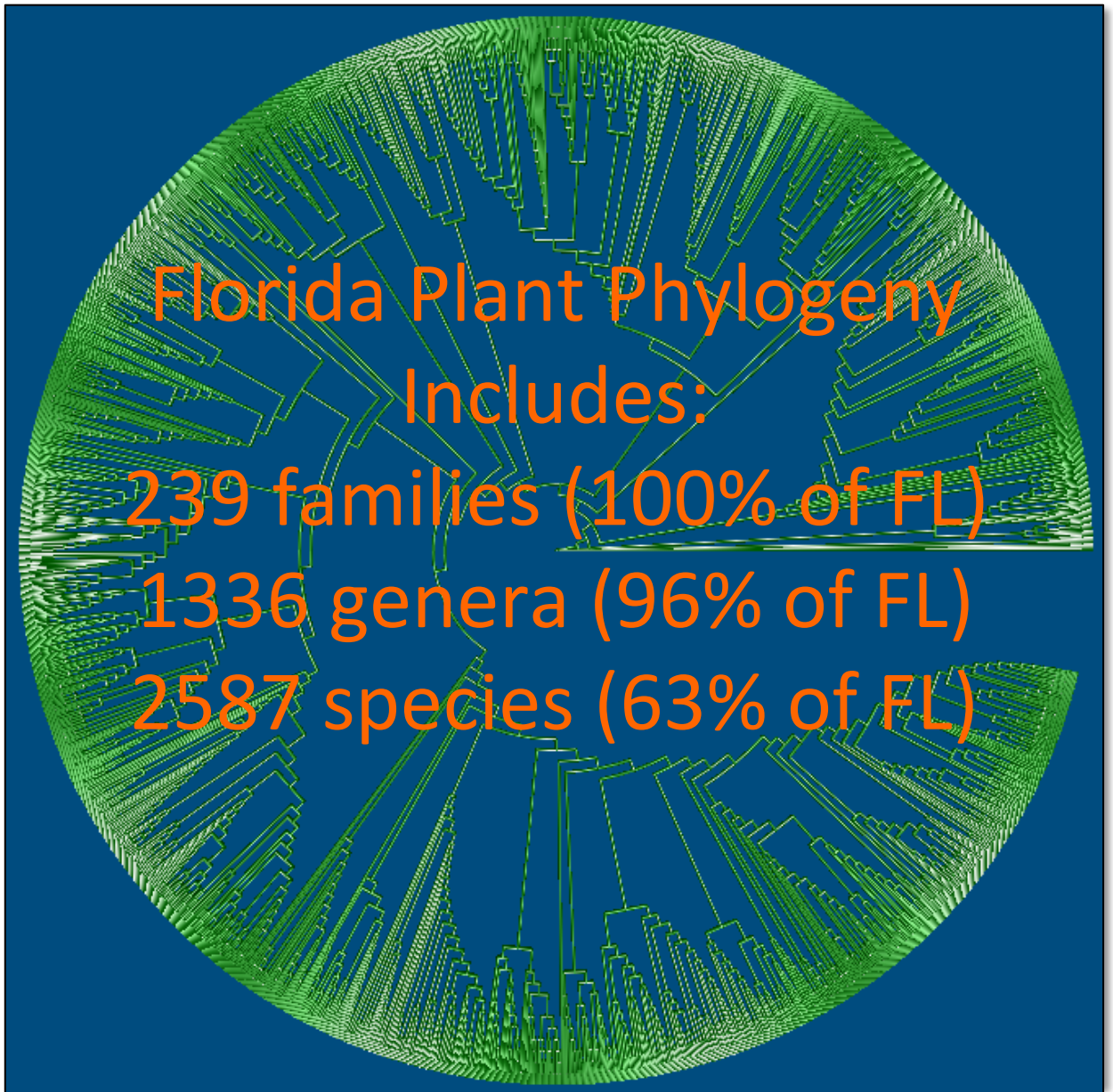
Genomics & Transcriptomics harnessing the ‘DNA Data Deluge’



