



UNIVERSITY OF SAN FRANCISCO  
CHANGE THE WORLD FROM HERE

# Hierarchical Data Visualization

# INTRODUCTION

## Hierarchical Data Visualization



# Hierarchical Data

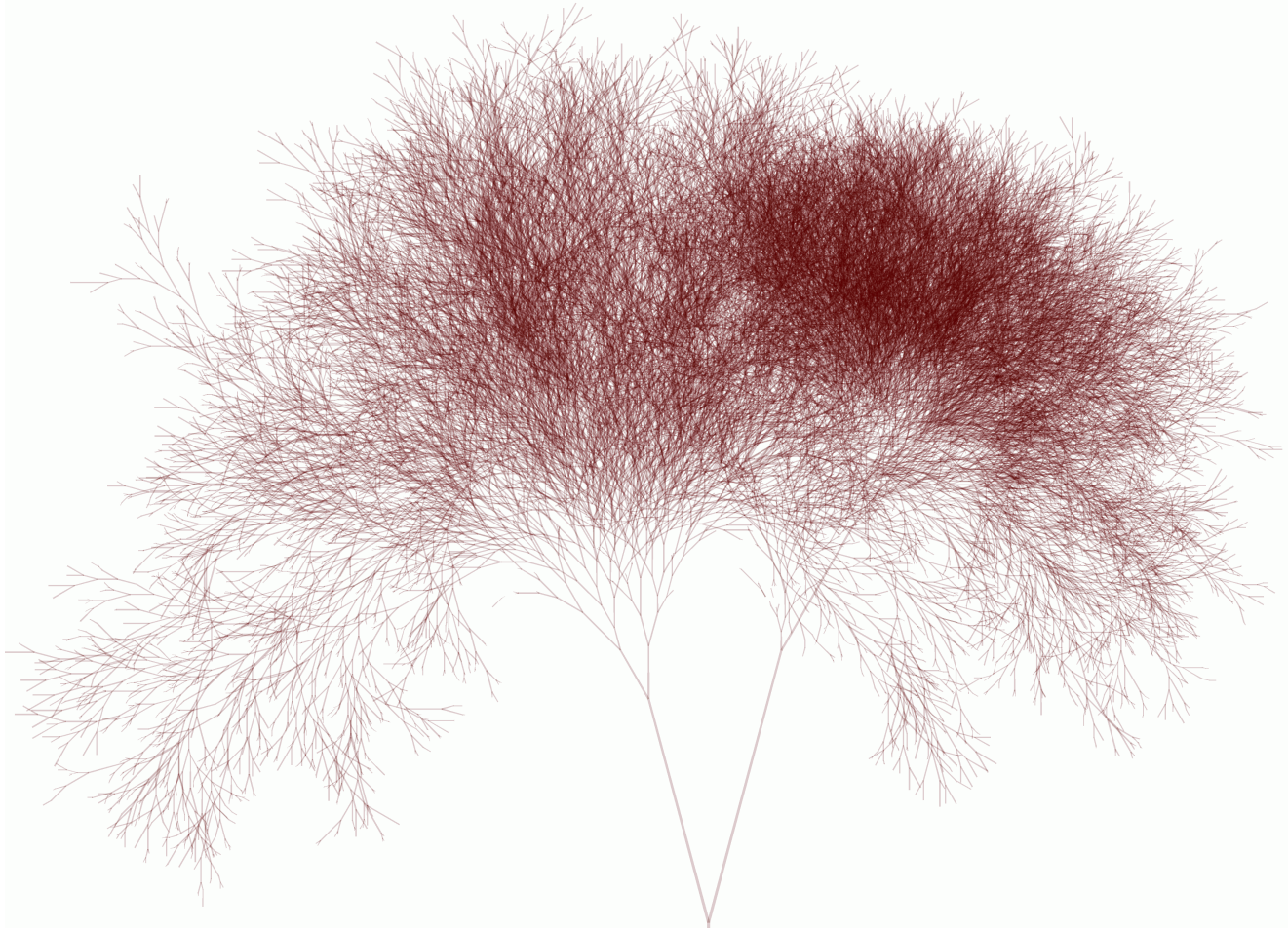
- Any data with some sort of **hierarchy**
  - *"Group of objects ranked so that every one but the topmost is subordinate to one above it."*
- Example hierarchy
  - Country: United States
  - Region: West
  - State: California
  - County: San Francisco County
  - City: San Francisco

<http://en.wiktionary.org/wiki/hierarchy>

# Examples of Hierarchical Data

- Evolutionary Tree
- Dendrograms
- File Directory Structure
- Dewey Decimal System
- Family History
- Organization Charts
- Outlines

# Tree Structures



<http://drunkenworkhere.org/219>

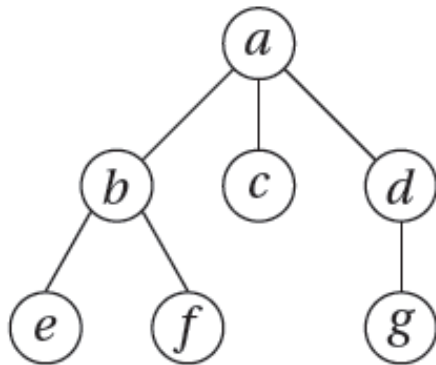
# Tree Structures

- Used to model hierarchical data
- Special type of graph
  - Must be **acyclic**, i.e. has no cycles or loops
  - Must be **undirected**, i.e. arrow-less edges
  - Usually **rooted** (a single node at top)
  - Each **subgraph** is also a tree (**subtree**)

<http://xlinux.nist.gov/dads/HTML/tree.html>

# Tree Terminology

FIGURE 2.8: TREE TERMINOLOGY AND NOTATION



$G = (N, E)$  where

$$N = \{ a, b, c, d, e, f, g \}$$

$$E = \{ (a, b), (a, c), (a, d), \\ (b, e), (b, f), (d, g) \}$$

Example tree  $G = (N, E)$ . Some observations: Each node has a unique label. Node  $a$  is the root node. Nodes  $a$ ,  $b$ , and  $d$  are internal nodes. Nodes  $c$ ,  $e$ ,  $f$ , and  $g$  are leaf nodes. Node  $d$  is a parent node to node  $g$ , and node  $g$  is a child node to  $d$ . Nodes  $e$  and  $f$  share the same parent node  $b$  and are considered siblings.

# Tree Visualization

- Node-Link Diagrams
  - Traditional node-link diagram
  - Dendograms
  - Hyperbolic trees
- Space-Filling Diagrams
  - Treemaps
  - Sunbursts

# Considerations

- Is the hierarchical structure visible?
- What is the level of a specific node?
- What is the height of the tree?
- How many nodes on level  $x$ ?
- Are the labels readable? All nodes visible?
- What type of interaction is supported?
  - Focus + Context
  - Overview + Detail
  - Zoom + Filter

# NODE-LINK DIAGRAMS

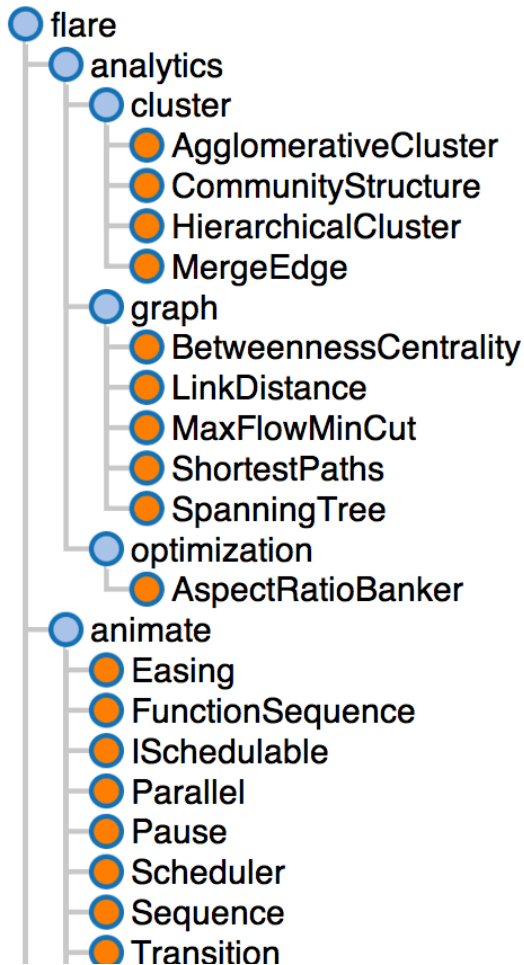
## Tree Visualization



# Node-Link Diagrams

- Indented Layout
  - Child nodes placed below parent and indented
  - Compact width
  - Height expands and shrinks
  - Often used to navigate file systems
  - Difficult to see all nodes of a specific level

