Contemporary Methods in Assembling and Using the Tree of Life

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The Circle of Life
Life is connected...

genealogically

ecologically

Grandmother Spider
And The Web Of Life
by Spider
Family 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
“As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feeble 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

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nothinginbiology.org
We are Just One Twig on the Tree of Life

You are here

D. Hillis
Many Genes

Nandina domestica plastid genome
156,624 bp
Genomics & Transcriptomics harnessing the ‘DNA Data Deluge’
Many Species
Many Species

Florida Plant Phylogeny
Includes:
239 families (100% of FL)
1336 genera (96% of FL)
2587 species (63% of FL)
Many Species: >55,000 plants!

Florida Plant Phylogeny
Includes:
239 families (100% of FL)
1336 genera (96% of FL)
2587 species (63% of FL)
Do we know the Tree of Life?
So Many Species...

Known Biodiversity (excluding microbes)
Approximately 1.7 million named species of plants and animals.

Estimated Biodiversity (excluding microbes)
10 million species

1 square = 10,000 species
~1.7 million described, 10 million total? 100 million?

[Diagram showing known and estimated biodiversity]

Known Biodiversity (excluding microbes)
Approximately 1.7 million named species of plants and animals.

Estimated Biodiversity (excluding microbes)
10 million species

1 square = 10,000 species
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 - $2.2 \times 10^{20}$ unrooted
  - 22 taxa - $3 \times 10^{23}$ unrooted (~ a mole of trees)
  - 228 taxa - $1.2 \times 10^{502}$ (more than the number of atoms in the universe...; Hillis, 1996)
A Universe of Possible Trees
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.
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

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

Asterids

Eudicots

Rosids
Amborella trichopoda

Pivotal Position in the Tree of Life

Angiosperms

- eudicots
  - Ceratophyllum
  - monocots
    - magnoliids
      - Chloranthaceae
      - Austrobaileyales
      - Nymphaeales
      - Amborella

Gymnosperms
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

coeffologically

Grandmother Spider
And The Web Of Life

by Spider
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


Florida Plant Phylogeny Includes:
- 239 families (100% of FL)
- 1336 genera (96% of FL)
- 2587 species (63% of FL)
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

[Image of Florida map with color gradient indicating species diversity]
Between Now and 2050...

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

# spp 2050 - #spp now
Sea Level Rise by 2050

The map shows the estimated sea level rise by 2050 in feet. The color gradient indicates the magnitude of the rise, with darker colors representing higher rises. The rise is expected to be significant, with some areas experiencing rises of over 4 meters (13 feet).
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!
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