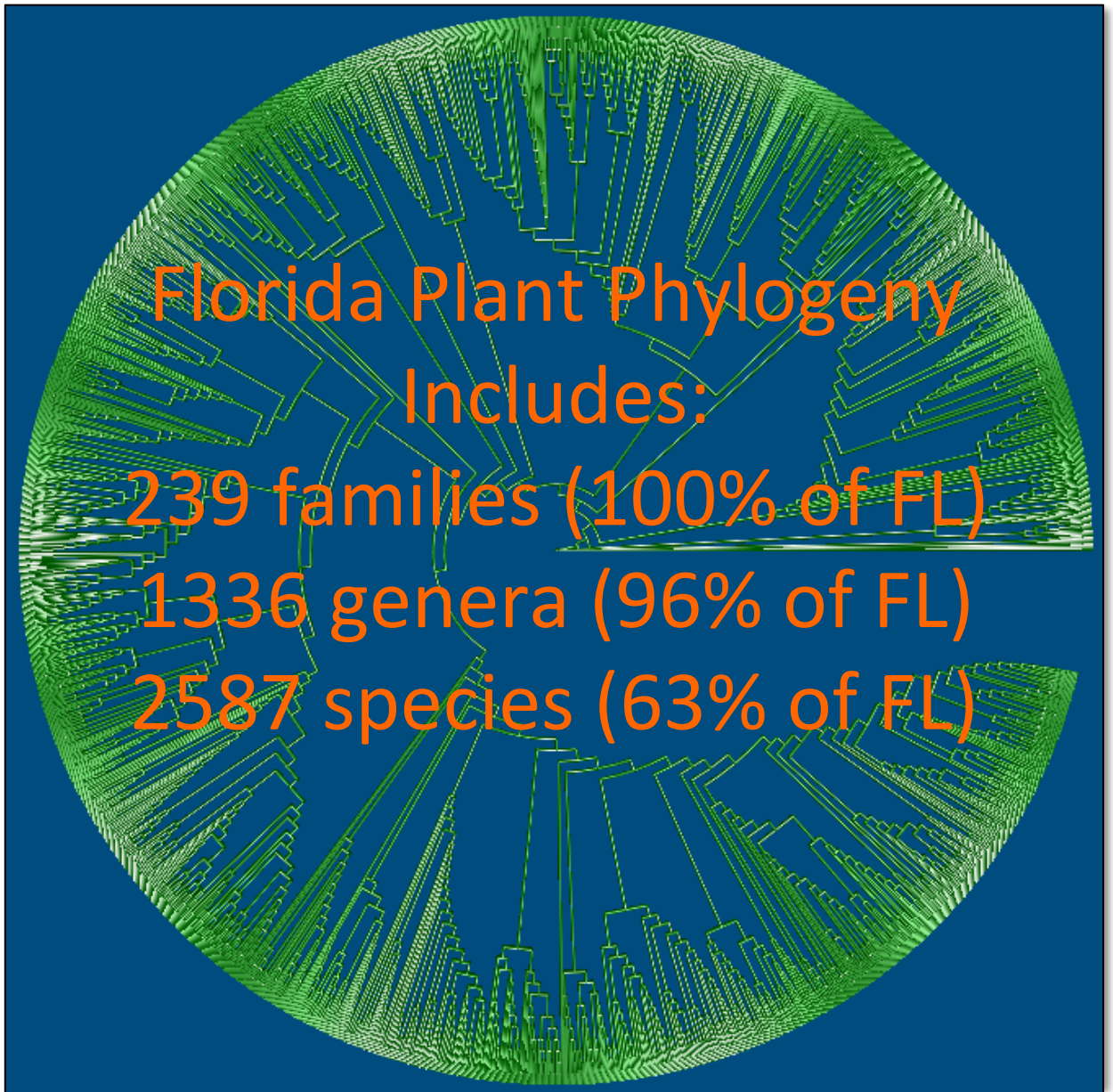
Many Species

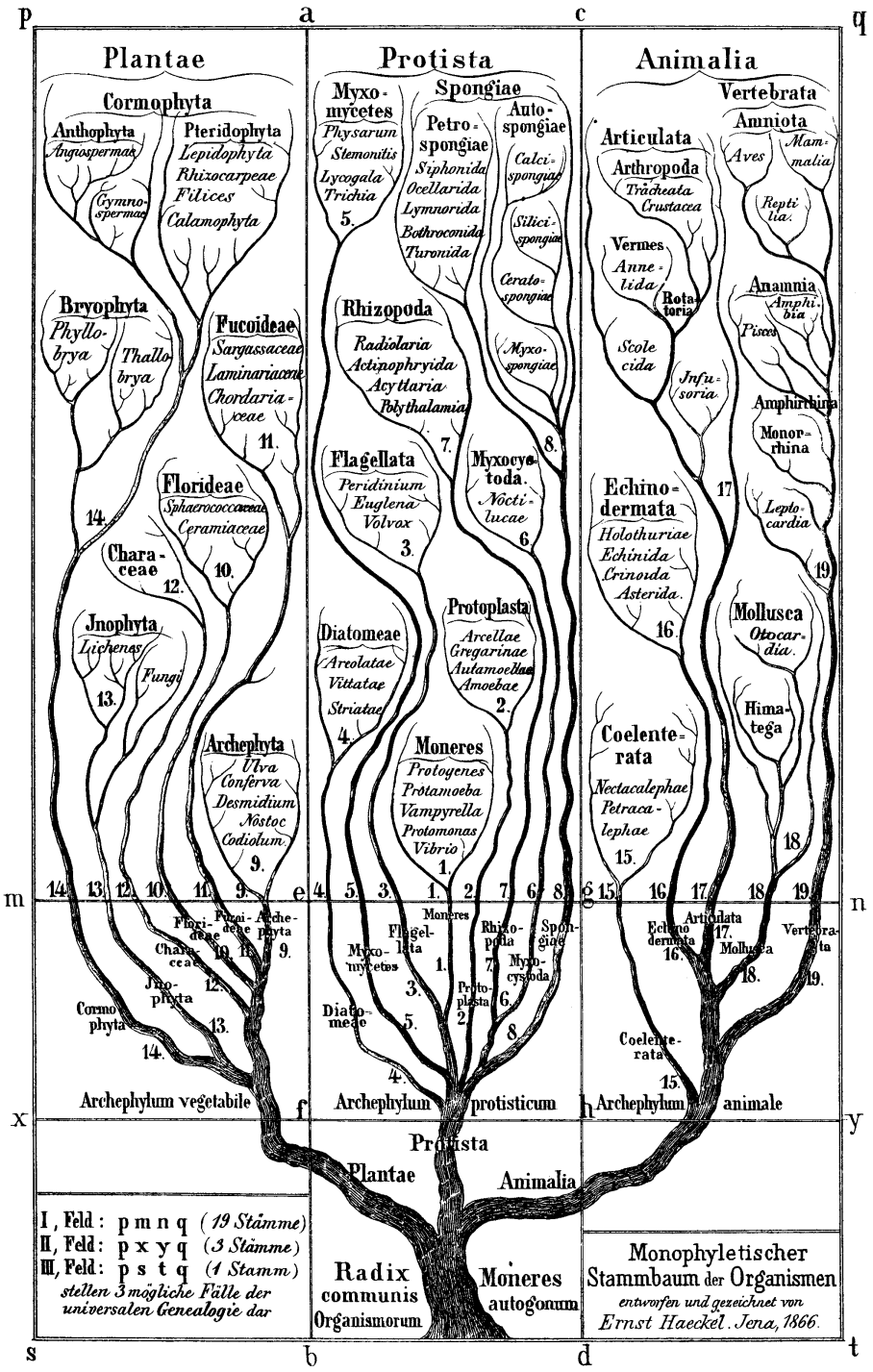


Many Species

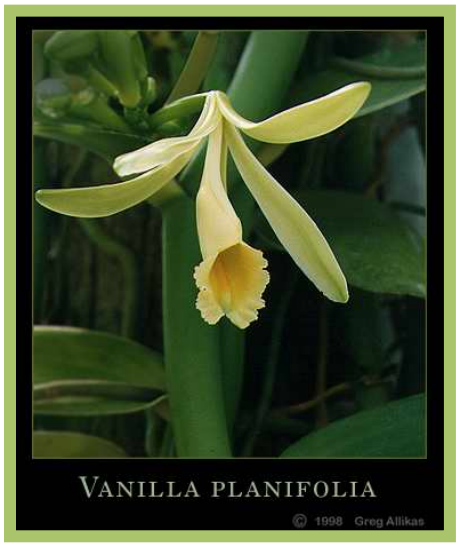


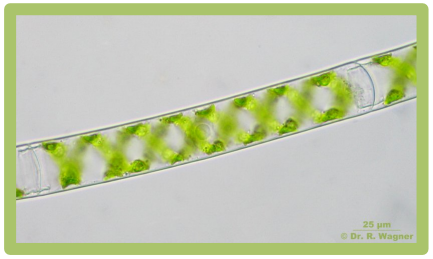
Many Species: >55,000 plants!

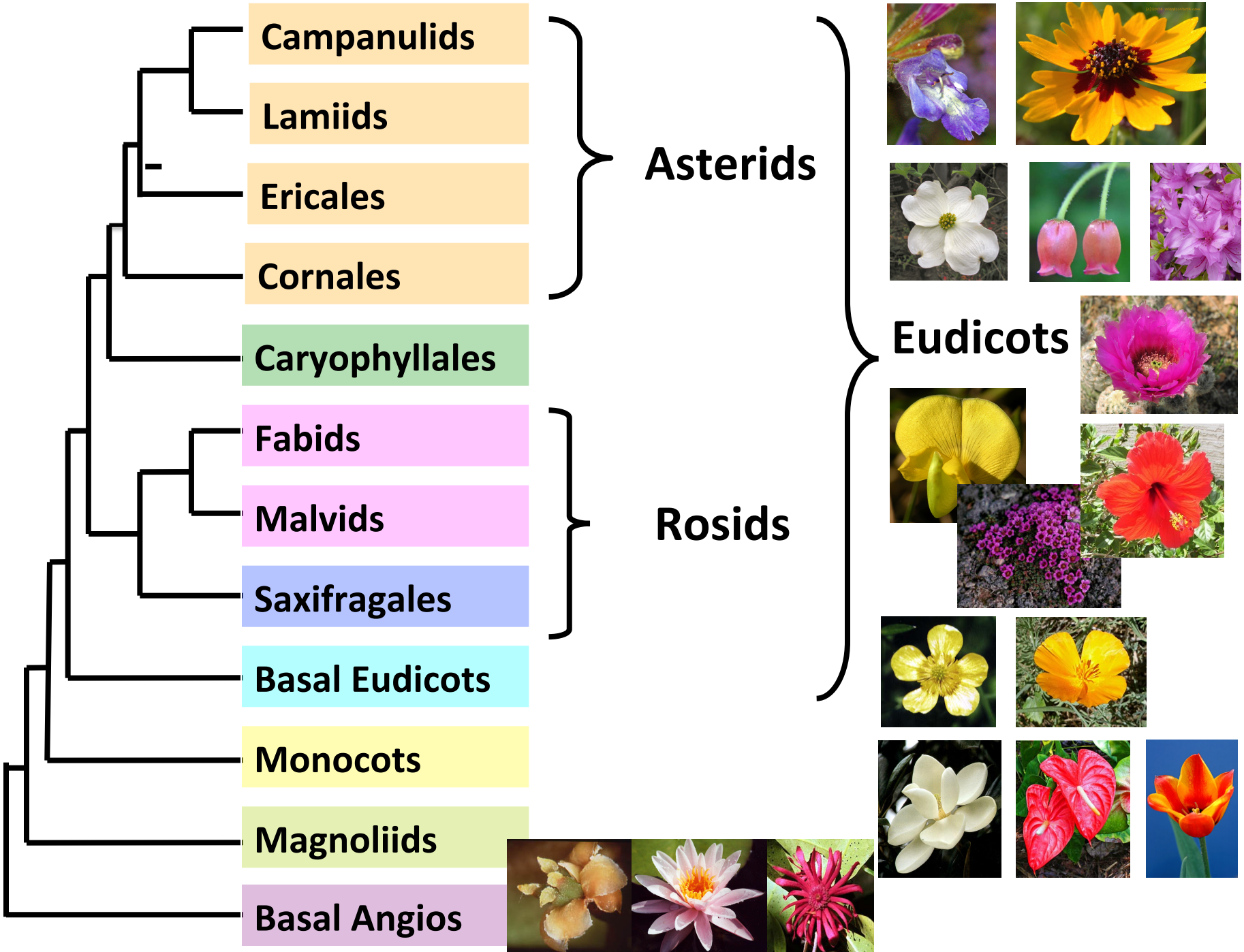


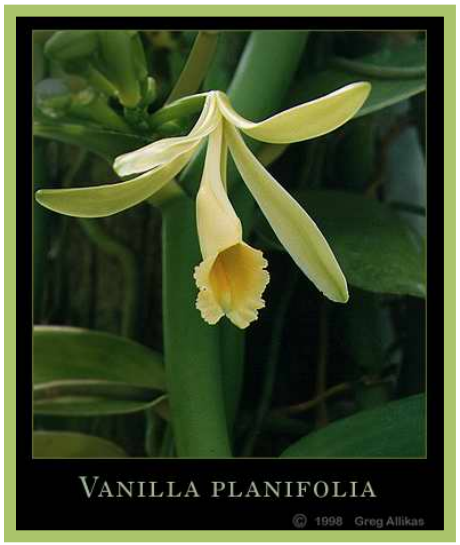


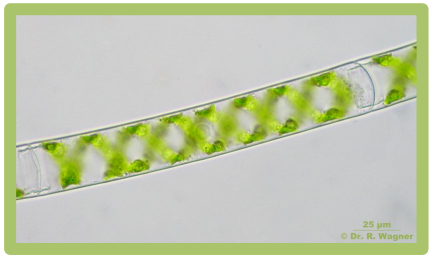
Do we know the Tree of Life?


VANILLA PLANIFOLIA
© 1998 Greg Allikas

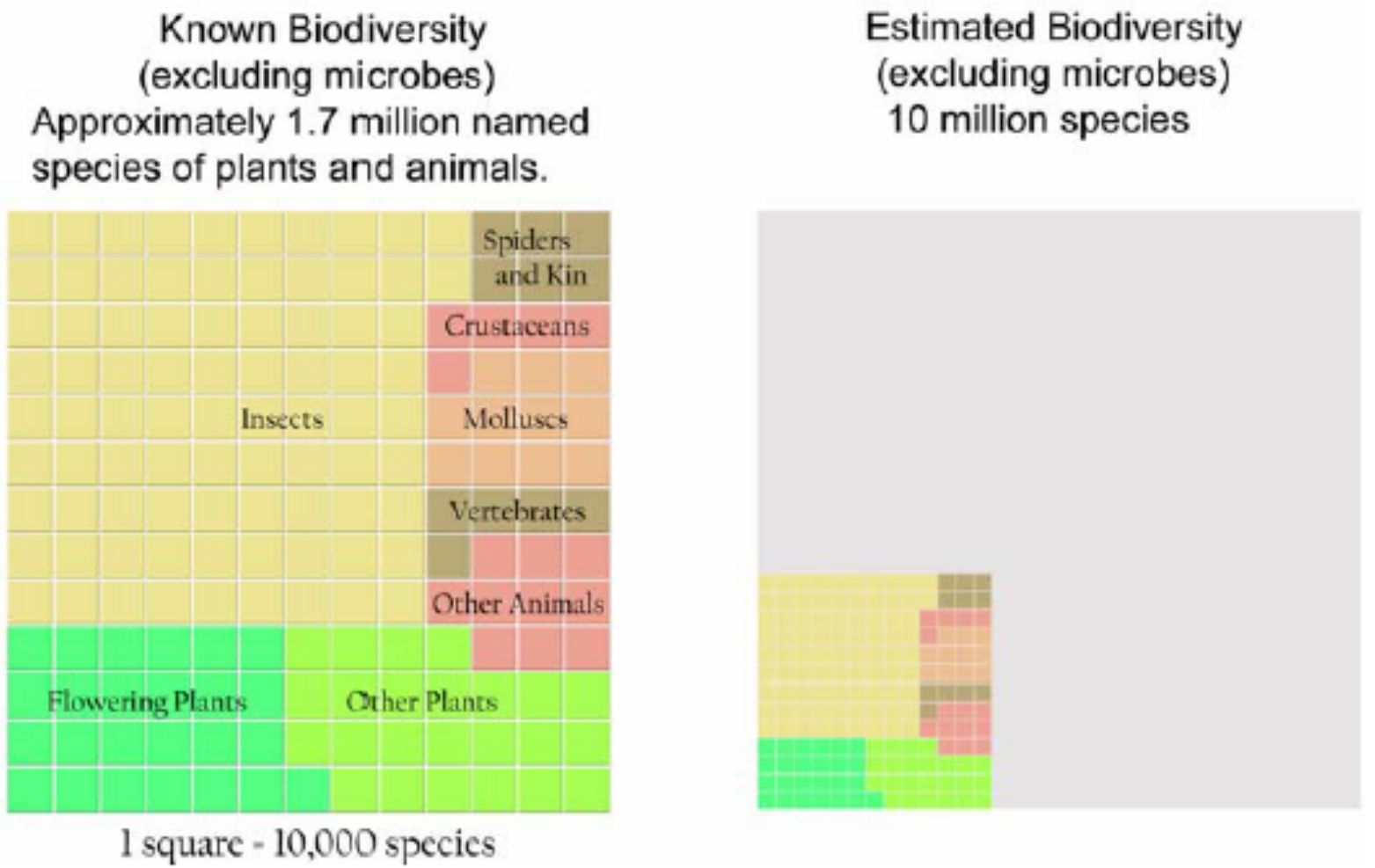

25 µm
© Dr. R. Wagner


Campanulids
Lamiids
Ericales
Cornales
Caryophyllales
Fabids
Malvids
Saxifragales
Basal Eudicots
Monocots
Magnoliids
Basal Angios
Asterids
Rosids
Eudicots