# Indented Layout



933KB

47KB

14KB

3KB

3KB

6KB

0KB

25KB

3KB

5KB

7KB

5KB

3KB

6KB

6KB

97KB

16KB

5KB

1KB

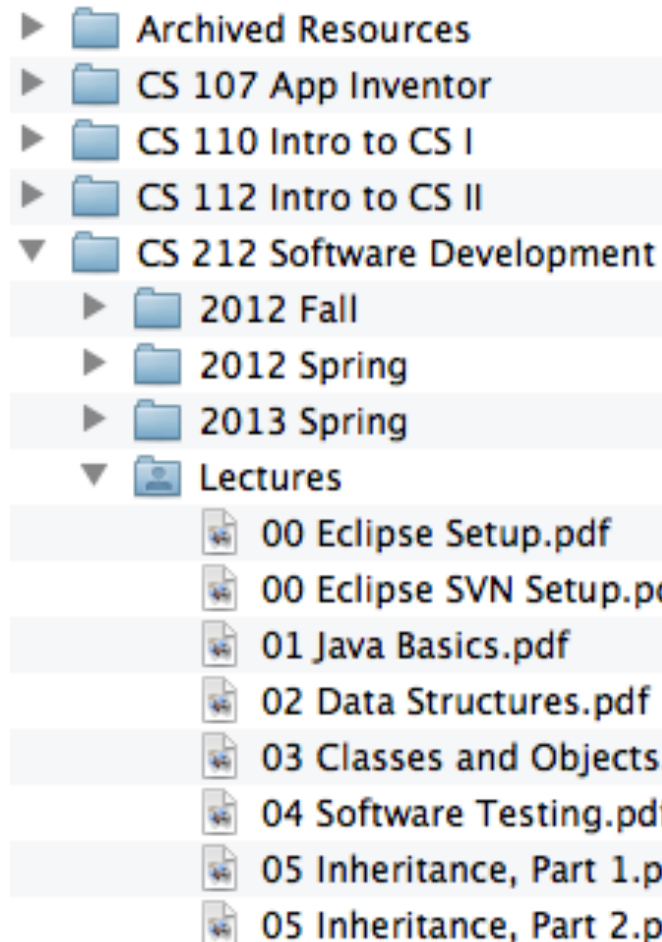
5KB

0KB

5KB

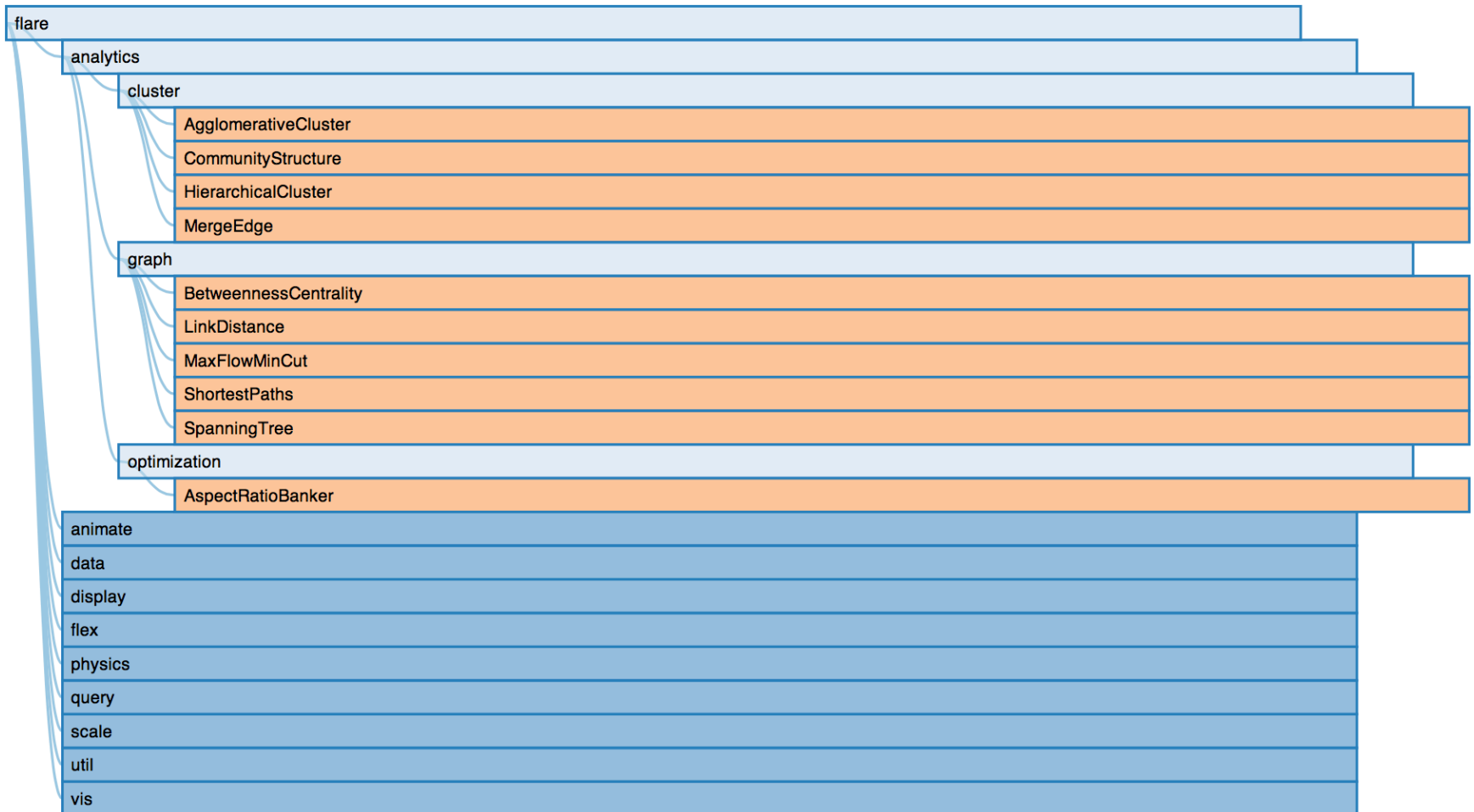
5KB

8KB



<http://mbostock.github.io/protovis/ex/indent.html>

# Indented Layout

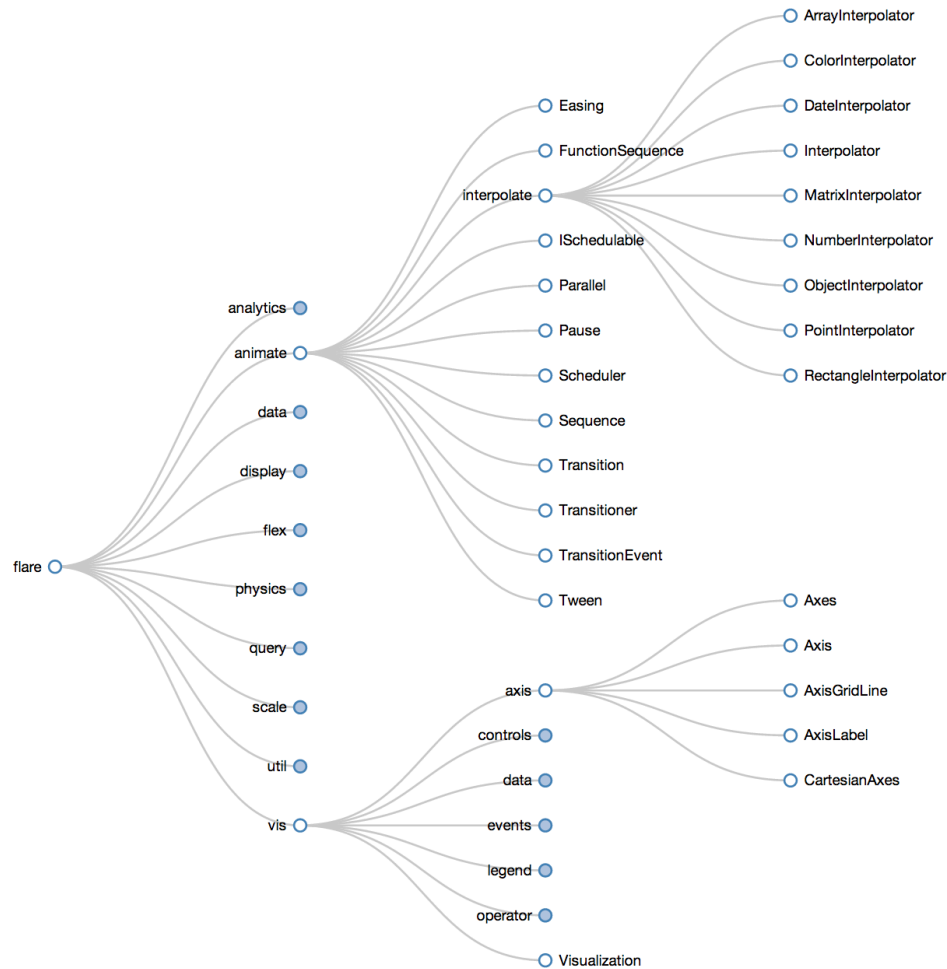


<http://bl.ocks.org/mbostock/1093025>

# Node-Link Diagrams

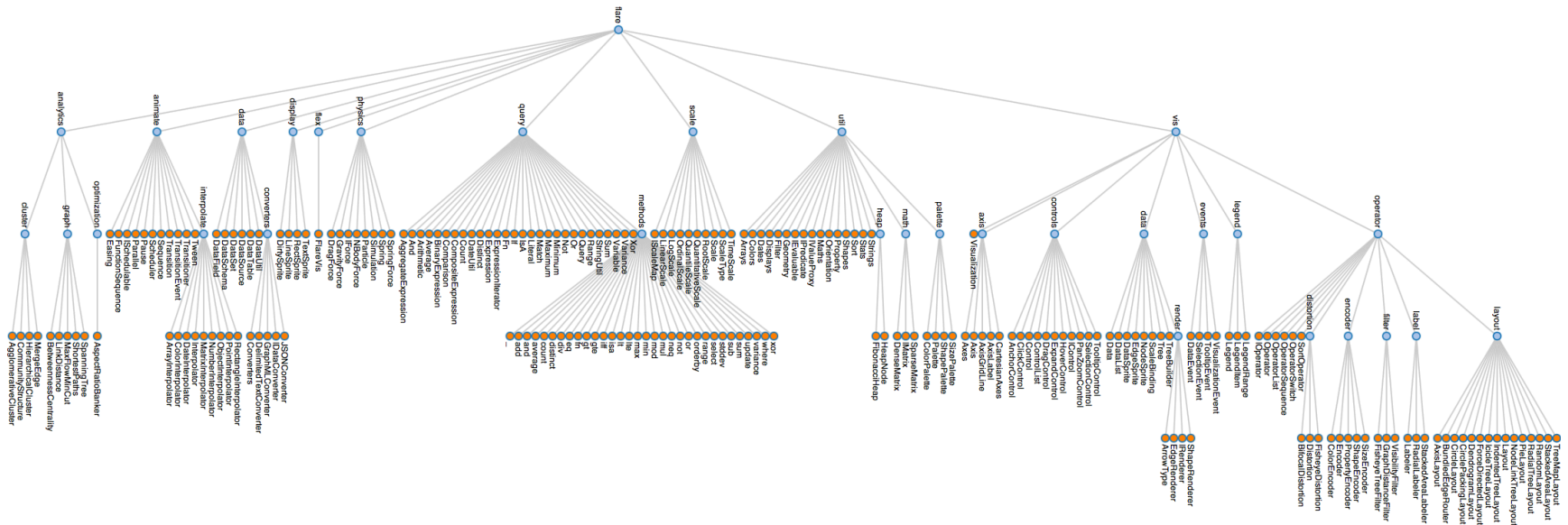
- Traditional Layout
  - Nodes laid out by level, root at top
  - Edges connect adjacent nodes
- Dendrogram
  - All leaves at bottom of diagram
  - Edges usually drawn with sharp corners
  - Often used to show clusters  
*(sometimes called cluster layout)*

# Traditional Layout



<http://mbostock.github.io/d3/talk/20111018/tree.html>

# Traditional Layout

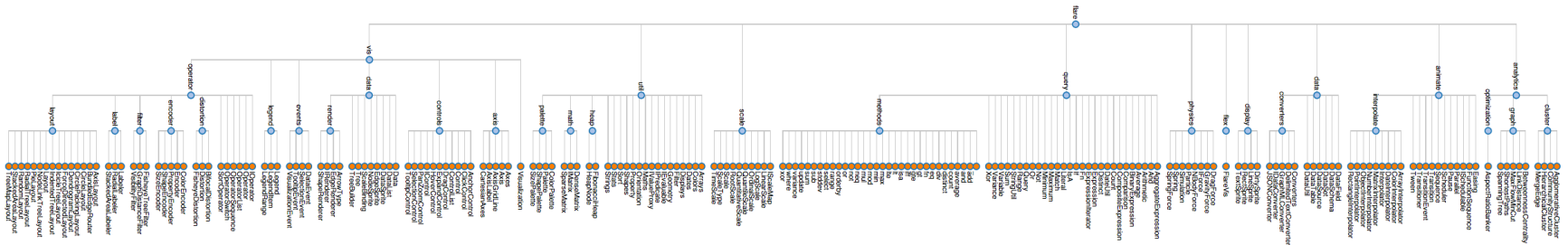


The Flare package tree laid out in horizontal layers. All the nodes in a given layer are at the same package depth.

Source: [Flare Visualization Toolkit](http://hci.stanford.edu/jheer/files/zoo/ex/hierarchies/tree.html)

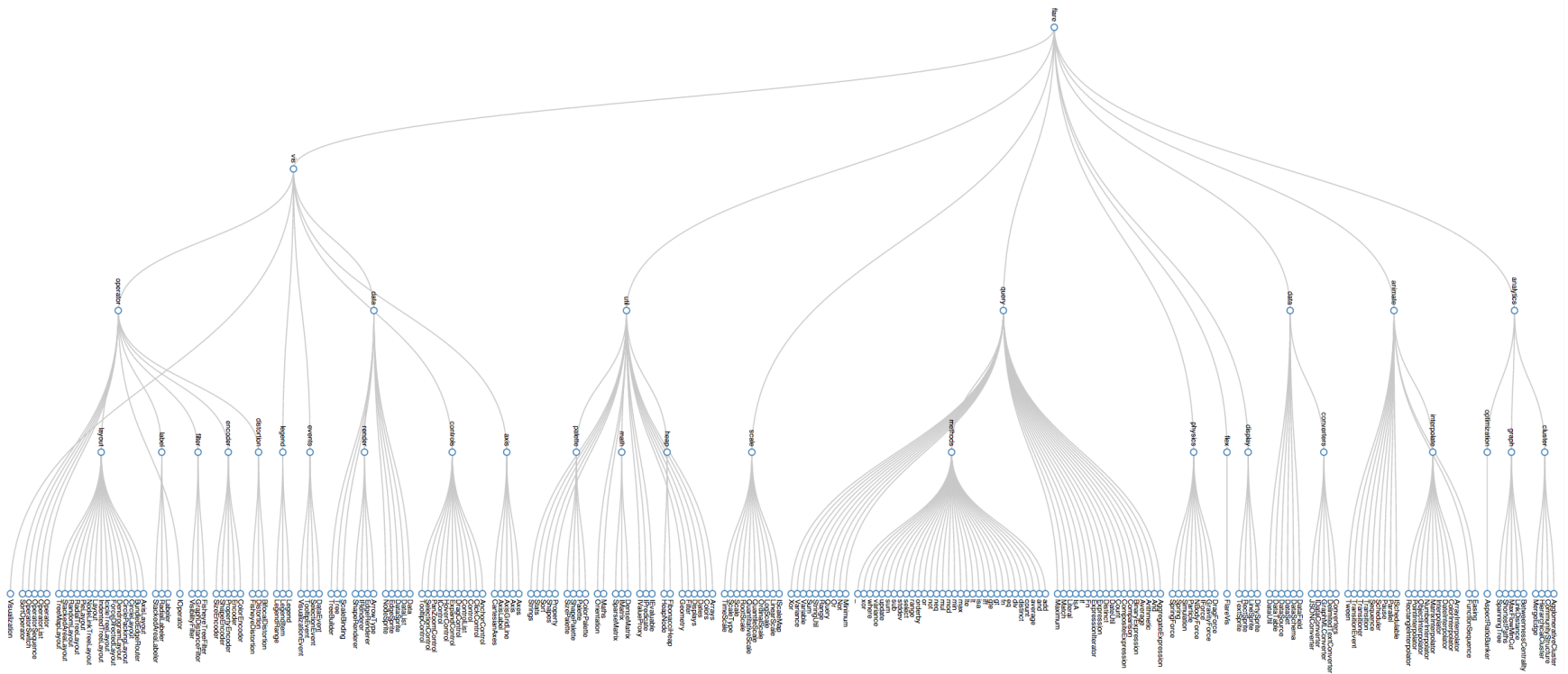
<http://hci.stanford.edu/jheer/files/zoo/ex/hierarchies/tree.html>