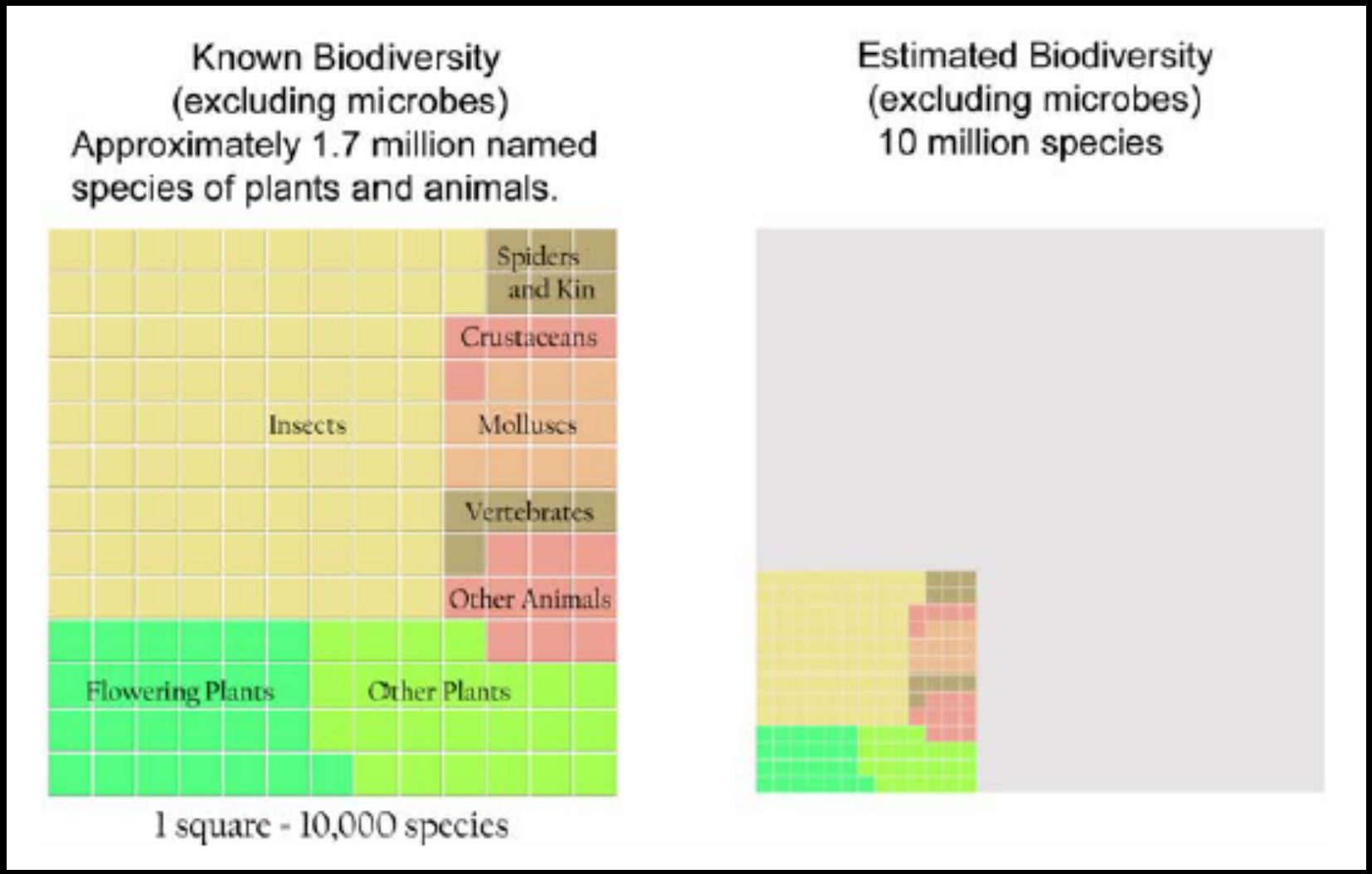

VANILLA PLANIFOLIA
© 1998 Greg Allikas


25 µm
© Dr. R. Wagner

So Many Species…



~1.7 million described, 10 million total? 100 million?



The Number of Possible Trees…

- Number of possible trees increases exponentially with the number of taxa
  - 3 taxa - 1 unrooted tree (or 4 rooted trees)
  - 4 taxa - 3 unrooted trees (or 15 rooted trees)
  - 10 taxa - 2 million unrooted (282 million rooted)
  - 20 taxa - 2.2×10^{20} unrooted
  - 22 taxa - 3×10^{23} unrooted (~ a mole of trees)
  - 228 taxa - 1.2×10^{502} (more than the number of atoms in the universe…; Hillis, 1996)

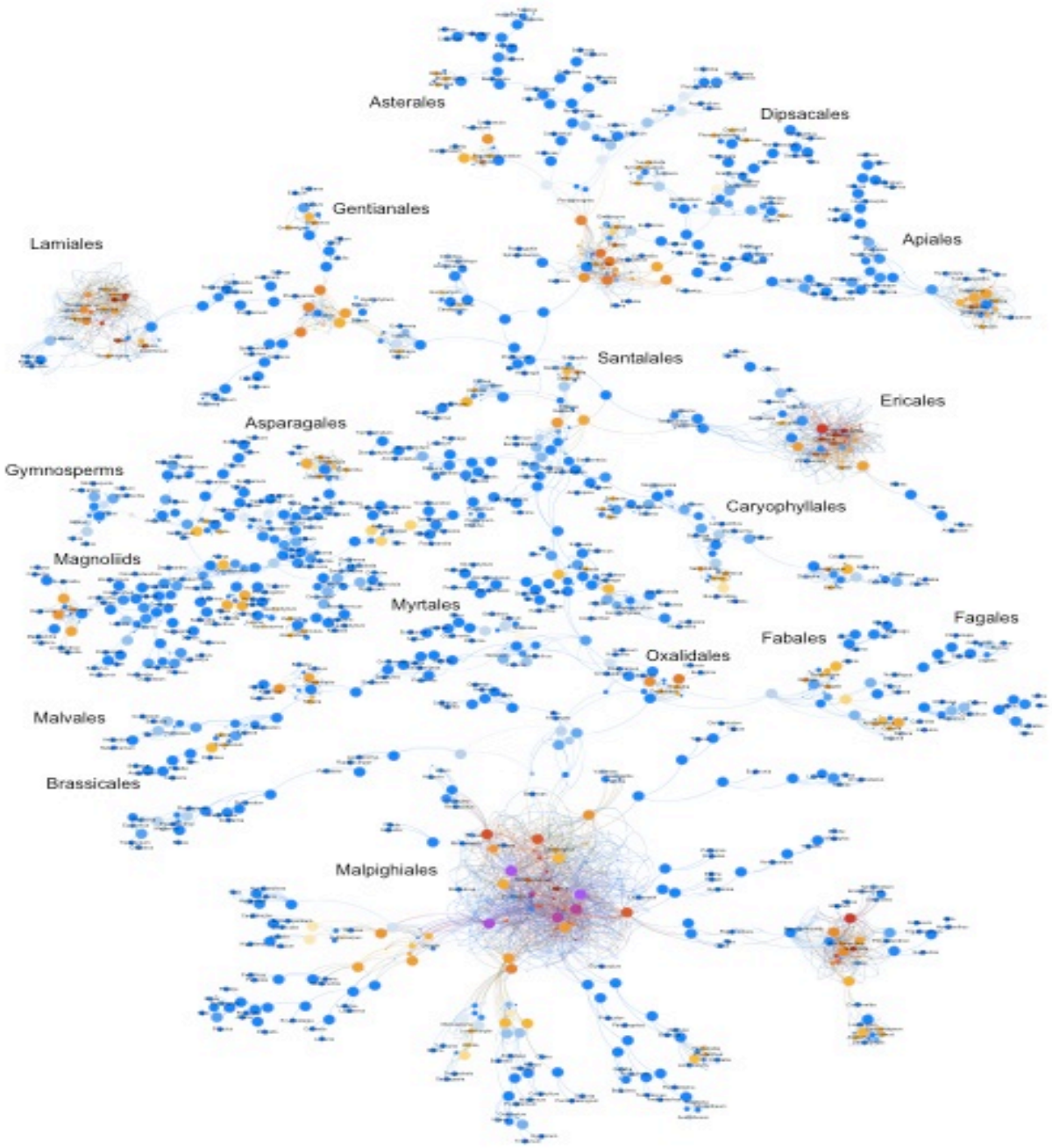
A Universe of Possible Trees

OPEN Tree of Life

This initial **tree of life will not be static**; instead, **we will develop tools for scientists** to update and revise the tree as **new data** come in.

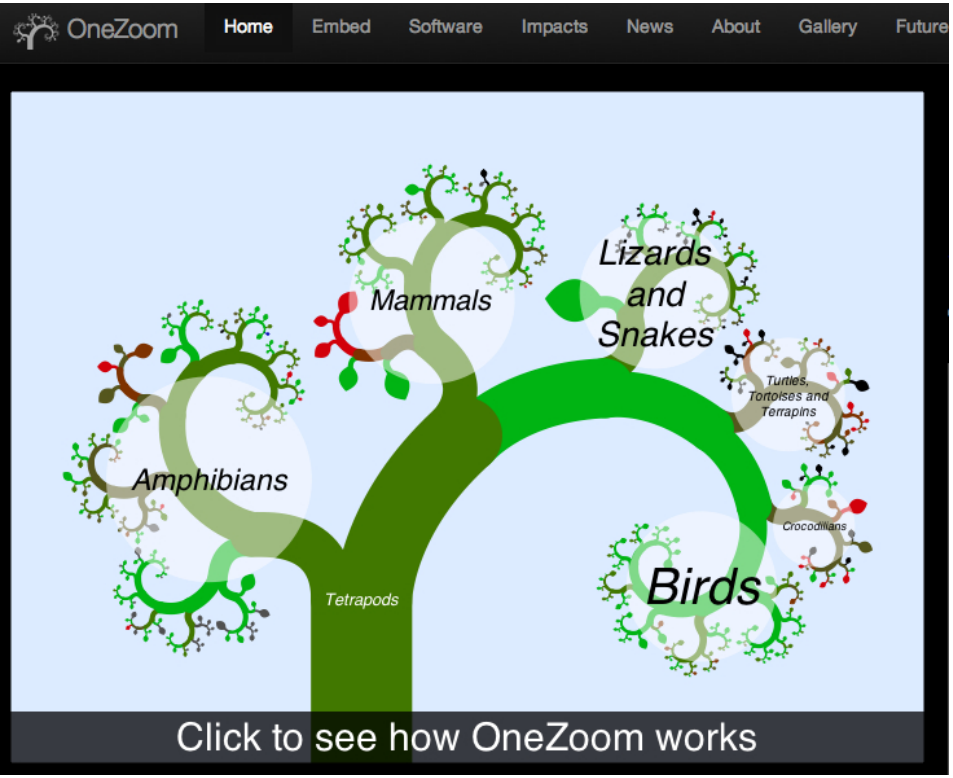
www.opentreeoflife.org

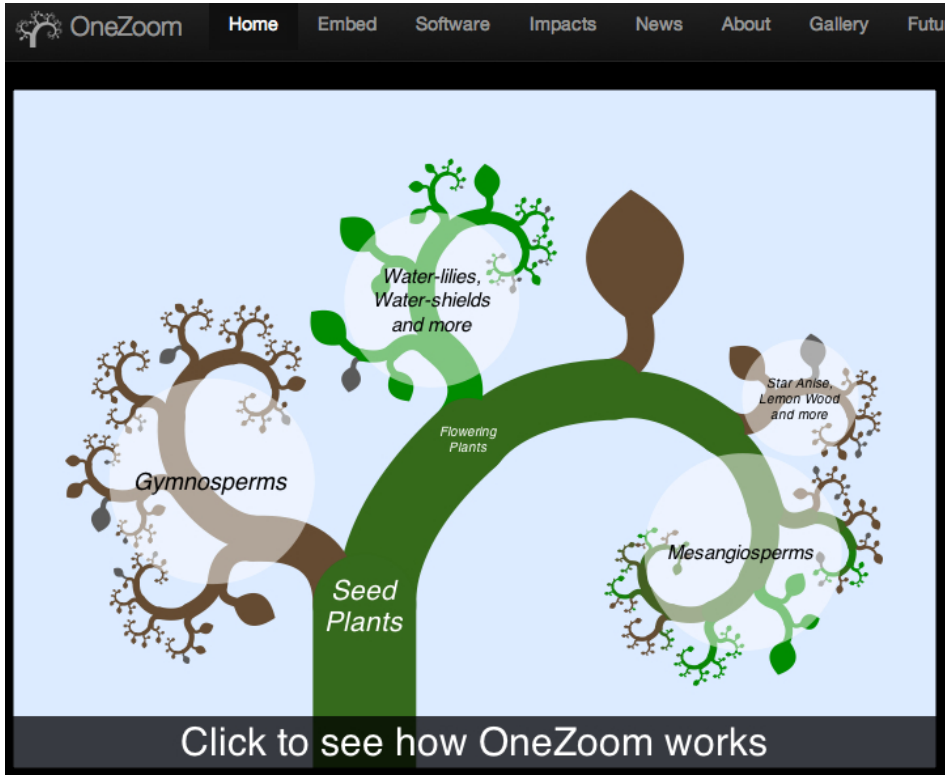
Graph Theory

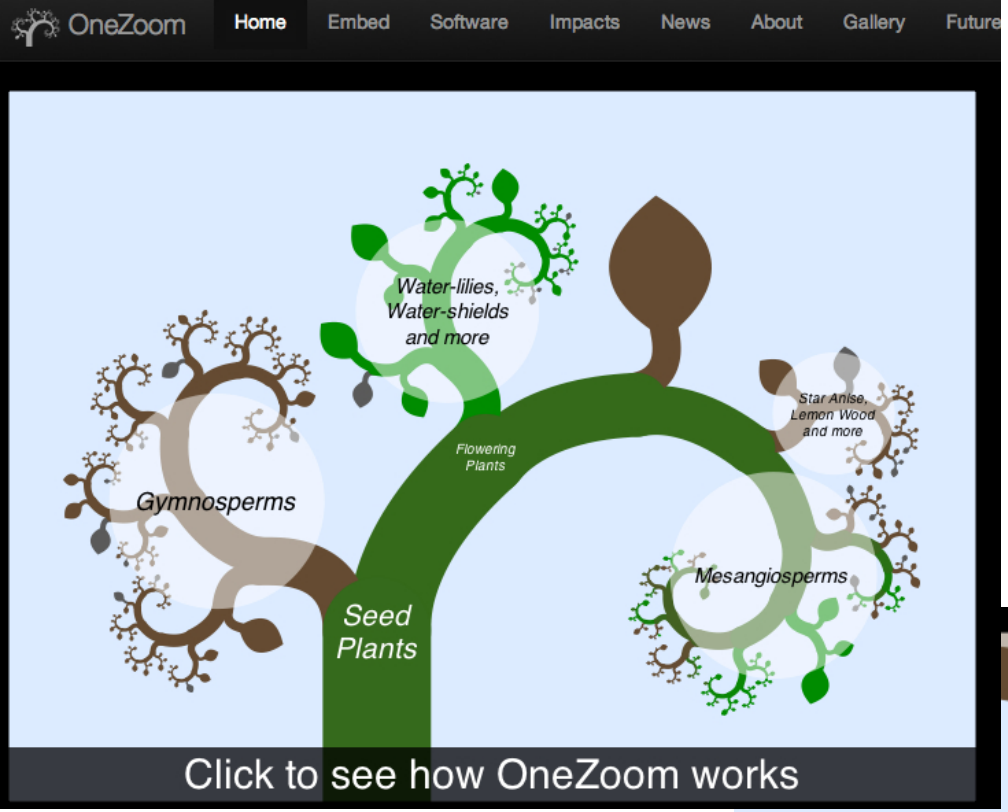


Smith et al. 2013
PLoS Comput Biol
9(9): e1003223.

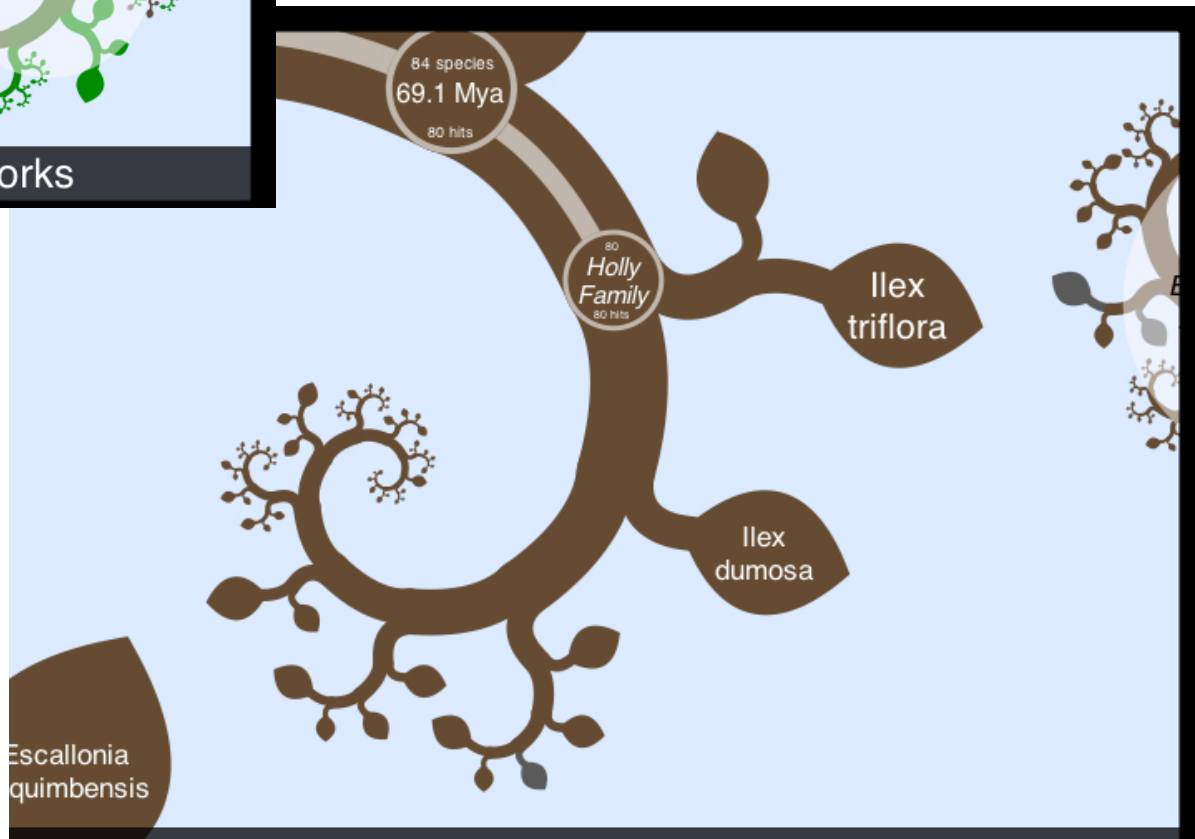
Visualizing the Tree…
OneZoom (www.onezoom.org)