# Dendrogram



<http://mbostock.github.io/protovis/ex/dendrogram.html>

# Dendrogram

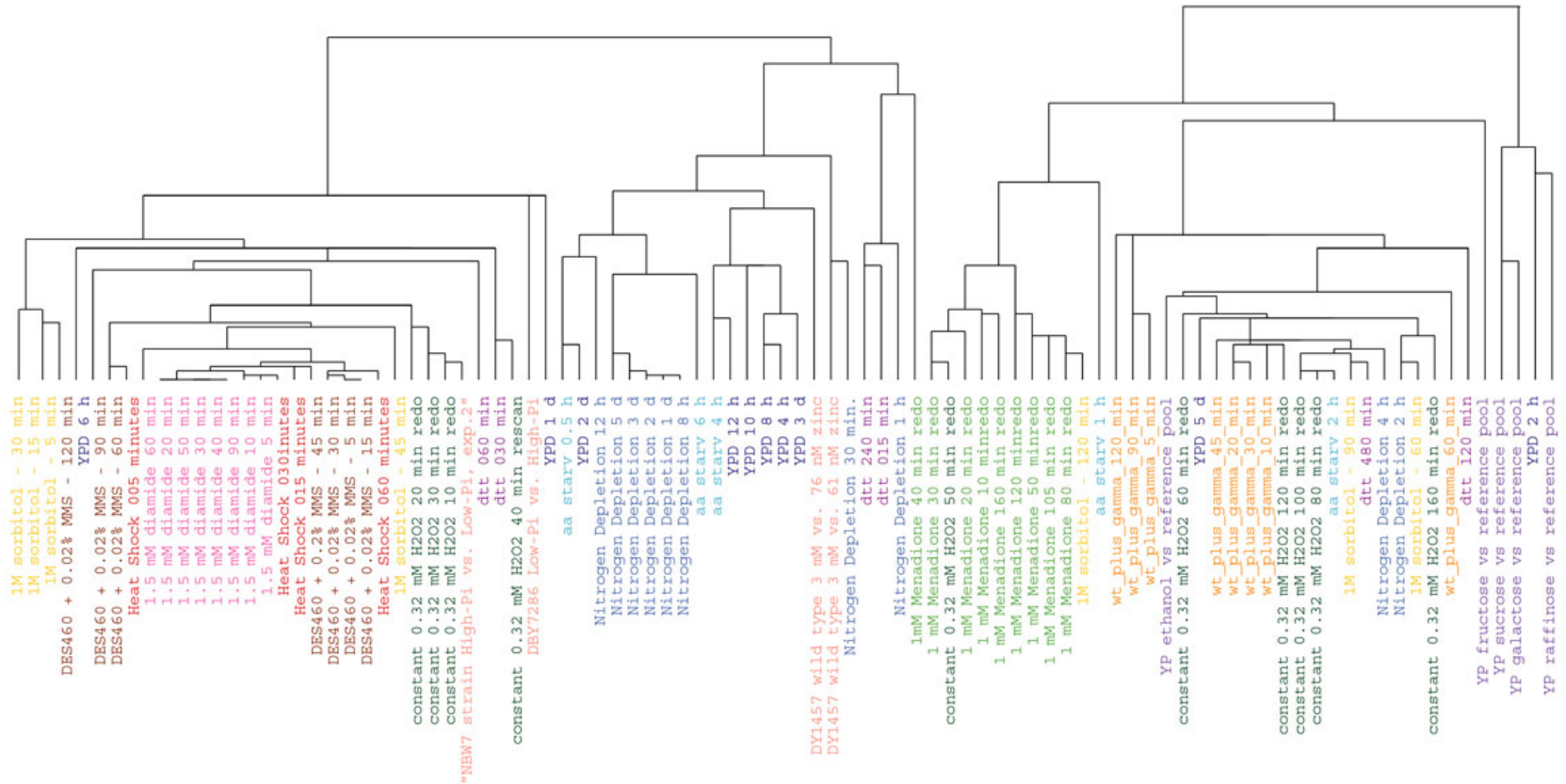


<http://mbostock.github.io/protovis/ex/dendrogram.html>



# Dendrogram

Cluster 11: protein folding chaperones



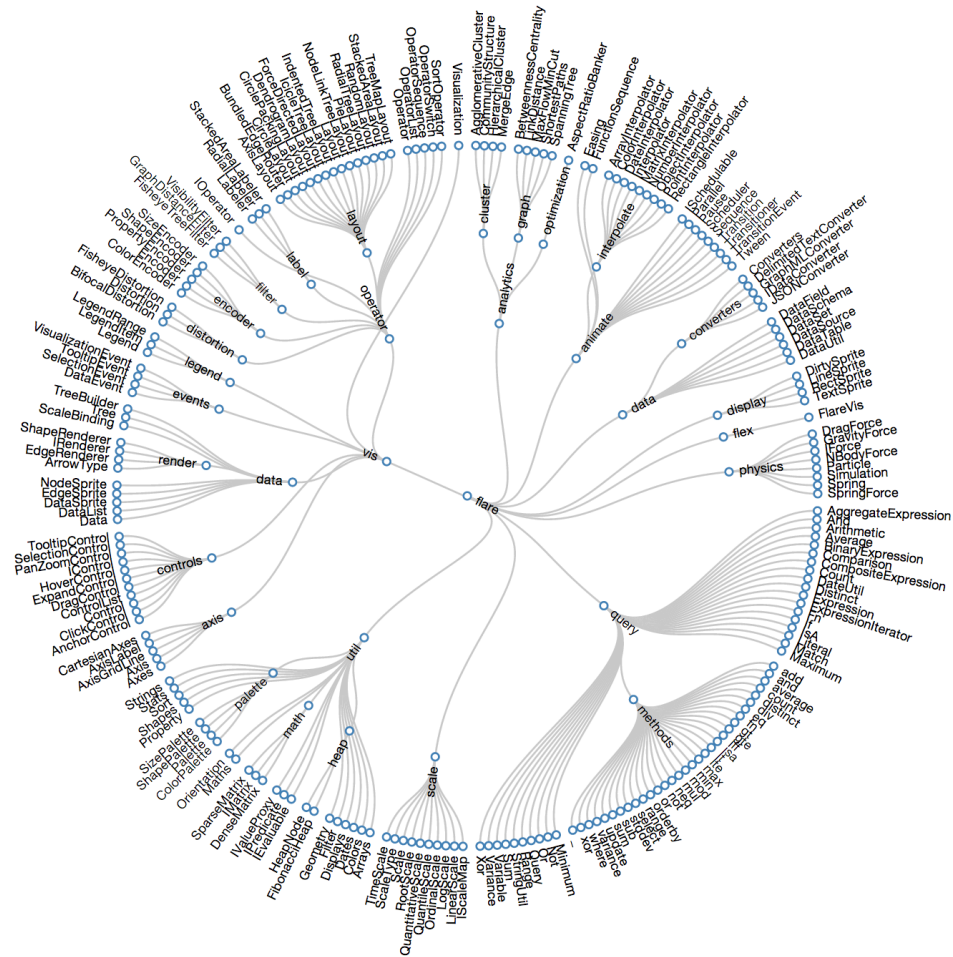
<http://rana.lbl.gov/FuzzyK/Home.htm>

# Circular Layout



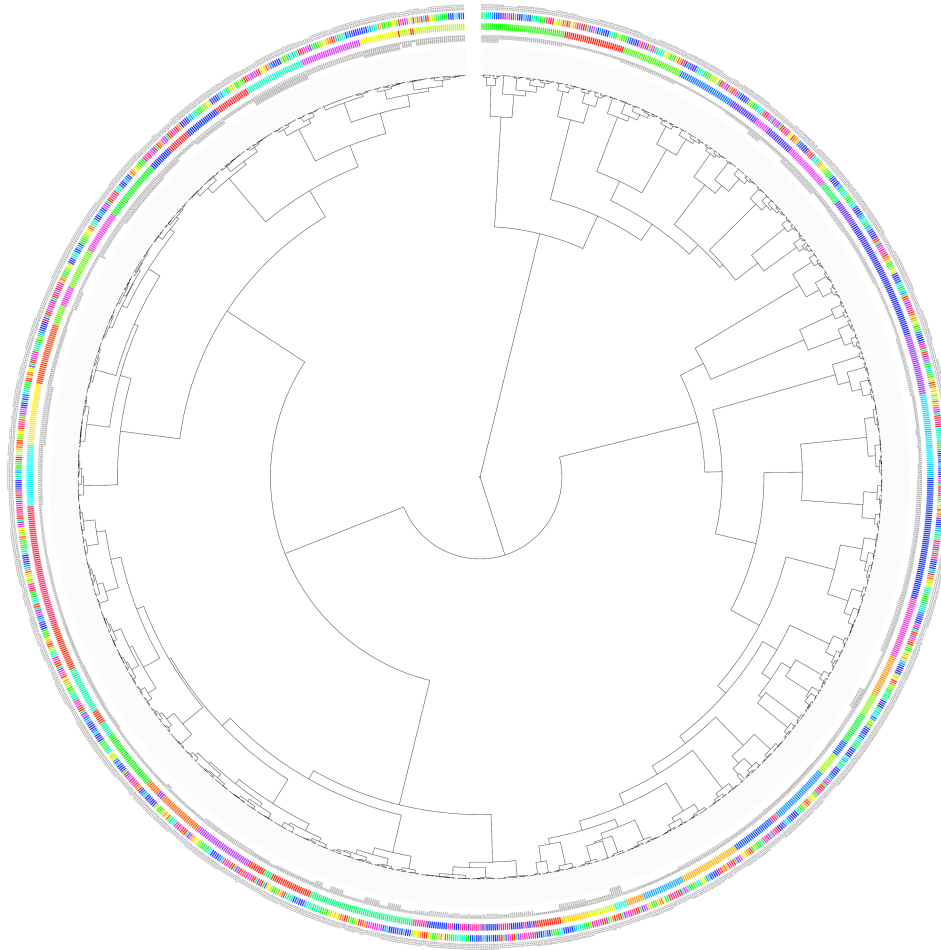
<http://bl.ocks.org/mbostock/4063550>

# Circular Dendrogram



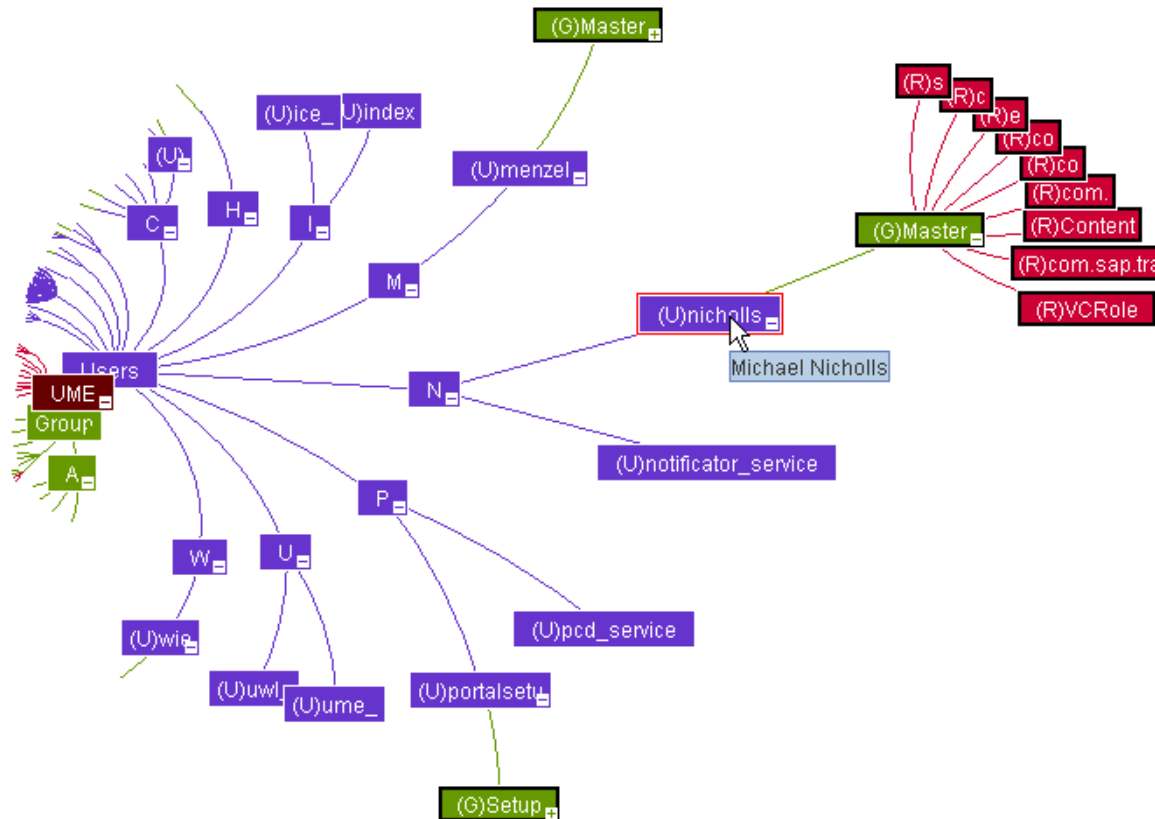
<http://mbostock.github.io/d3/talk/20111018/cluster.html>

# Circular Dendrogram



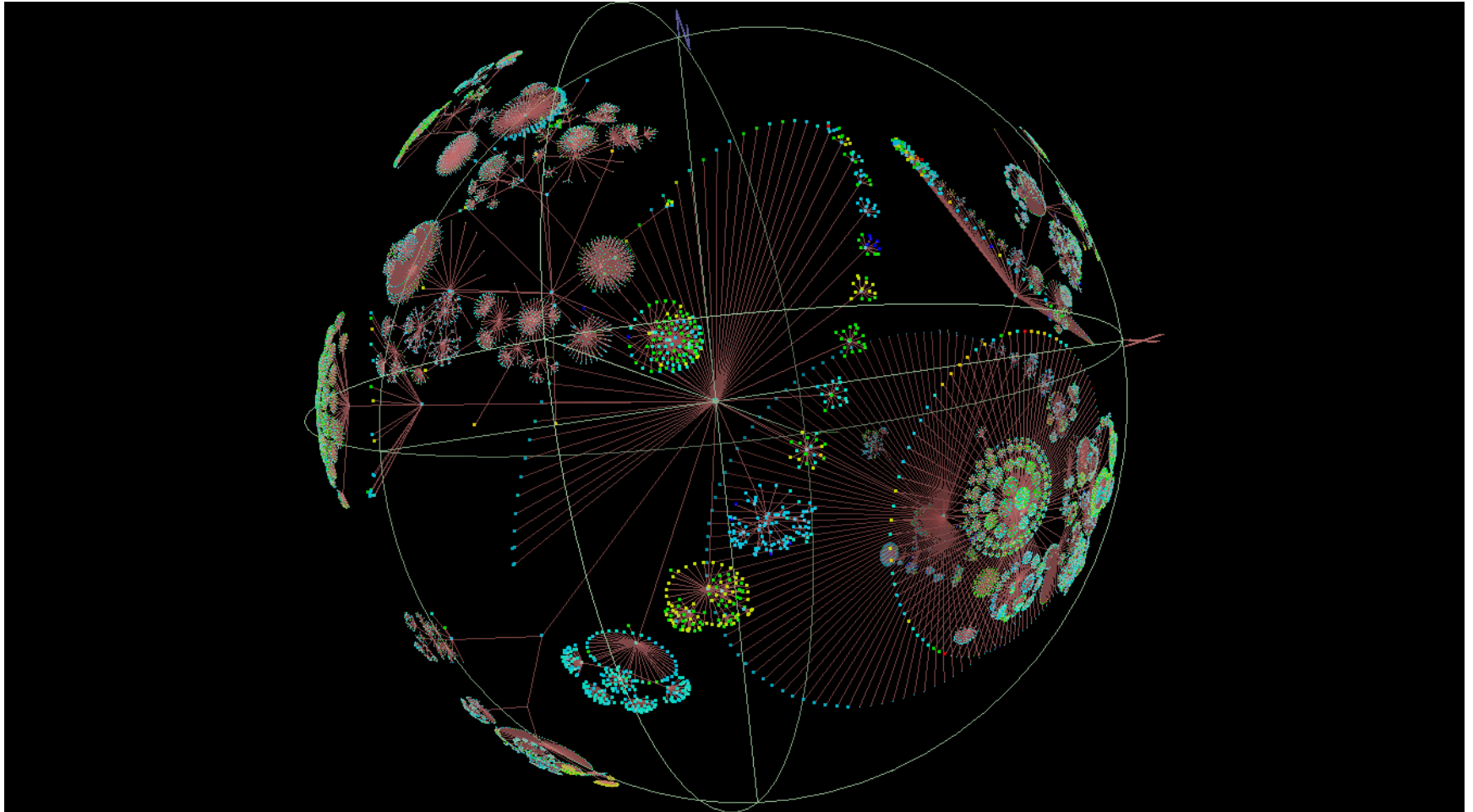
<http://cs.jhu.edu/~razvanm/fs-expedition/2.6.x.html>

# Hyperbolic Tree



<http://wiki.sdn.sap.com/wiki/display/EmTech/StarTree+examples>

# Hyperbolic Tree (3D)



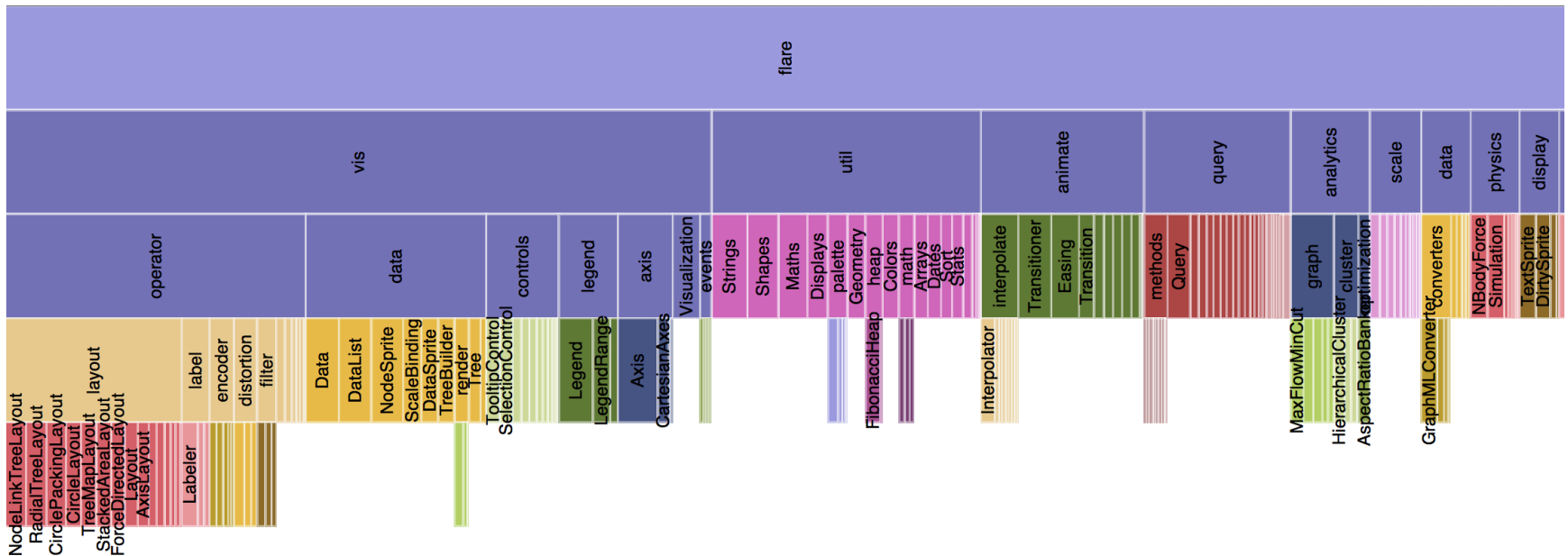
<http://www.caida.org/tools/visualization/walrus/>