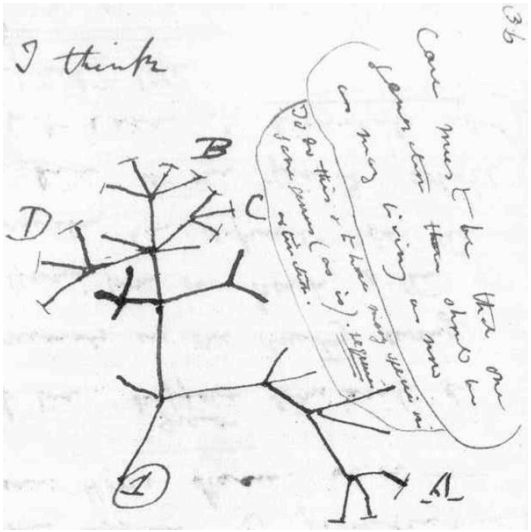


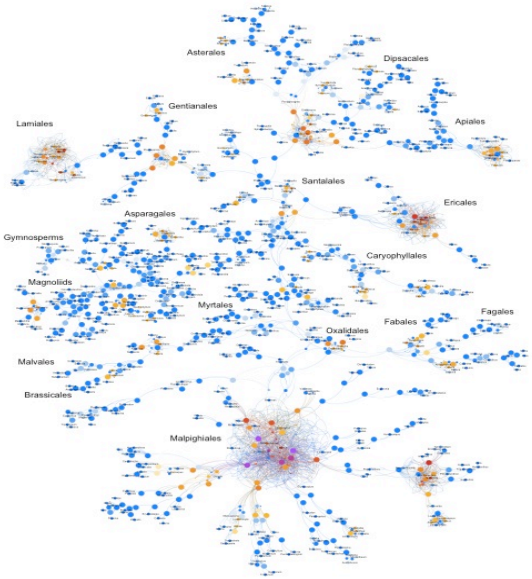


>30,000 plant species



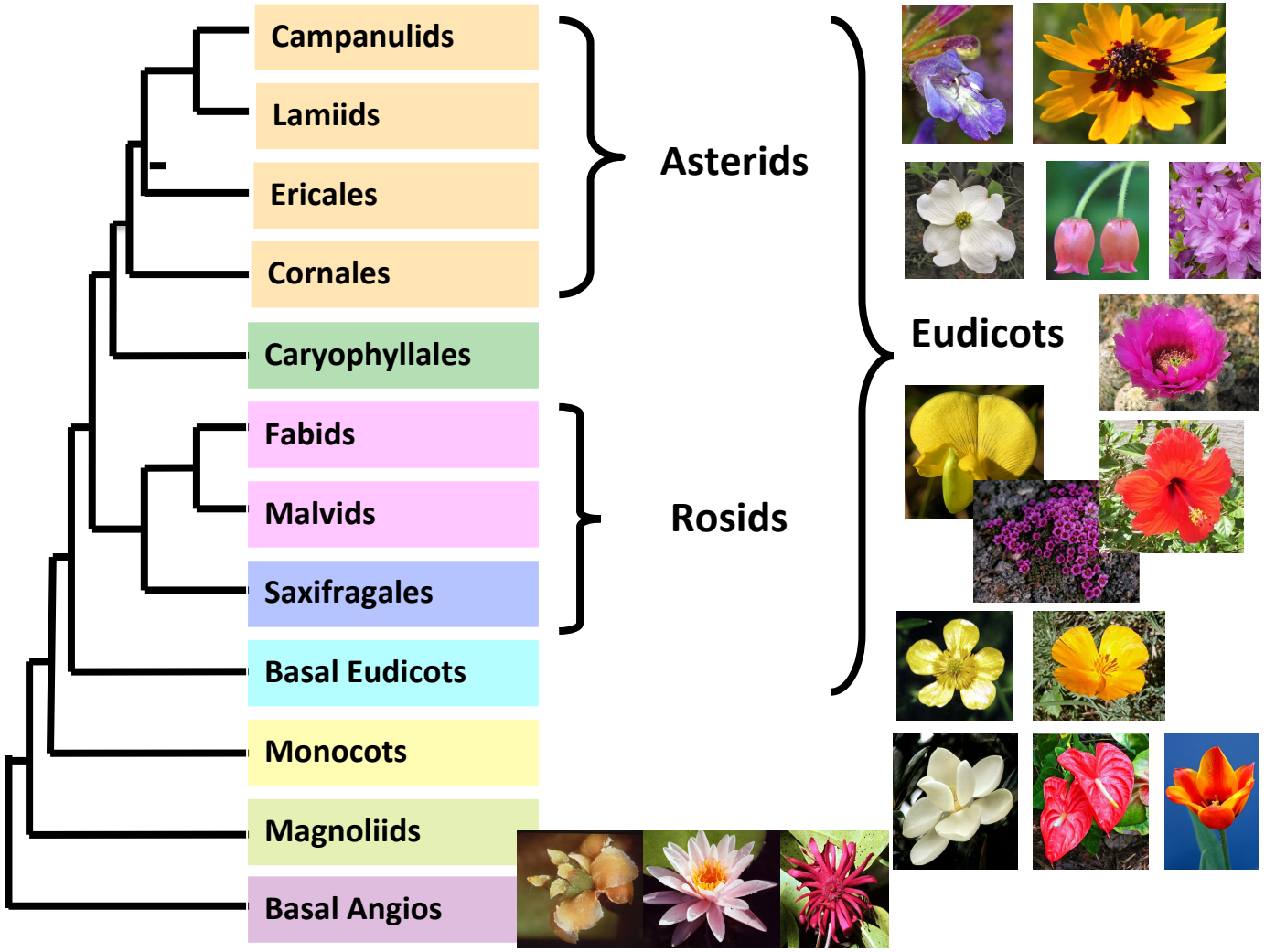
Building the Tree of Life



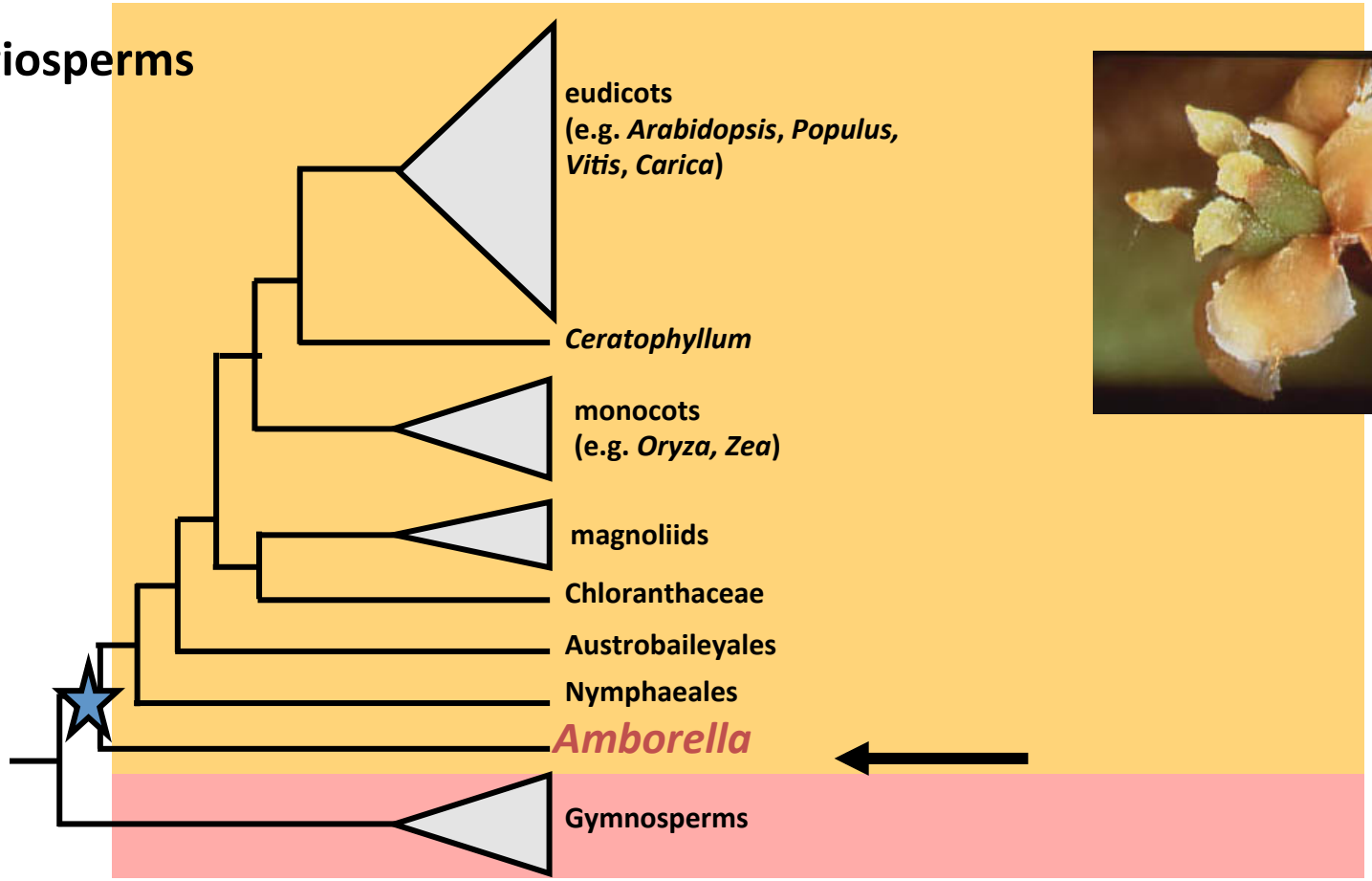


- Exciting, dynamic field:
  - Exploration
  - Innovation in DNA sequencing
  - Advances in computation
  - Novel visualization

Interpreting & Using the Tree of Life



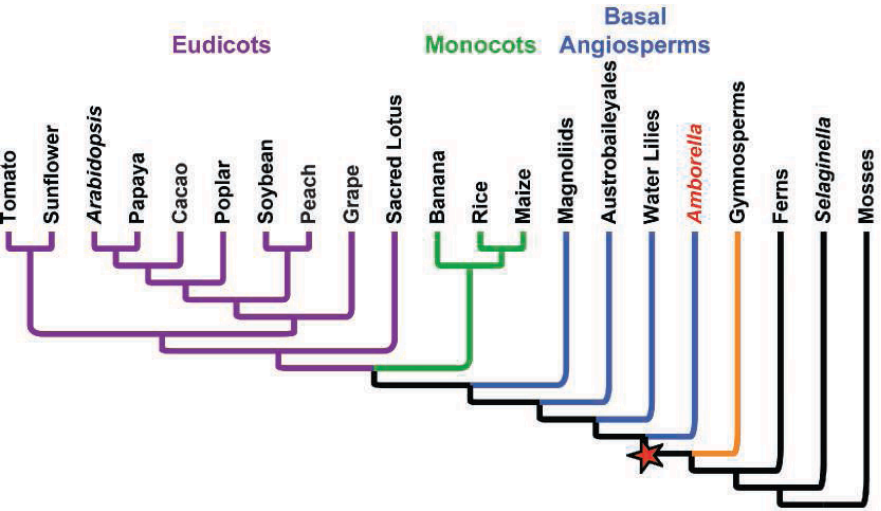
Amborella trichopoda
Pivotal Position in the Tree of Life