# SPACE-FILLING DIAGRAMS

## Tree Visualization



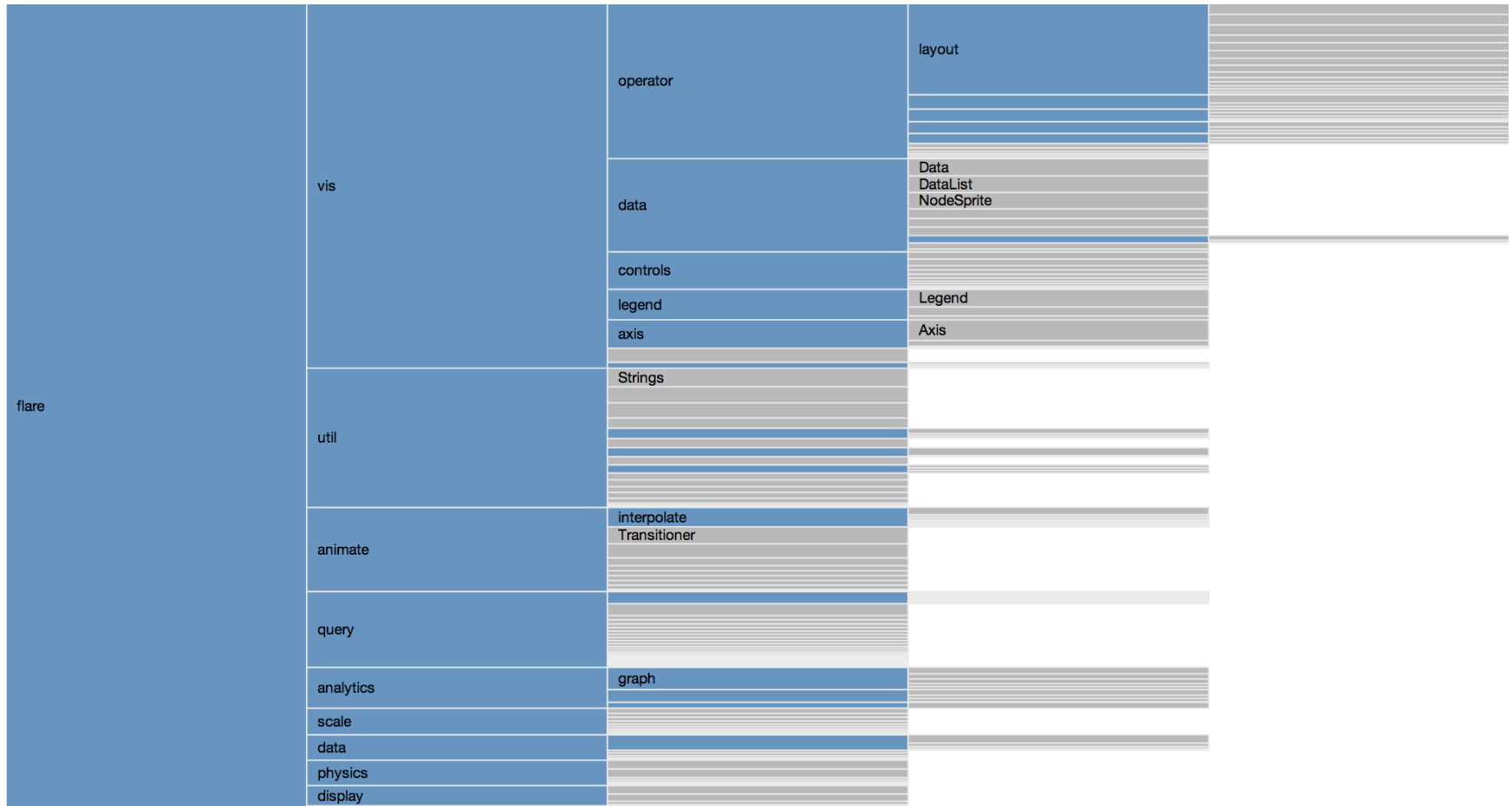
# Icicle Diagram



<http://mbostock.github.io/protovis/ex/icicle.html>



# Icicle Diagram



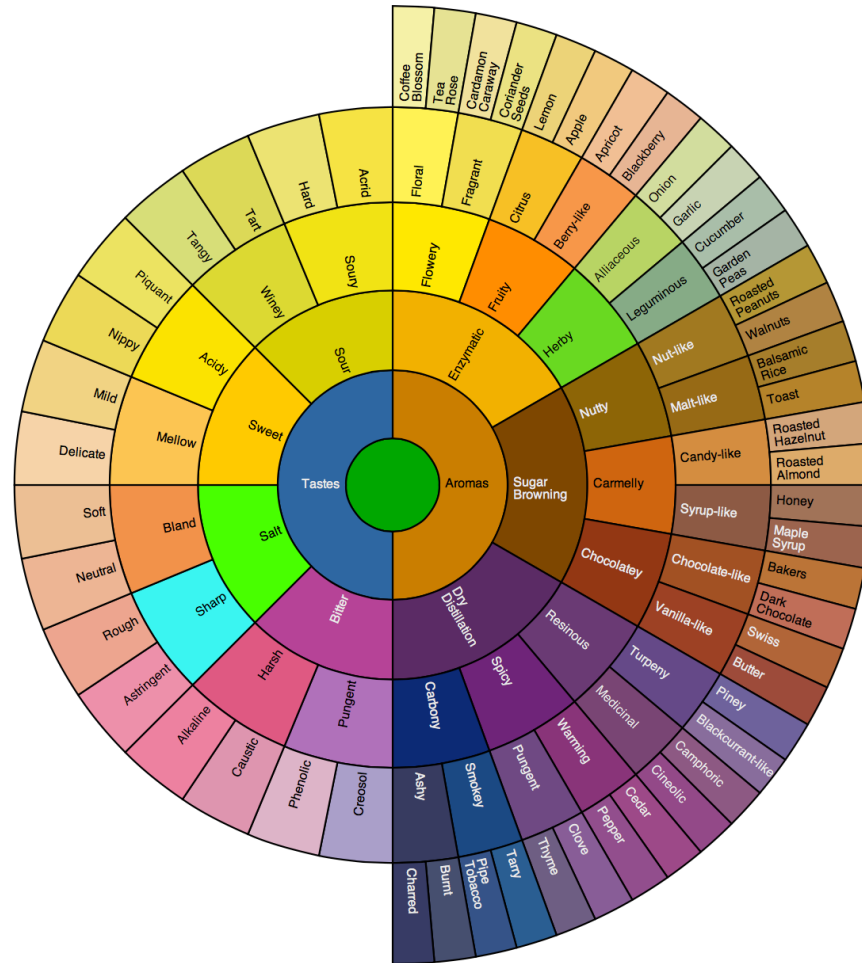
<http://mbostock.github.io/d3/talk/20111018/partition.html>

# Sunburst Diagram



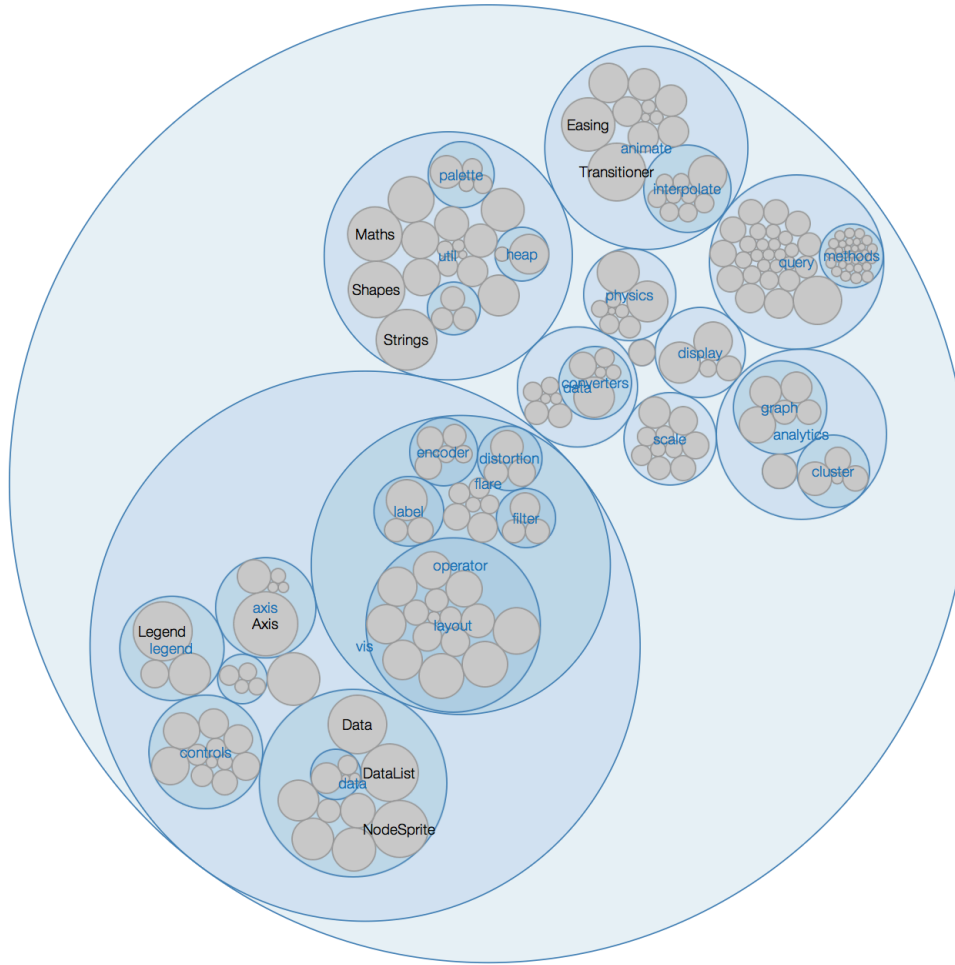
<http://bl.ocks.org/mbostock/4063423>

# Sunburst Diagram



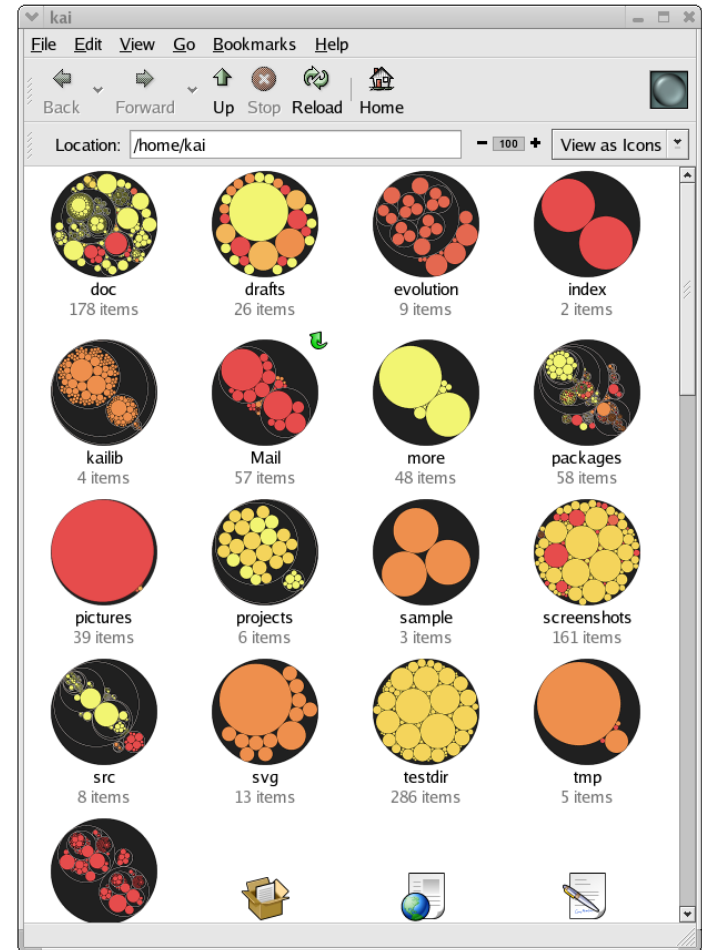
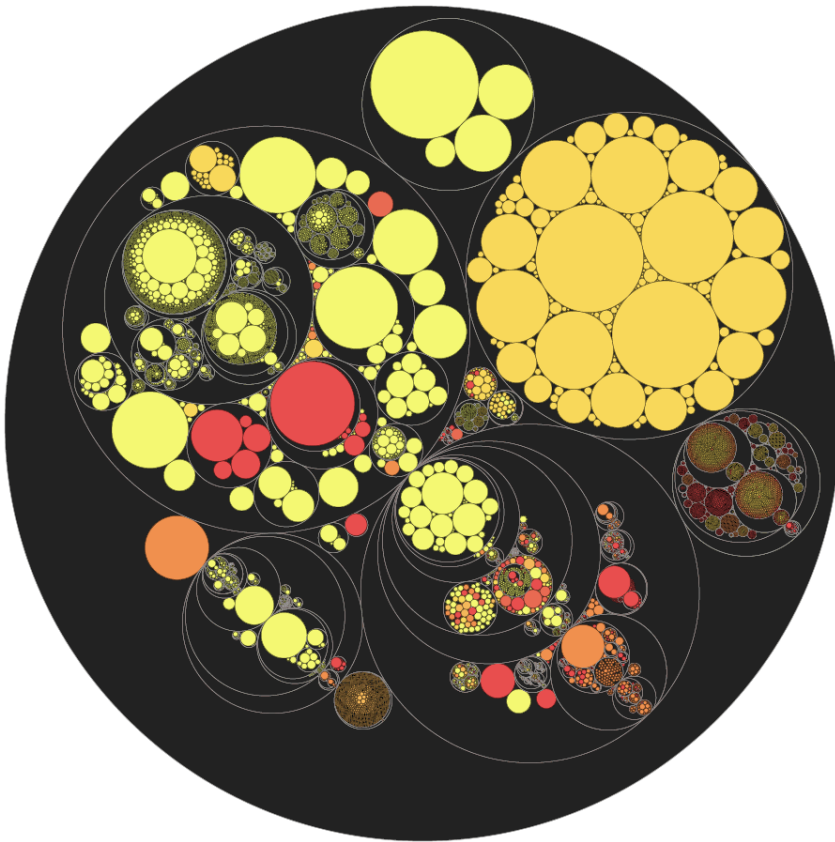
<http://www.jasondavies.com/coffee-wheel/>

# Circle Packing



<http://mbostock.github.io/d3/talk/20111116/pack-hierarchy.html>

# Pebbles File Manager



<http://lip.sourceforge.net/ctreemap.html>

# PRTG Network Monitor



[https://prtg.paessler.com/help/general\\_layout.htm](https://prtg.paessler.com/help/general_layout.htm)

# TREEMAPS

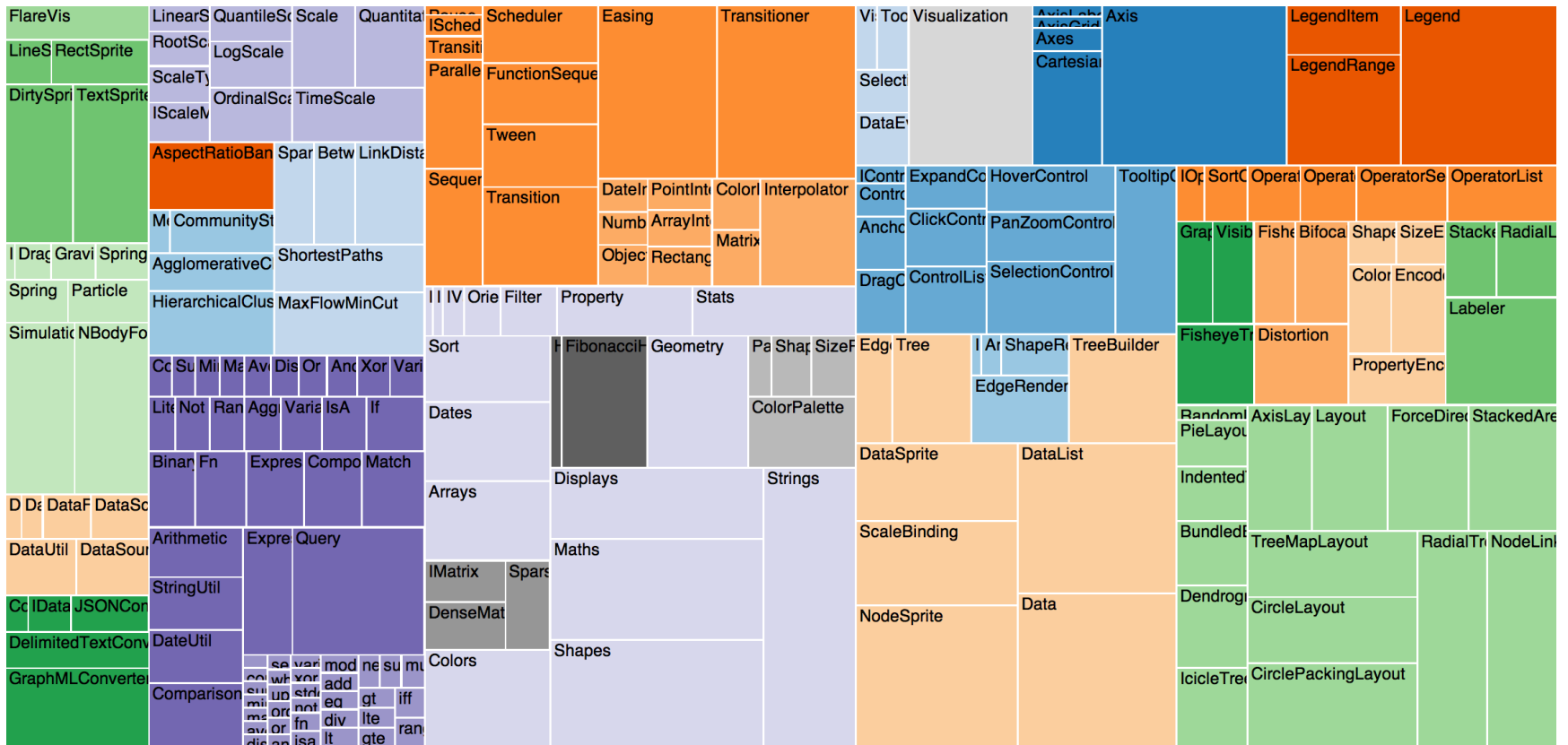
## Space-Filling Diagrams

# Treemaps

- Root is entire rectangle
- Recursively divide rectangles to show levels
- Two common visualization tasks
  - Promote comparison
  - Visualize hierarchy
- Task affects encoding
  - Use of color, outlines, shading, etc.
- See <http://www.cs.umd.edu/hcil/treemap-history/>



# Treemaps



<http://bl.ocks.org/mbostock/4063582>

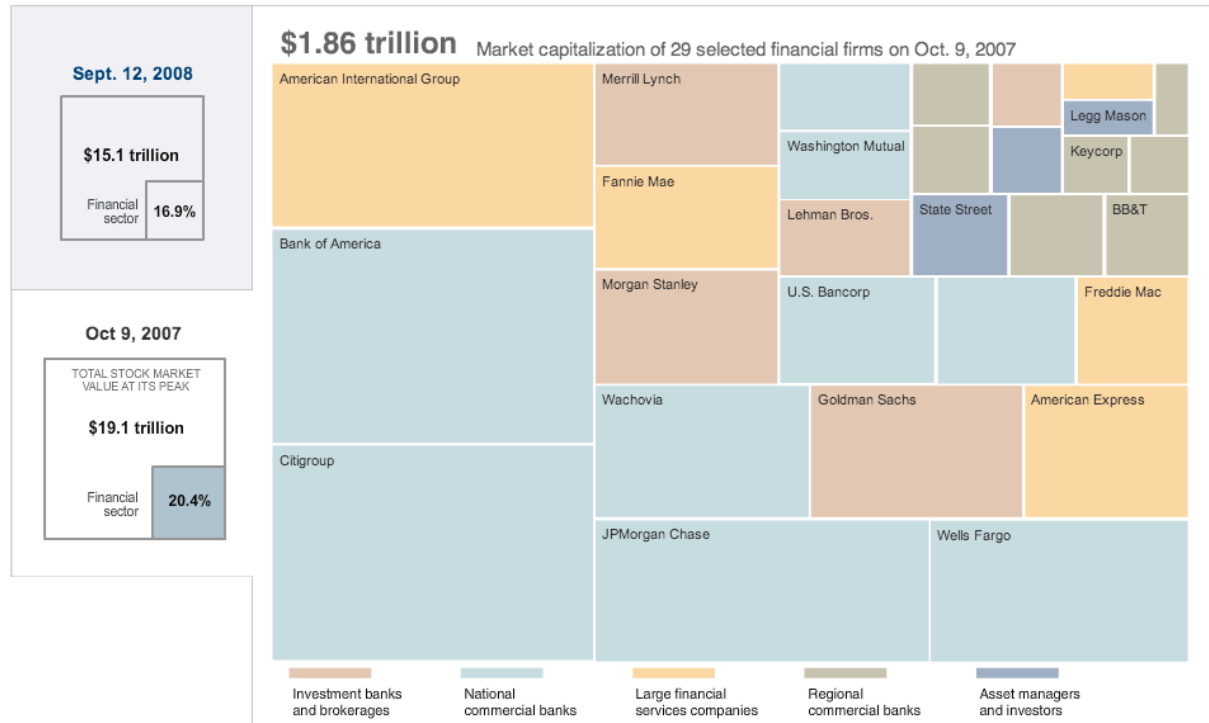
# A Year of Heavy Losses

September 15, 2008

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## A Year of Heavy Losses

A year ago, financial companies were flying high. But as problems in the mortgage and credit markets have grown, the stocks of many Wall Street firms have been hard hit. Some of the biggest companies have been bought out, taken over by the government or gone bankrupt.



These two snapshots of the U.S. stock market and the financial sector are based on the Dow Jones Wilshire 5000 index, the market's broadest measure. Each box represents the market value of one company, which is found by multiplying the number of a company's shares outstanding by its stock price.

Source: Wilshire Associates

Kevin Quealy and Dylan Loeb McClain / The New York Times

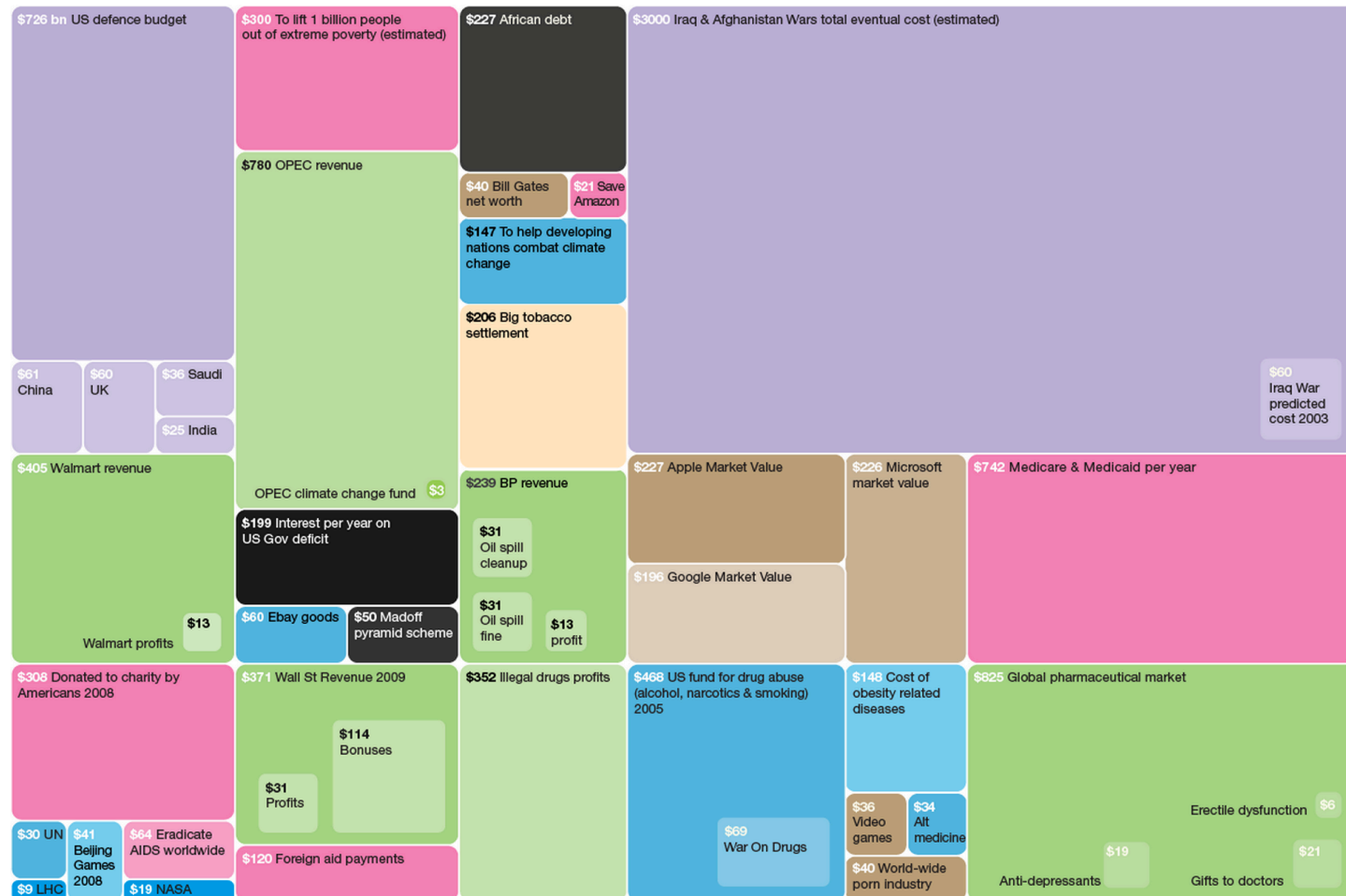
<http://www.nytimes.com/interactive/2008/09/15/business/20080916-treemap-graphic.html>

# How the Giants of Finance Shrank



<http://www.nytimes.com/interactive/2009/09/12/business/financial-markets-graphic.html>

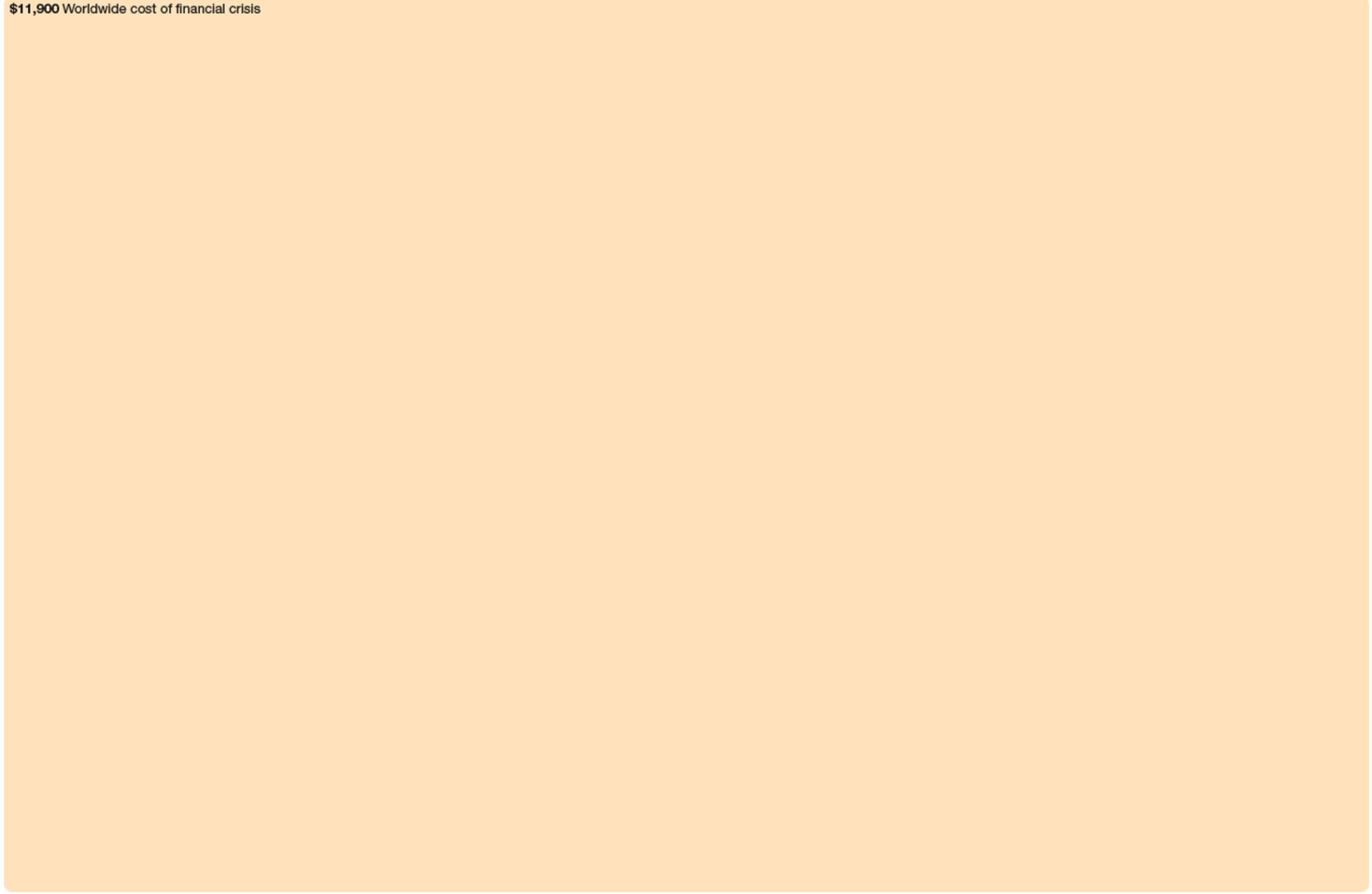
# Billion-Dollar-O-Gram



<http://www.informationisbeautiful.net/visualizations/the-billion-dollar-o-gram-2009/>