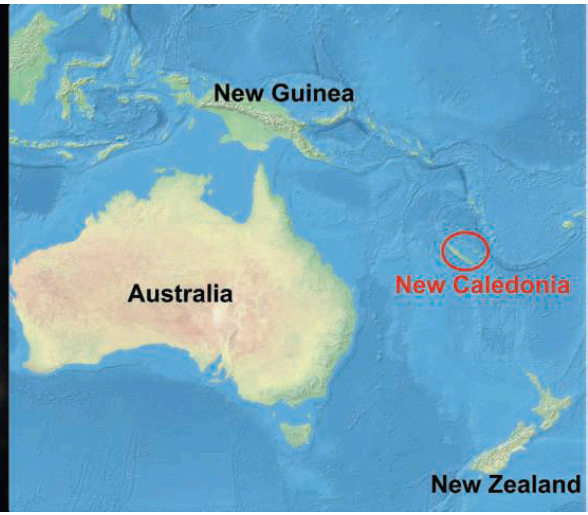


The *Amborella* Genome and the Evolution of Flowering Plants

Amborella Genome Project*†

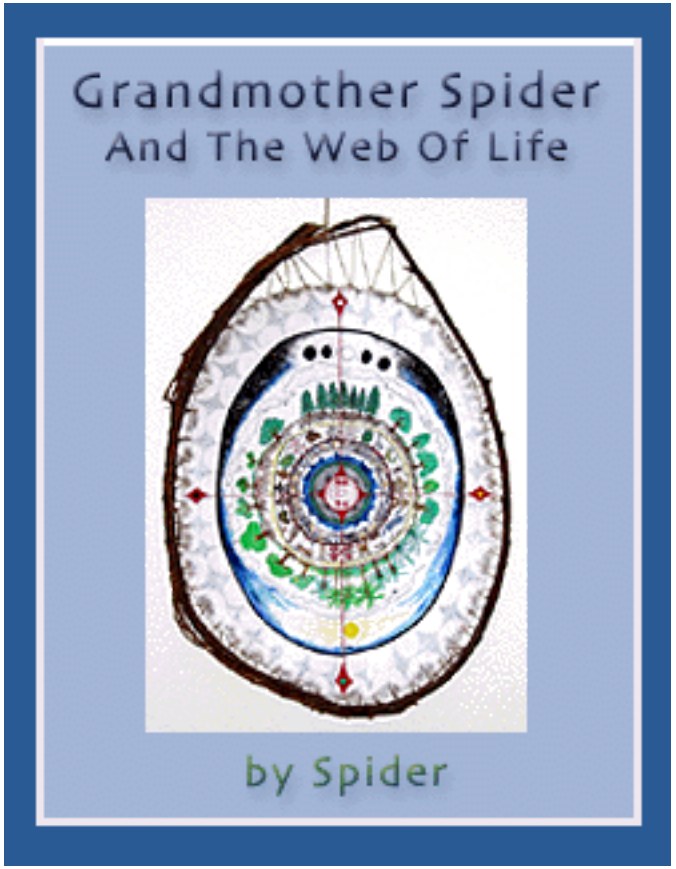
contain one or more introns, with 86.9% of the splice sites supported by transcript evidence. Refined gene models were further curated through manual comparisons with *Amborella* complementary DNA transcript assemblies, gene family analyses, and homologous full-length genes from other species (*17*). Many of the resulting gene





Life is connected…

genealogically



ecologically

iDigBio
Integrated Digitized Biocollections
www.idigbio.org

National center for digitization of biodiversity collections

Capture information & images for **1 billion museum** specimens in US!

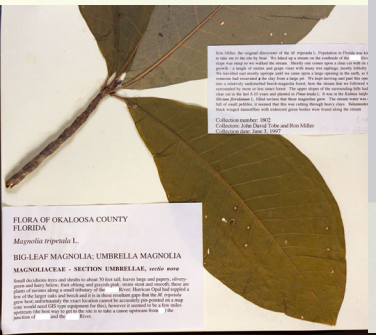
Coordinate digitization and databasing of US collections

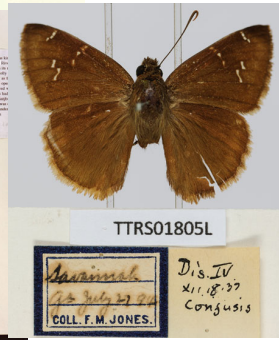
Ingest, serve, integrate data:

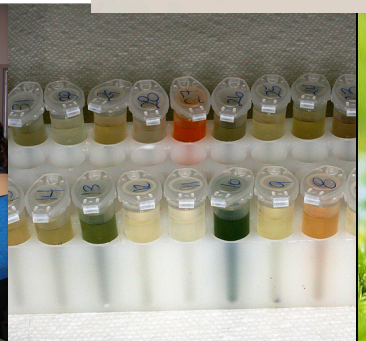
Localities

Dates

Images

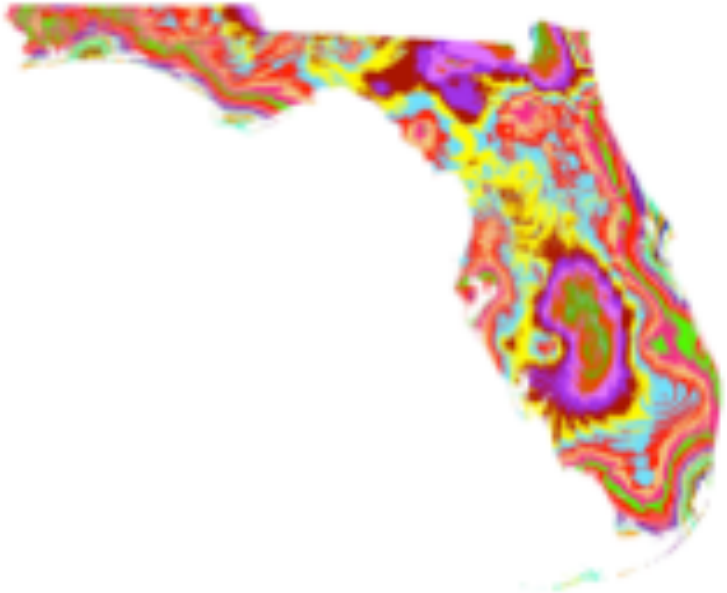


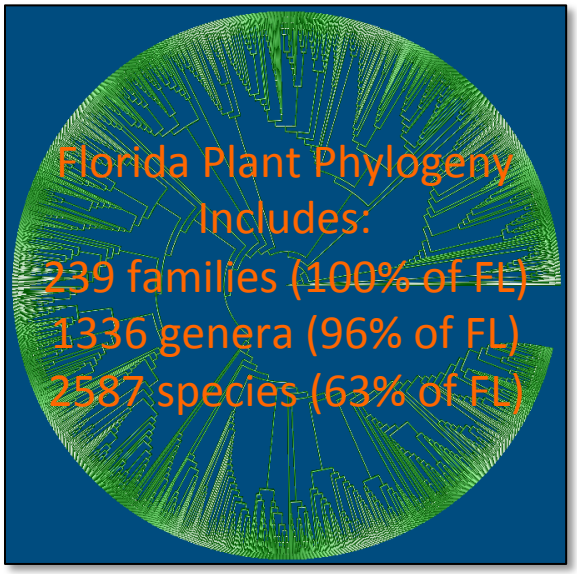




Florida Plant Diversity in a Changing Climate

Integrating herbarium specimen data, climate change models, and phylogeny





Today, 2050, 2080

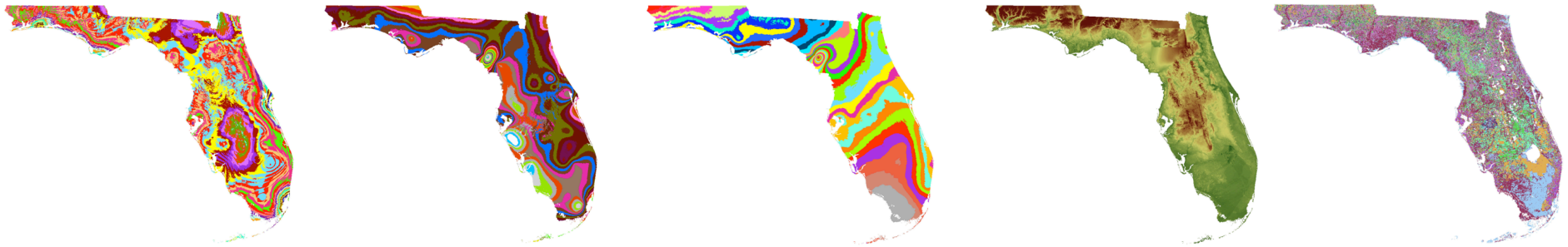
iDigBio
Integrated Digitized Biocollections

NSF

C. Germain-Aubrey, J. Allen,
K. Neubig, L. Majure, R. Abbott, R. Guralnick, J. M. Ponciano, D. Soltis, P. Soltis

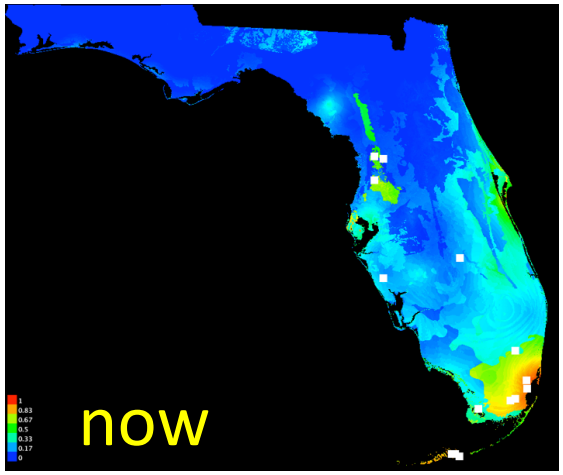
Modeling the Distribution of Species

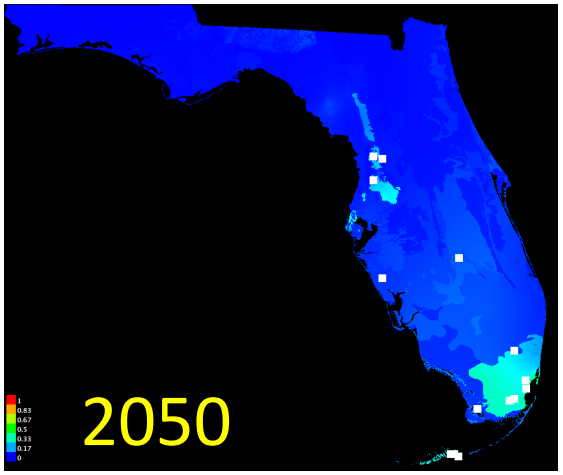
- Location information and environmental data
- Software to model the range of each species
- Project onto future climate conditions
- For Florida plants:
  - >2700 plant species (of 4200 species)
  - >511,000 georeferenced points
  - Environmental features: temperature, precipitation, soil, etc.