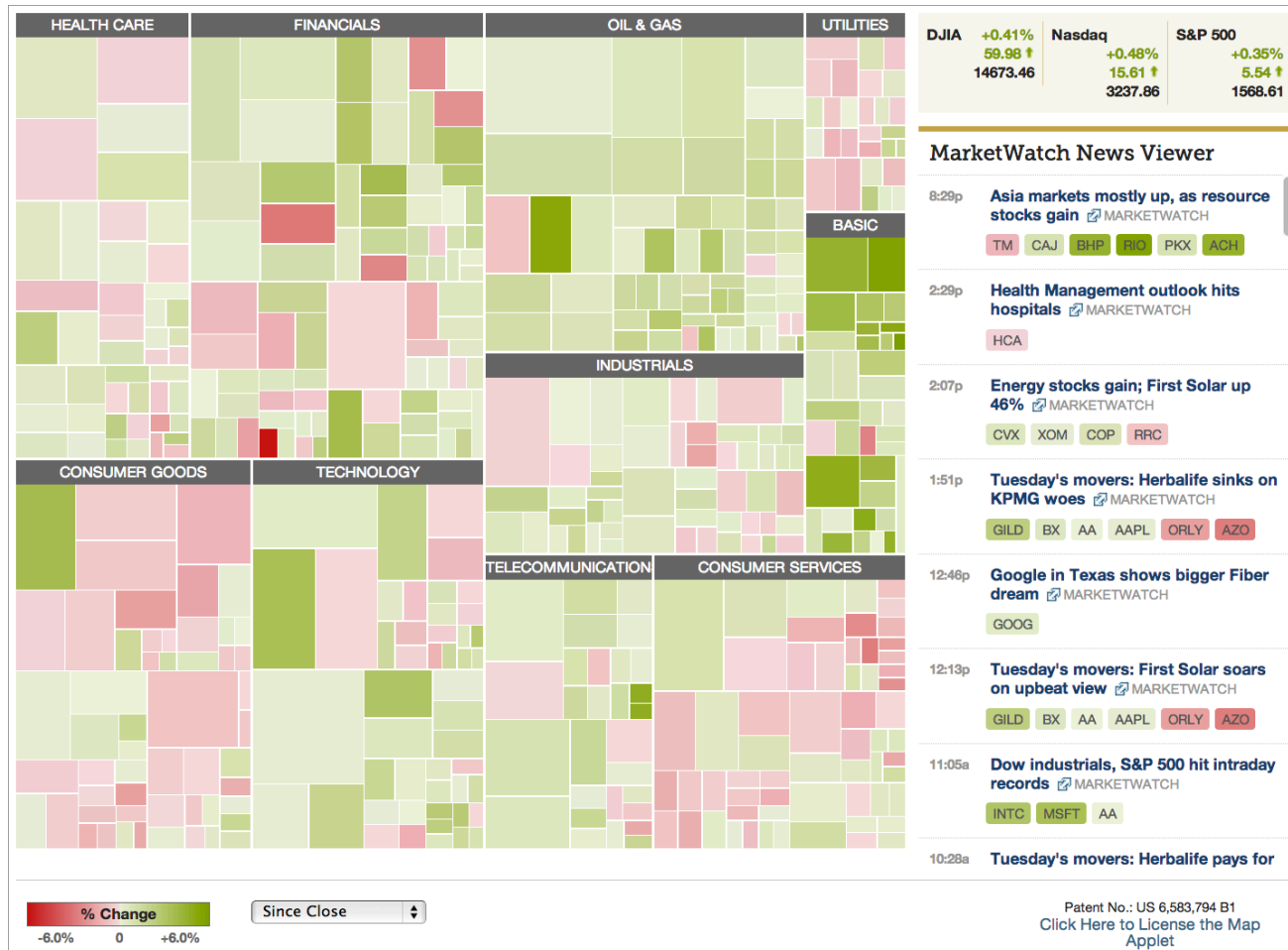
# Billion-Dollar-O-Gram

\$11,900 Worldwide cost of financial crisis



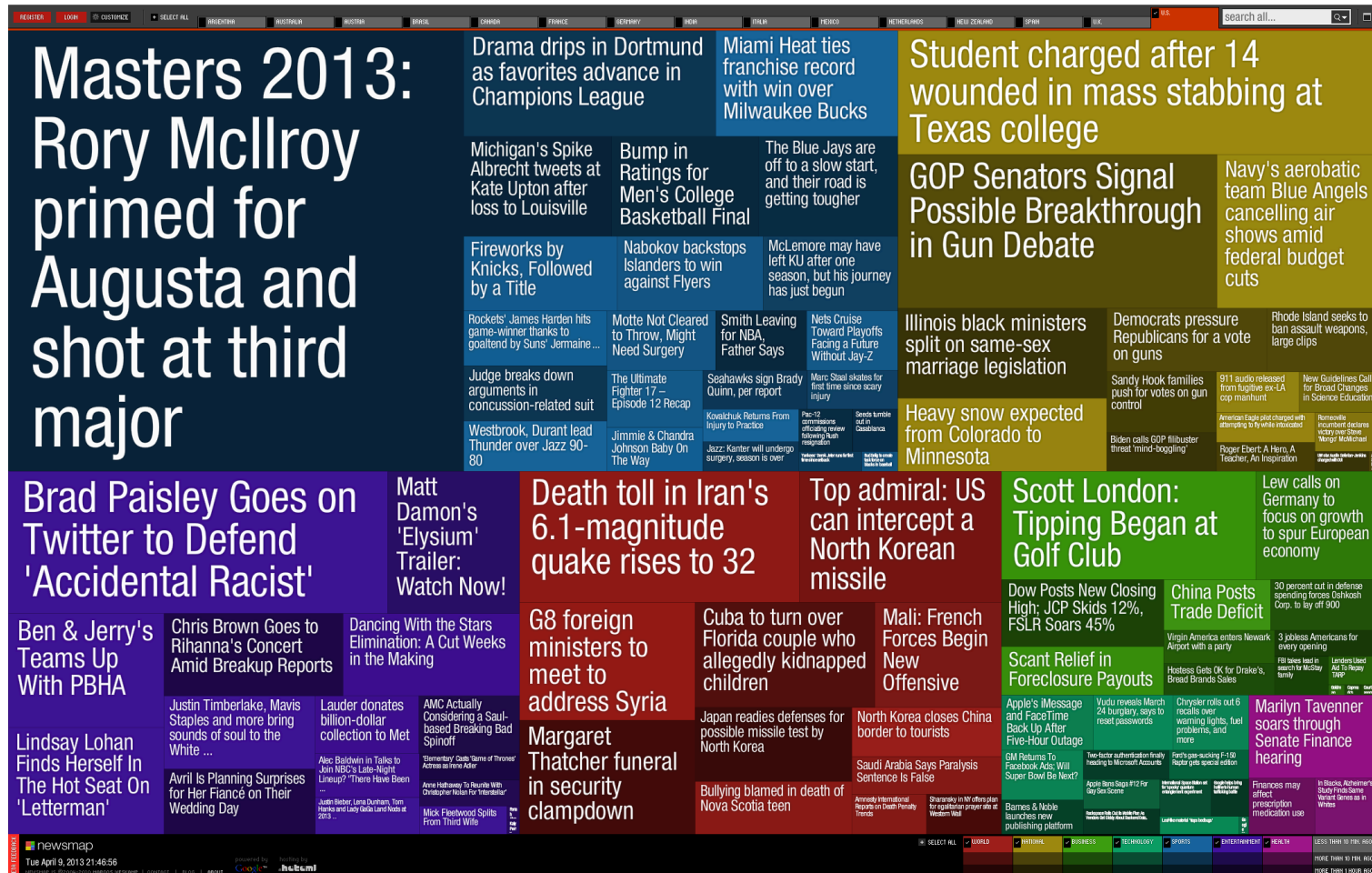
<http://www.informationisbeautiful.net/visualizations/the-billion-dollar-o-gram-2009/>

# Map of the Market



<http://www.smartmoney.com/map-of-the-market/>

# News Map



<http://newsmap.jp/>

# Cushion Treemap

## Cushion TreeMaps

In this example a static JSON tree is loaded into a Cushion Treemap.

**Left click** to set a node as root for the visualization.

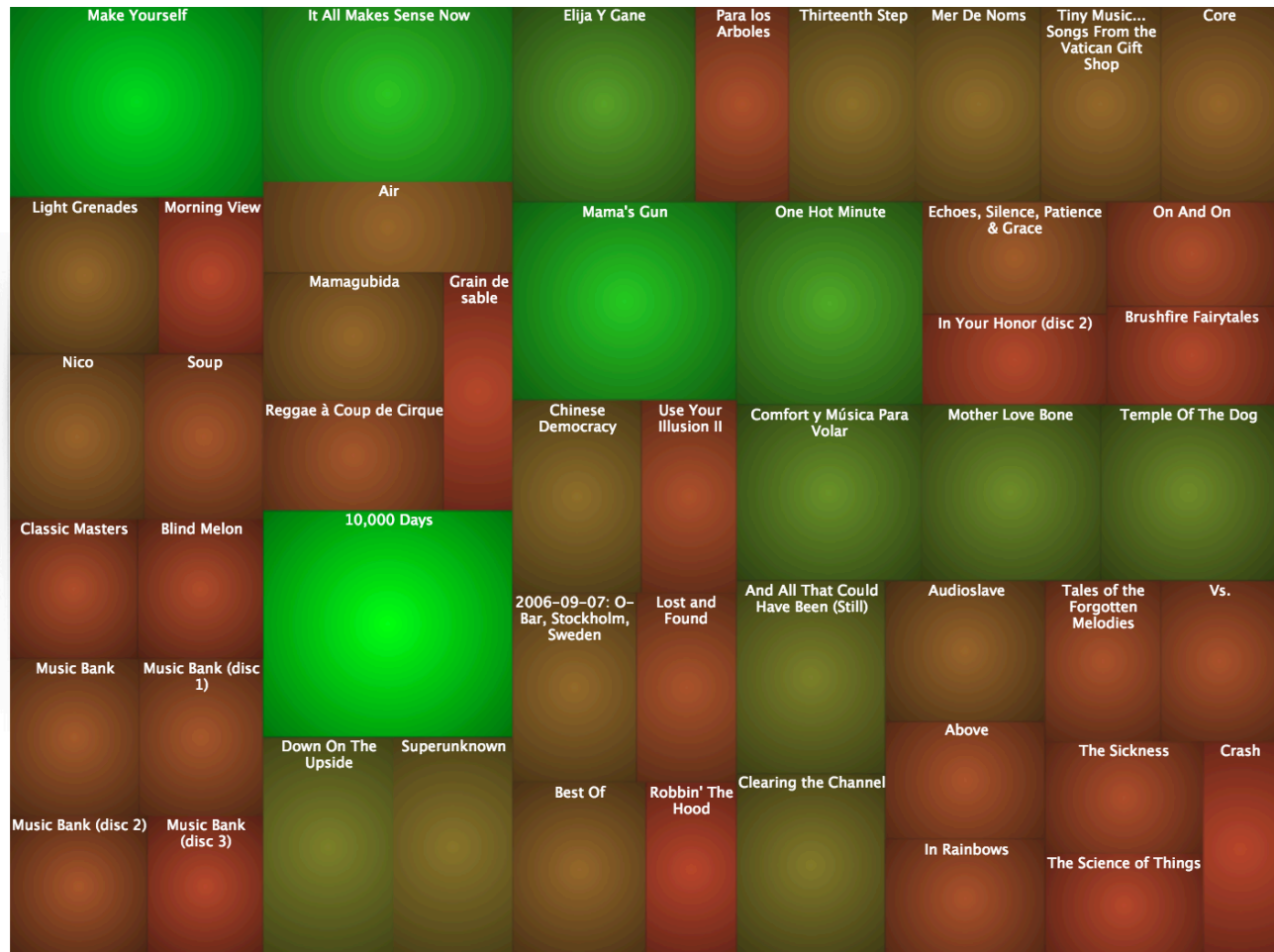
**Right click** to set the parent node as root for the visualization.

You can choose a different tiling algorithm below:

Squarified ☒  
Strip ☐  
SliceAndDice ☐

Go to Parent

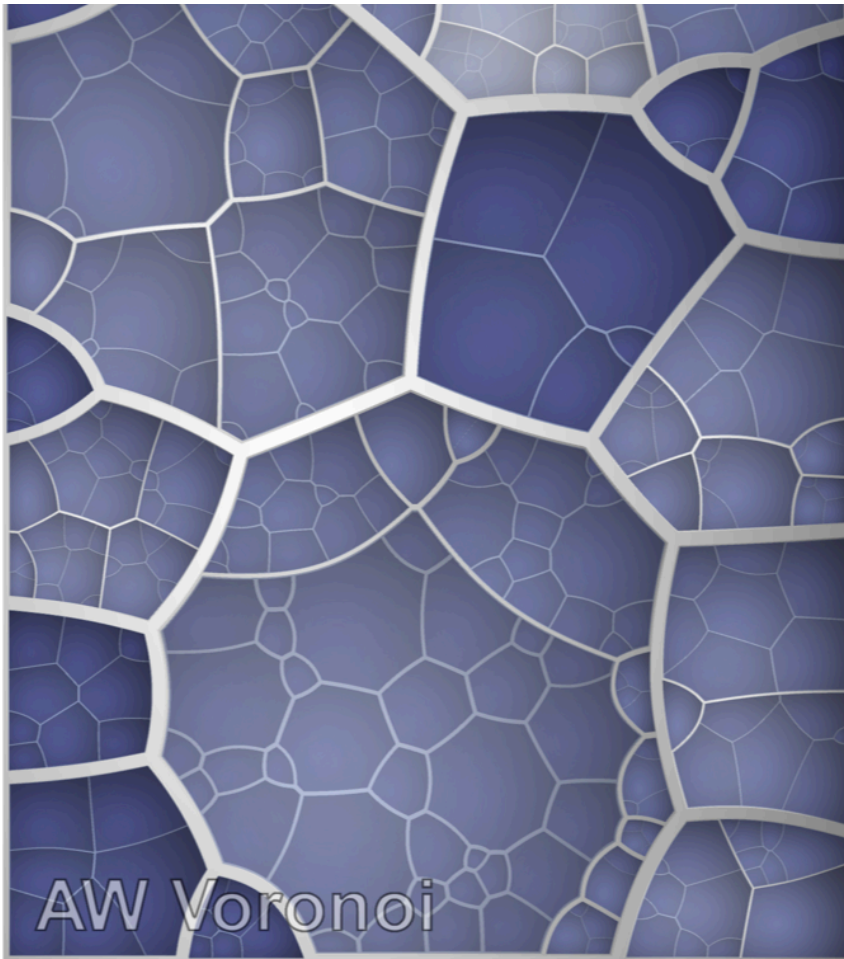
[See the Example Code](#)



<http://philogb.github.io/jit/static/v20/Jit/Examples/Treemap/example3.html>

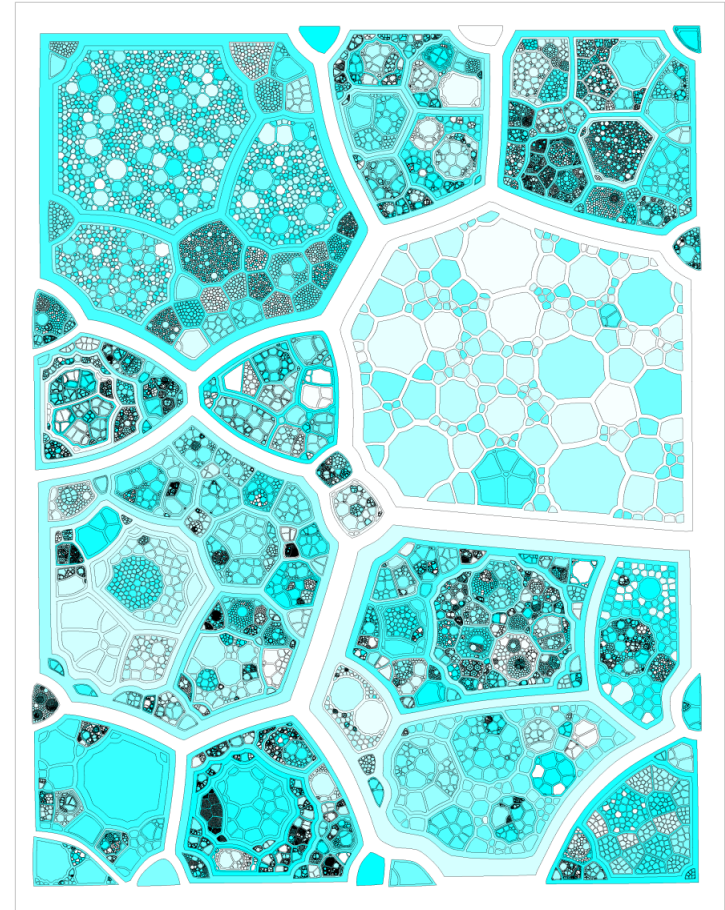
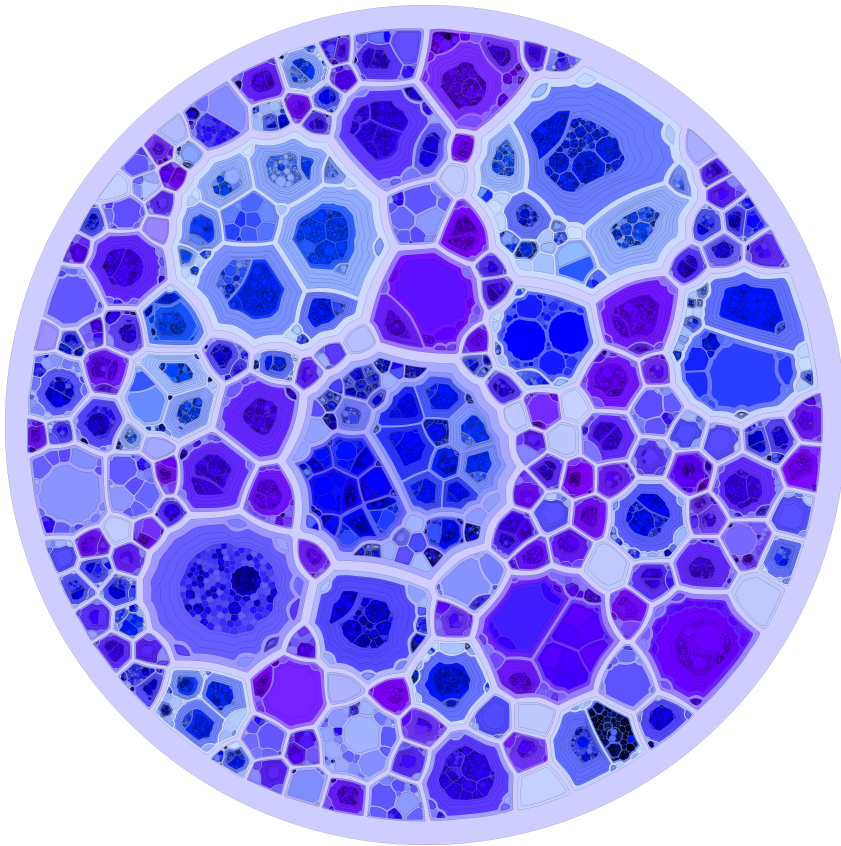


# Voronoi Treemaps



<http://www.informatik.uni-konstanz.de/en/deussen/publications/>

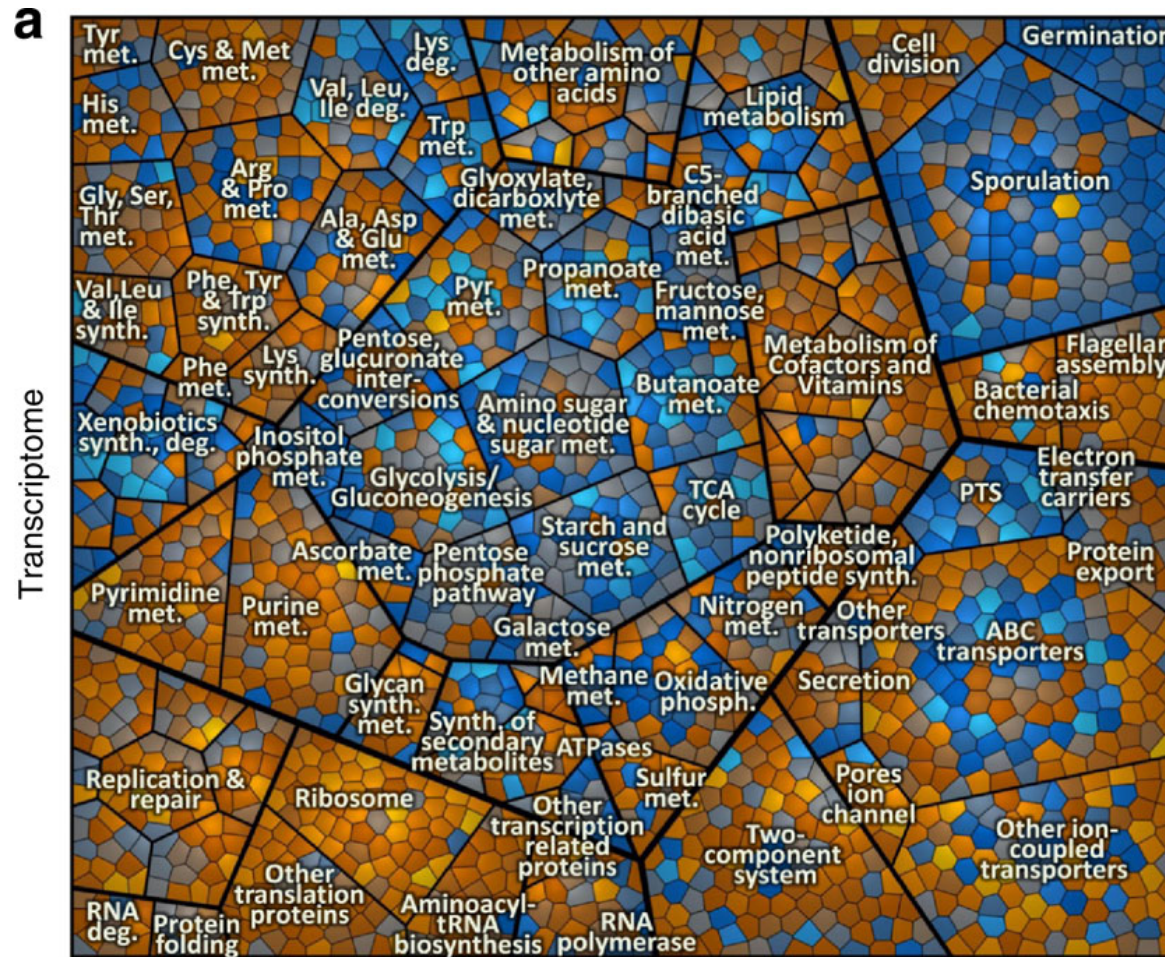
# Voronoi Treemaps



<http://graphics.uni-konstanz.de/~deussen/php/voronoitreemaps.php>



# KEGG-Orthology Treemap



<http://www.nature.com/ncomms/journal/v1/n9/full/ncomms1137.html>

# All of Inflation's Little Parts

🔍 ZOOM IN

🔍 ZOOM OUT

## Food and beverages 15%

The high price of oil is a factor that has made food prices rise quickly.

## Miscellaneous 3%

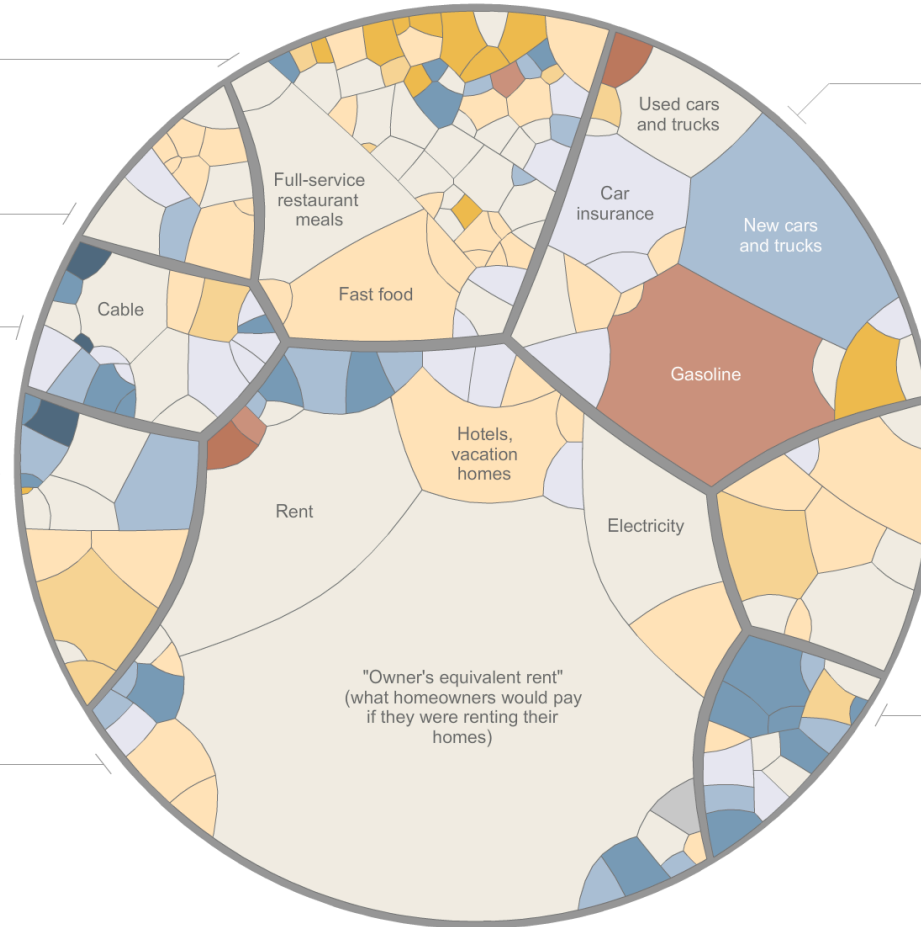
## Recreation 6%

## Education/Communication 6%

Cellphones were added to the index in 1997. Because the Consumer Price Index can be slow to add new goods, which are often cheaper, it may overstate parts of inflation.

## Housing 42%

In the C.P.I., home ownership costs track rent prices more closely than housing prices. This means inflation may have been understated when home prices were rising faster than rents.



## Transportation 18%

Gas is 5.2 percent of spending nationwide, but only 3.8 percent in the New York area.

## Health care 6%

As a group, the elderly spend about twice as much of their budget on medical care.

## Apparel 4%

The ratio of spending on women's clothes to that on men's clothes is about 2 to 1.

[http://www.nytimes.com/interactive/2008/05/03/business/20080403\\_SPENDING\\_GRAPHIC.html](http://www.nytimes.com/interactive/2008/05/03/business/20080403_SPENDING_GRAPHIC.html)

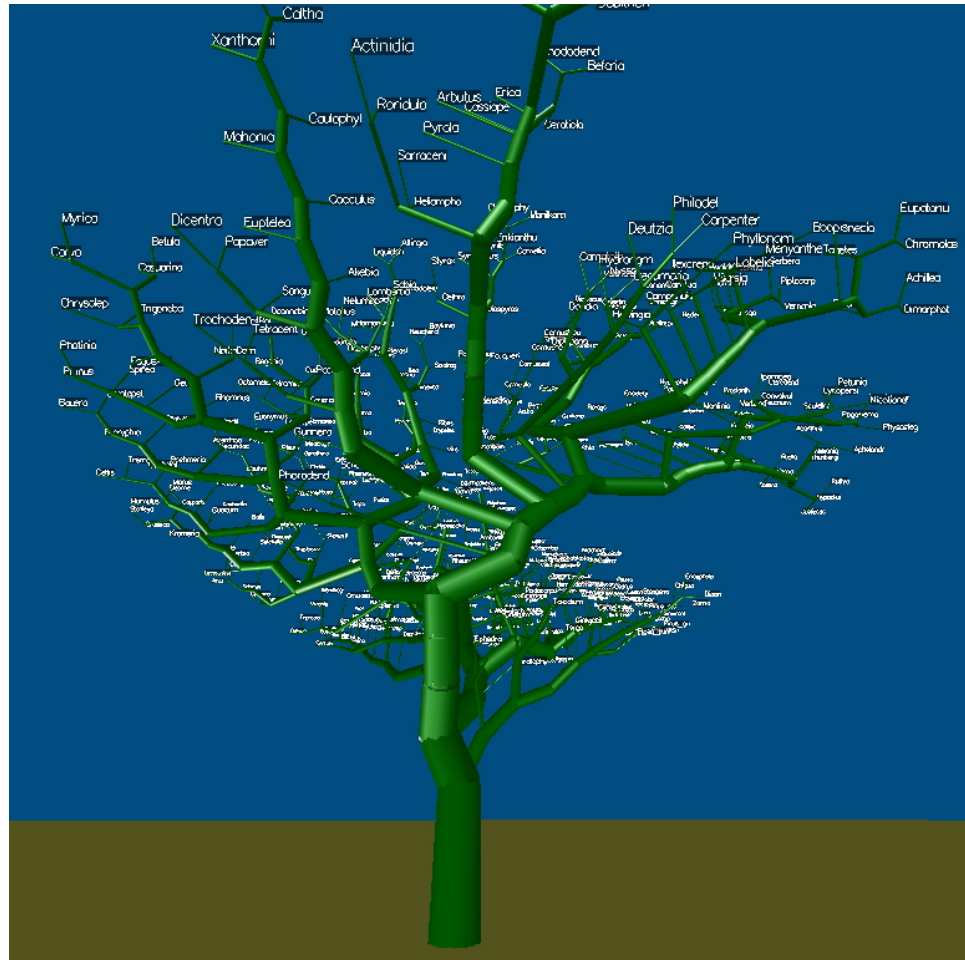
# TREE OF LIFE

## Case Study

# Tree of Life

- Specifically **phylogenetic** tree of life
  - Evolutionary tree, showing where species branch
- Can be thousands to tens of thousands of nodes
- Many tools for the ToL exist using different visualization techniques
- See <http://tolweb.org/tree/phylogeny.html>