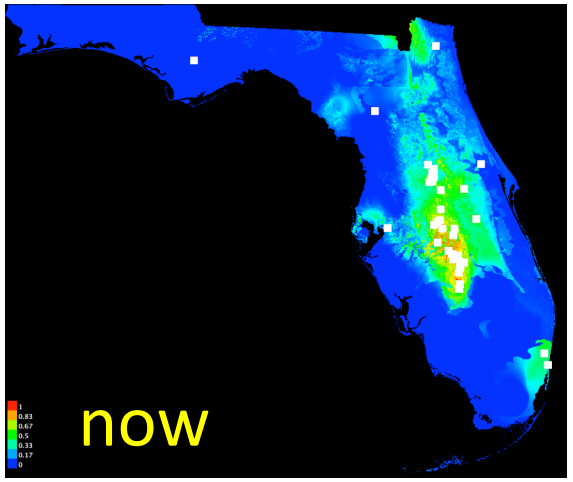
Responses to Climate Change: Winners & Losers

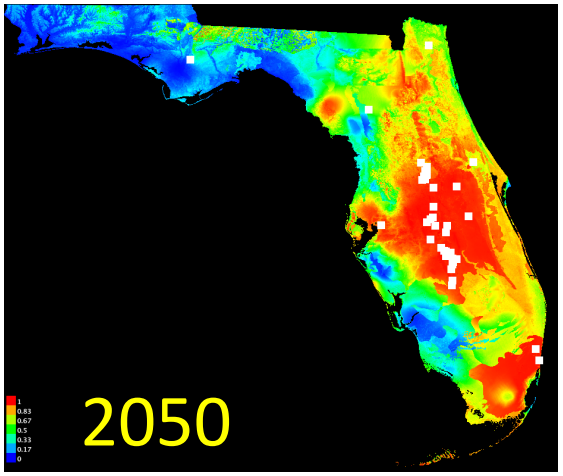
Abildgaardia ovata (flatspike sedge)





Prunus geniculata (scrub plum)

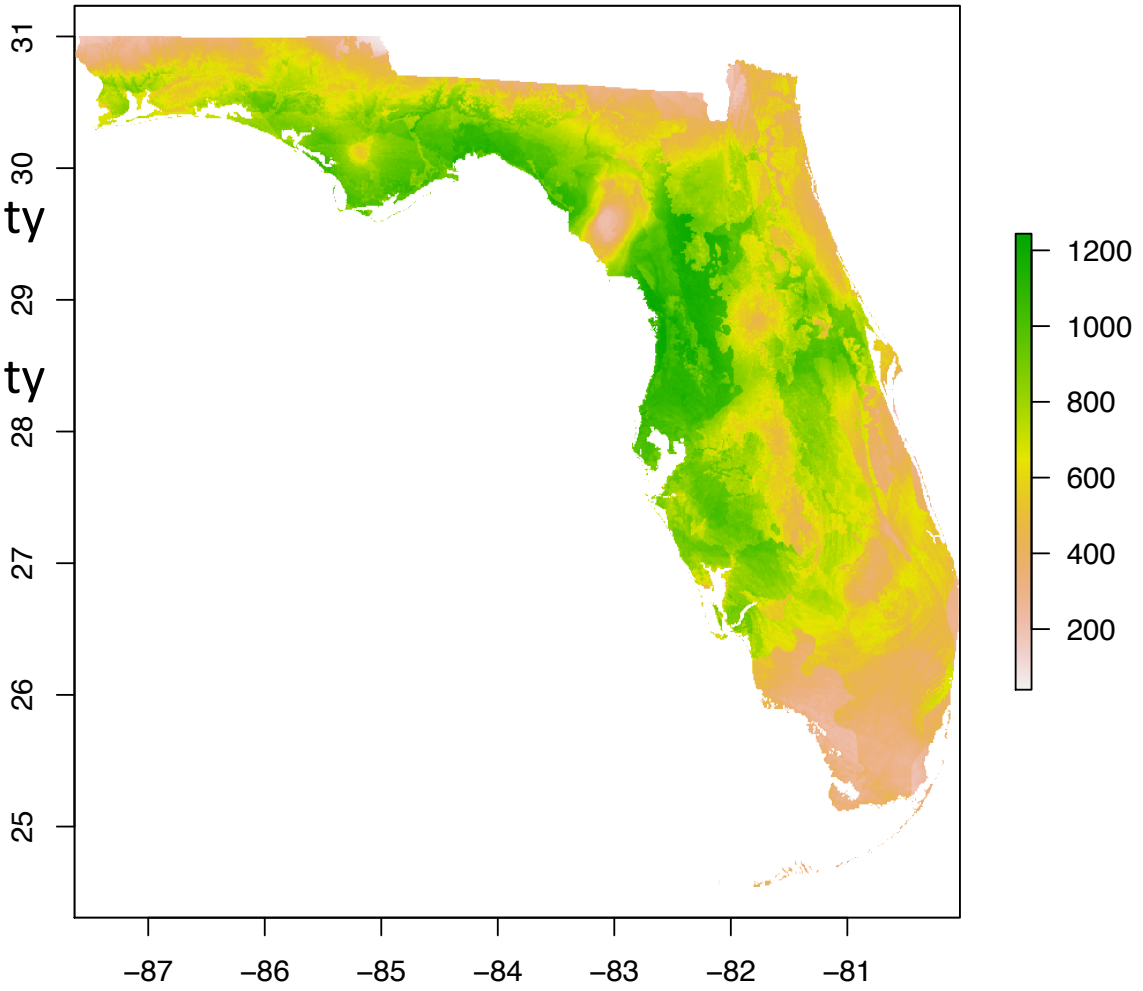




Florida Plant Diversity Now

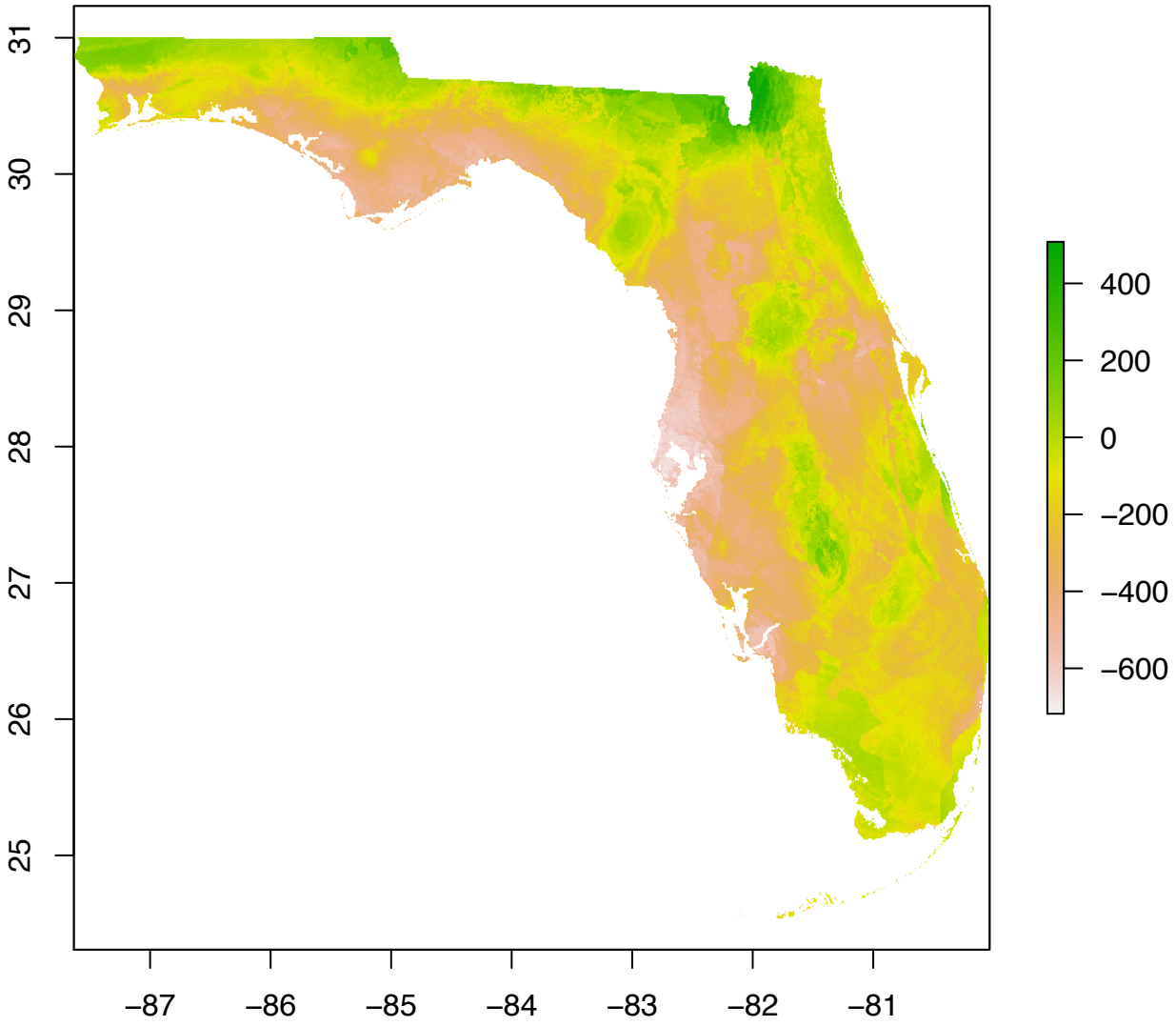
High species diversity

Low species diversity



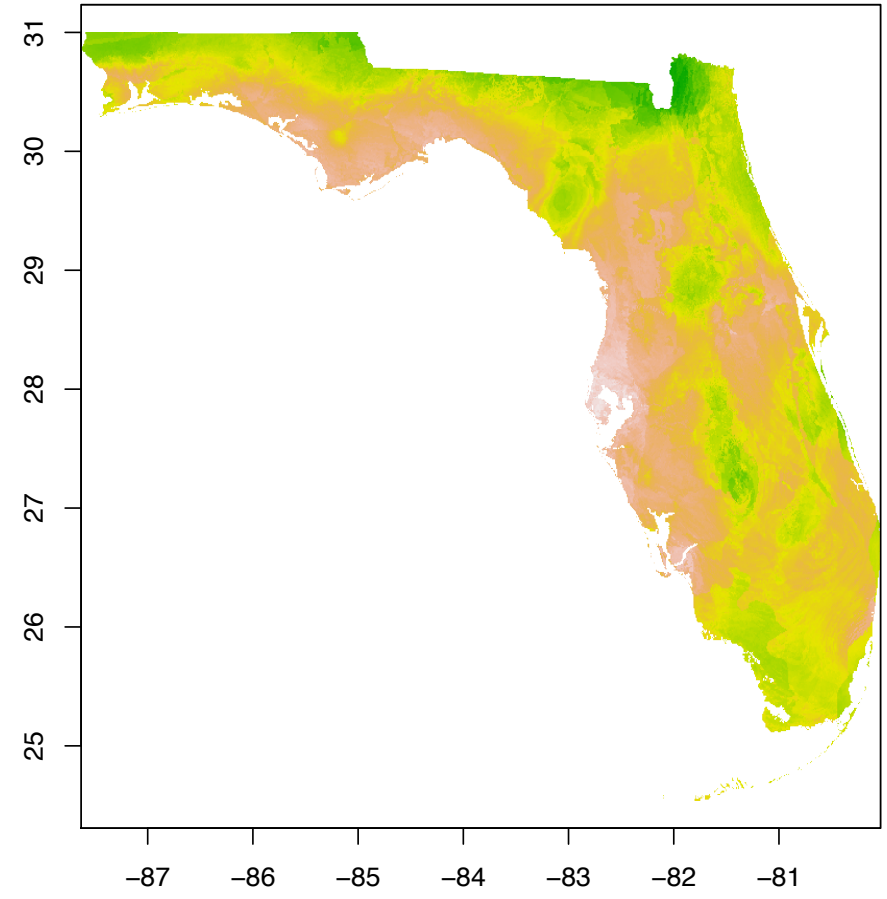
Between Now and 2050…

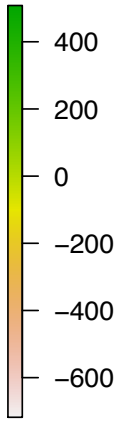
- Panhandle species moving NORTH!
- Peninsula species moving SOUTH!

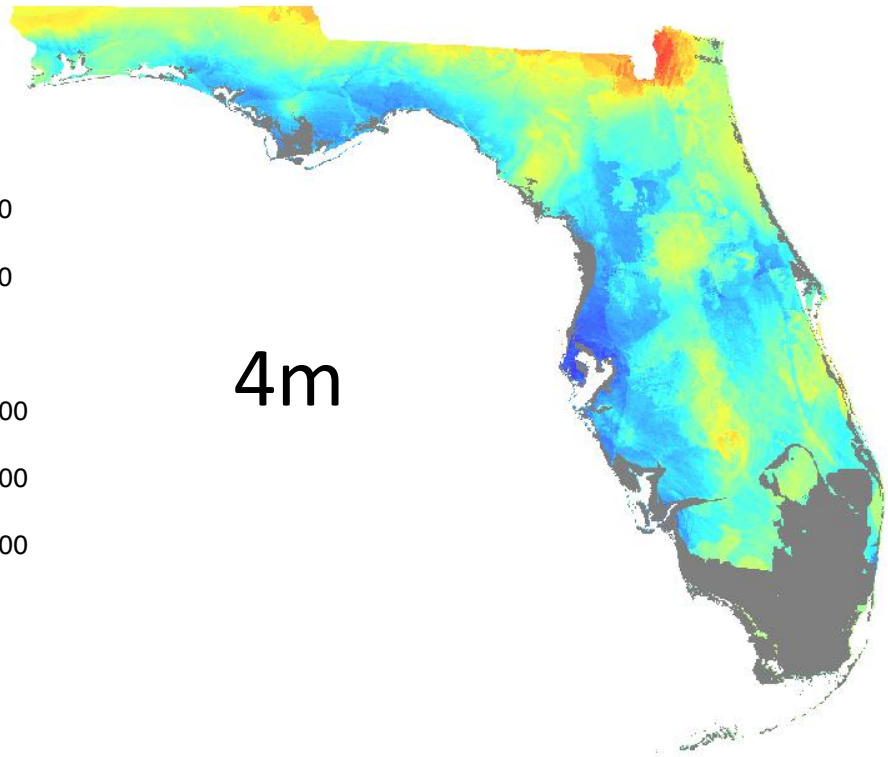


spp 2050 - #spp now

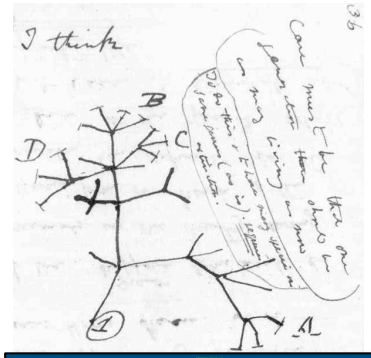
Sea Level Rise by 2050

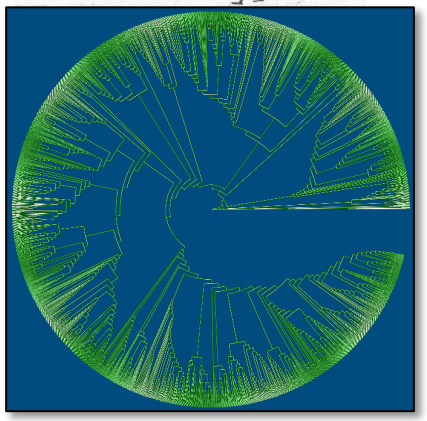


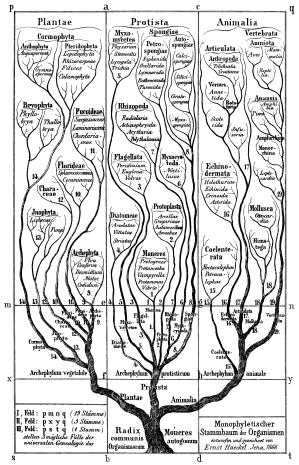


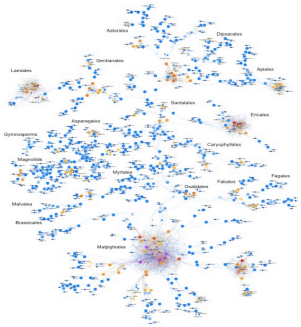


The Tree of Life



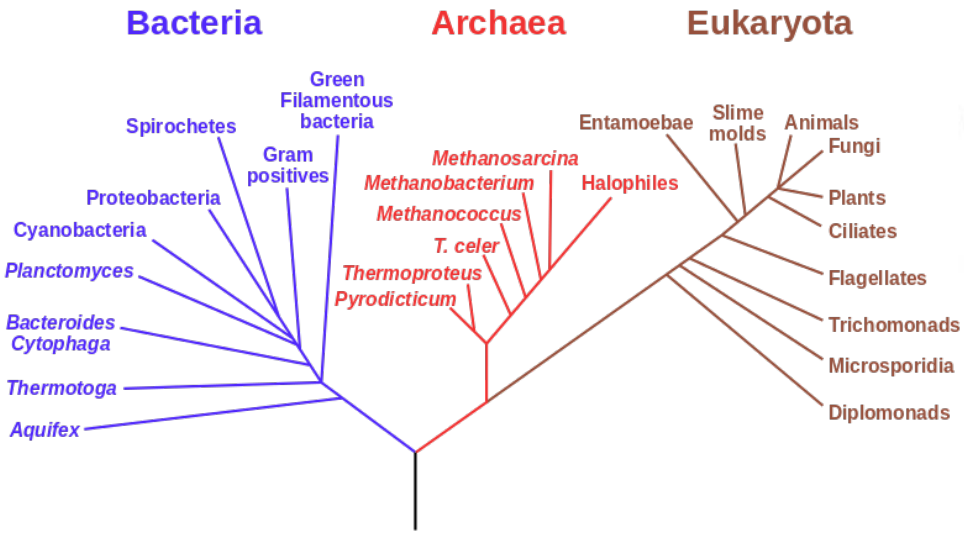


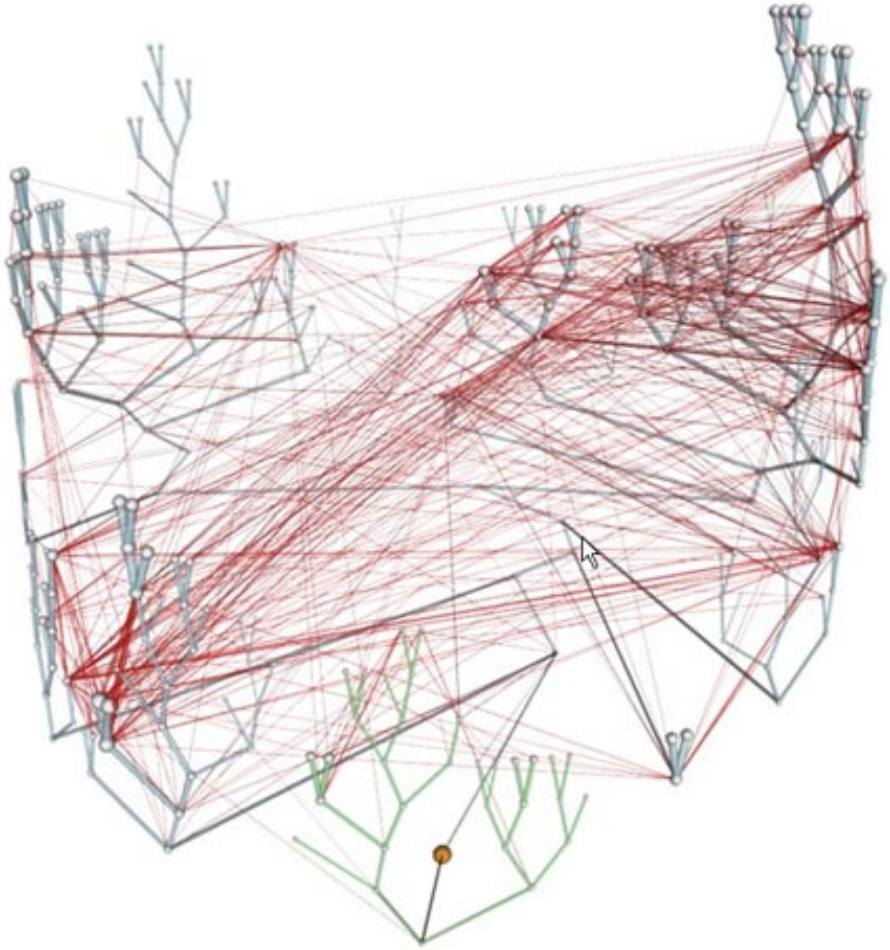




- Exciting, dynamic field:
  - Exploration
  - Innovation in DNA sequencing
  - Advances in computation
  - Novel visualization
  - COUNTLESS USES!

Bush and Vine of Life?
A View of Prokaryotes





Acknowledgments

- LOTS of colleagues… especially
  - Doug Soltis
  - Angiosperm AToL group
  - *Amborella* Genome Project
- LOTS of students and post-docs… especially
  - Andre Chanderbali
  - Charlotte Germain-Aubrey
  - Julie Allen
- Funding… especially
  - the National Science Foundation

Where Do You Go From Here?

Themes & Resources

- The role of PASSION!
- The role of COMMUNITY!
- Opportunities and excitement!
- Pure science AND the greater good!
- MANY resources:
  - Advisors, professors, students, research offices
  - Volunteer, shadow [APPLY TO FLMNH!]
  - Summer experiences:
    - NSF's REUs – stipend and experience
    - Professional societies – travel and research funds
  - Special programs: universities, NSF, societies
  - New colleagues and mentors!


MAKE
ART
NOT
SURF TEAM

Themes & Resources

- The role of PASSION!
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