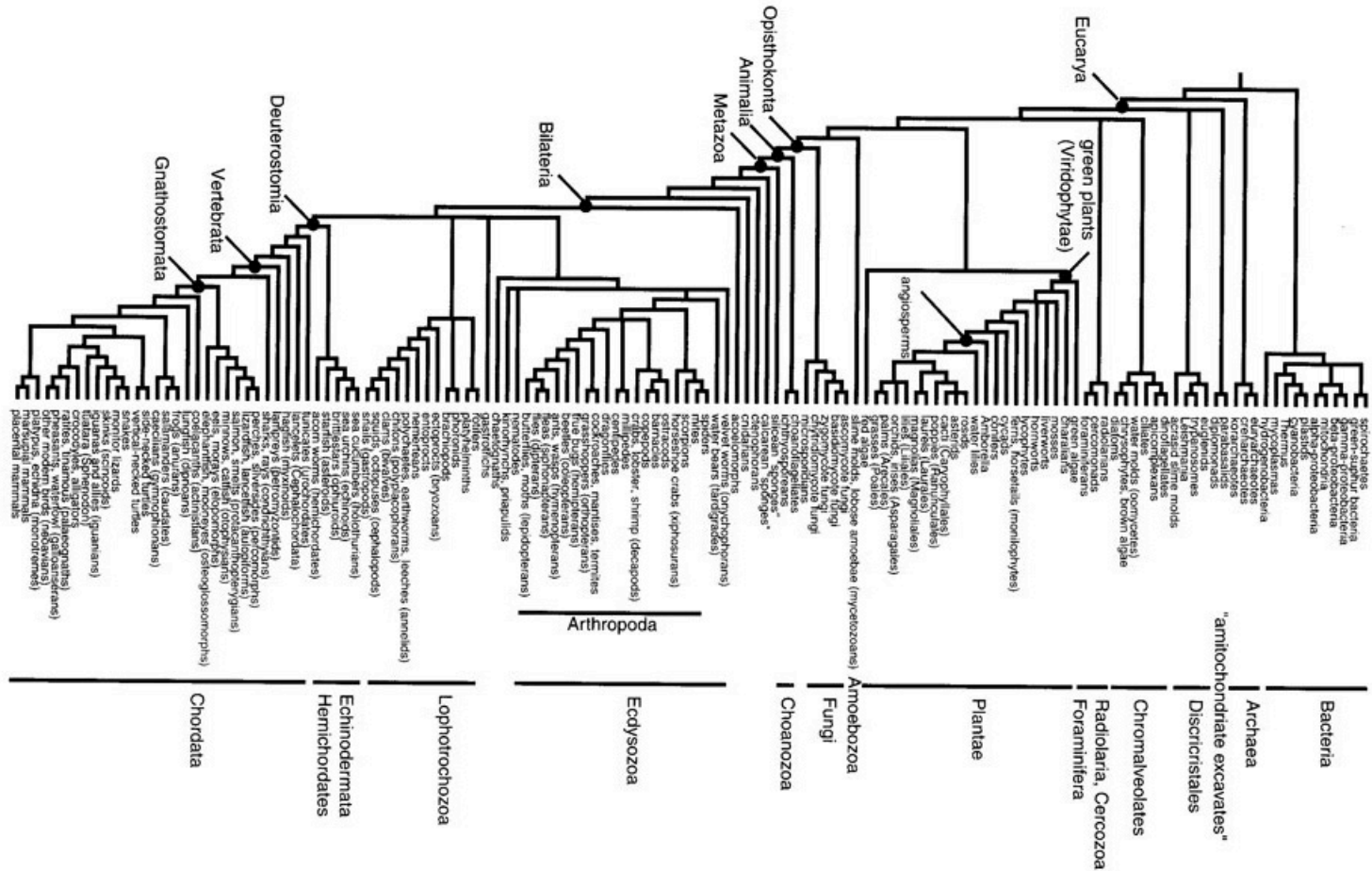
# Paloverde



<http://loco.biosci.arizona.edu/paloverde/paloverde.html>



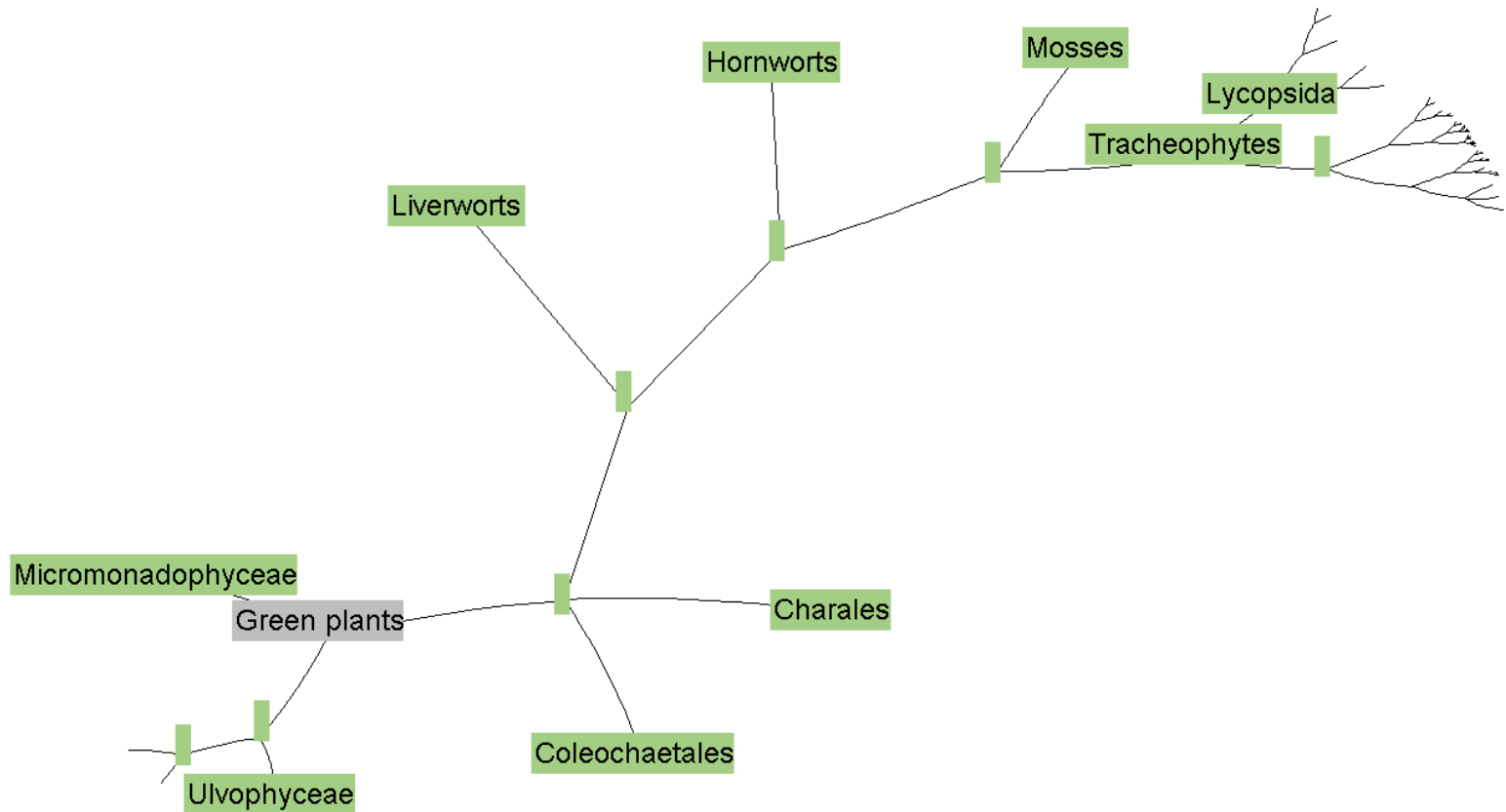
# Teachable ToL



<http://www.rebeccashapley.com/cipres/telescoping.htm>

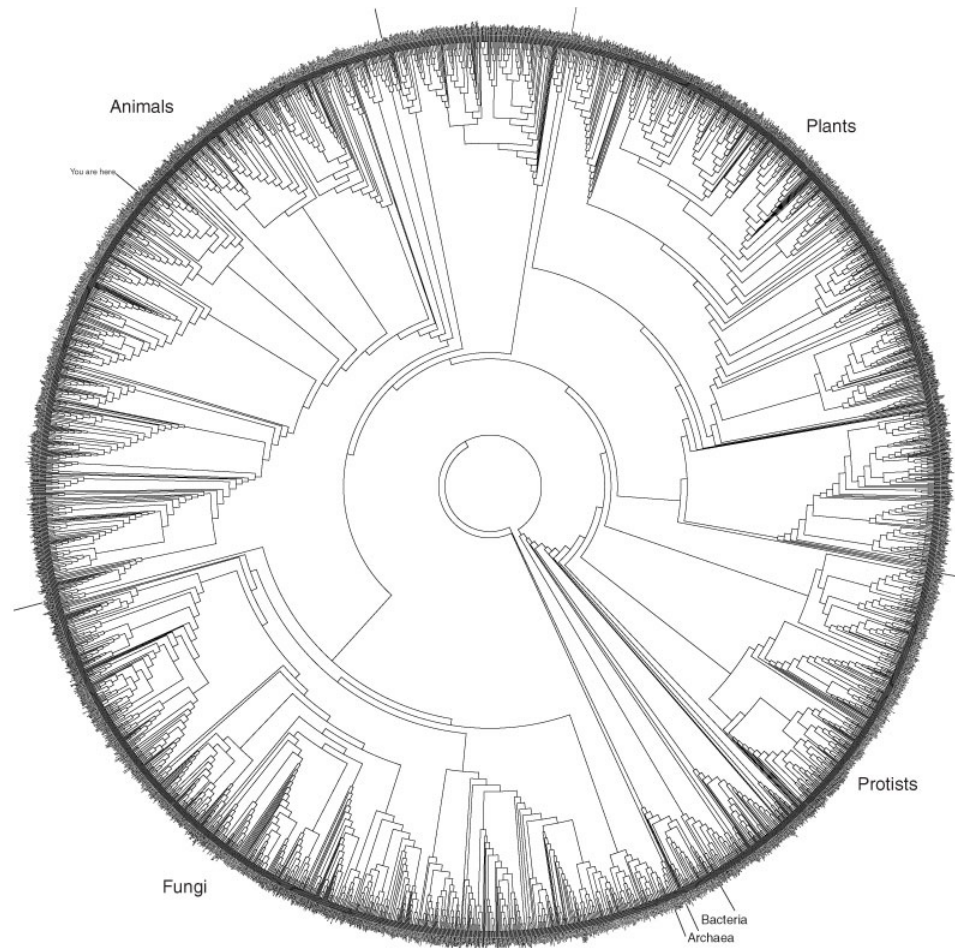


# Hyperbolic ToL (Plants Only)



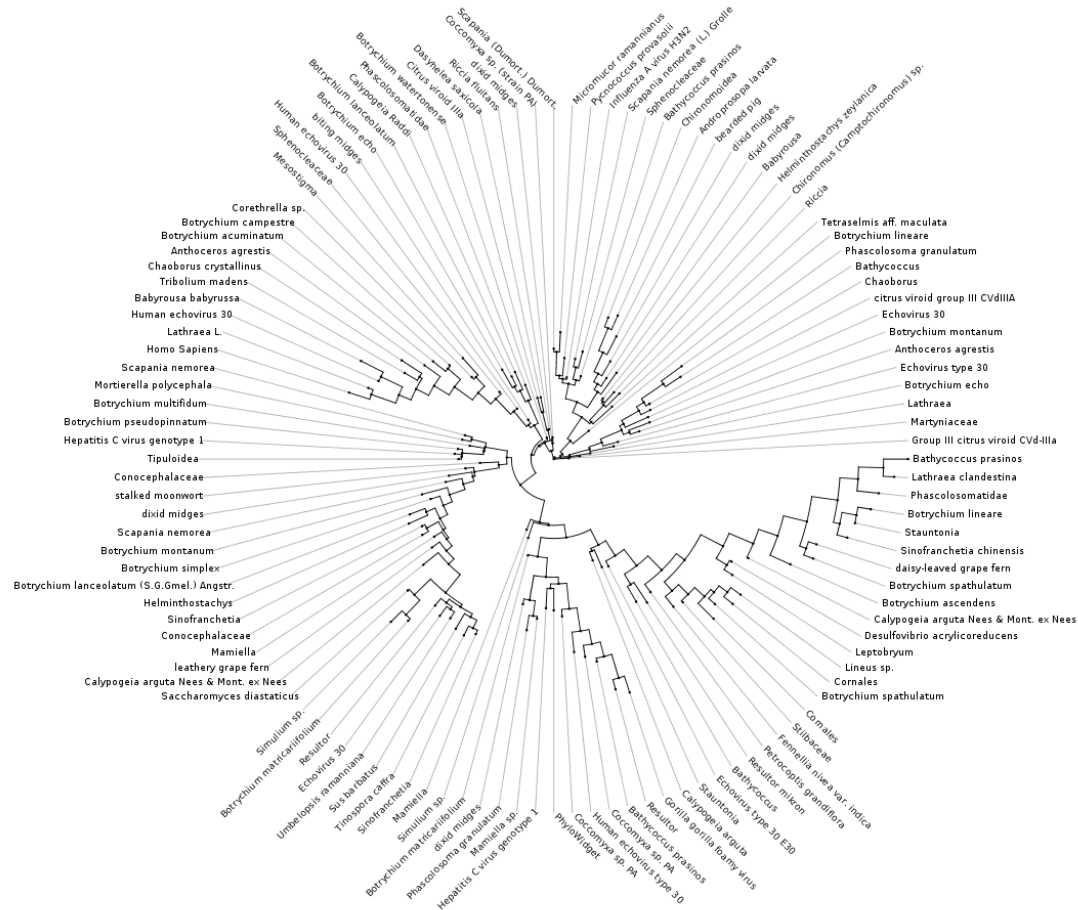
<http://ucjeps.berkeley.edu/TreeofLife/hyperbolic.php>

# Subset of 3,000 Species



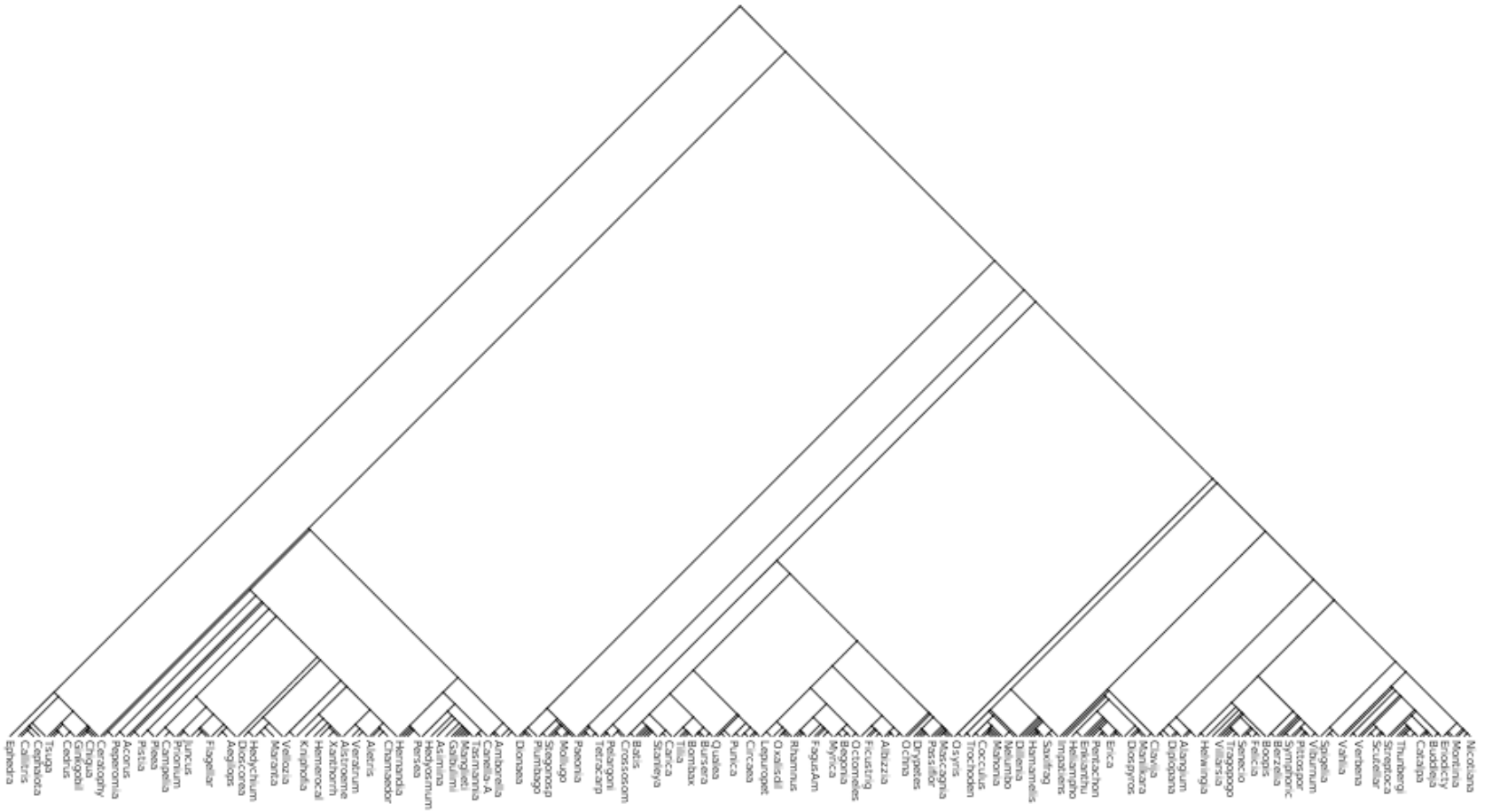
<http://www.zo.utexas.edu/faculty/antisense/DownloadfilesToL.html>

# PhyloWidget



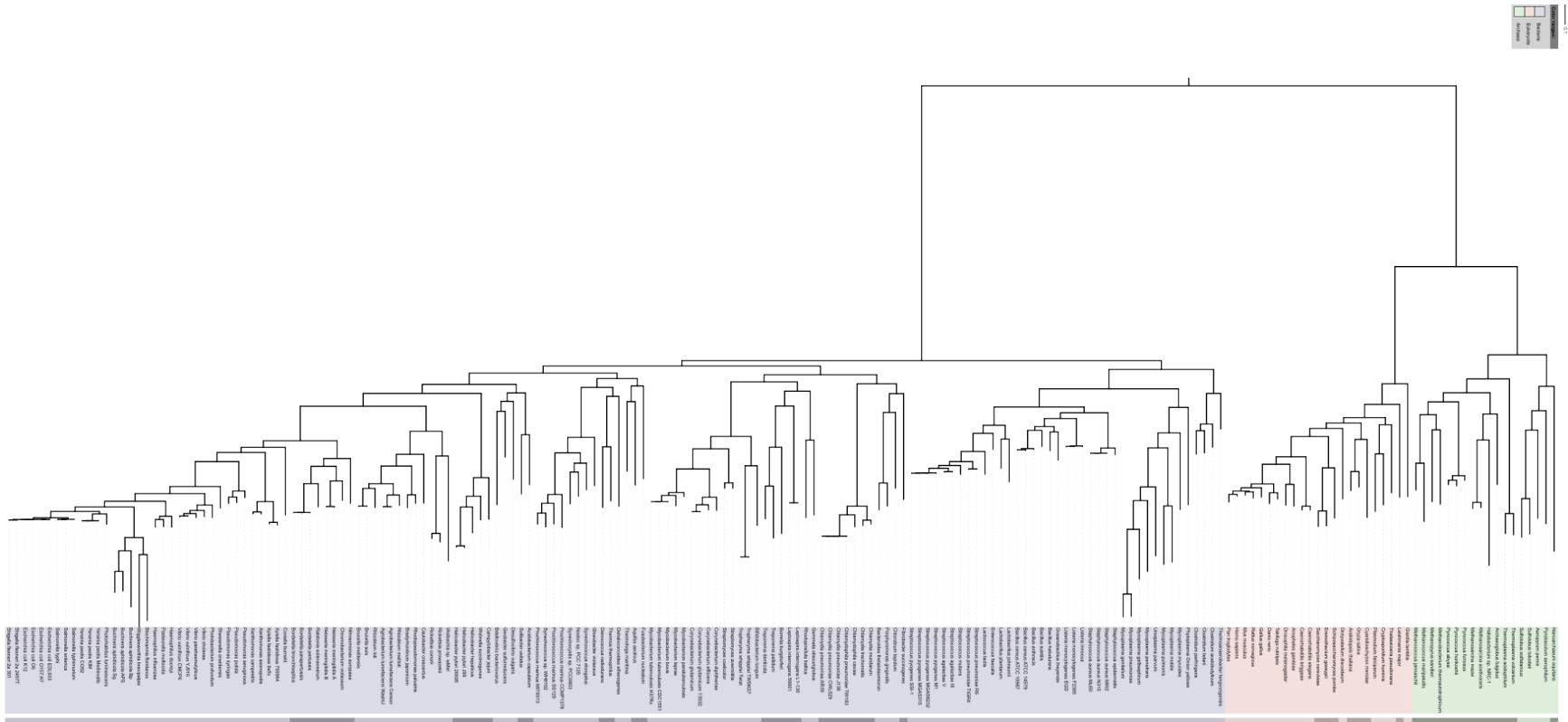
<http://www.phylowidget.org/>

# PhyloWidget



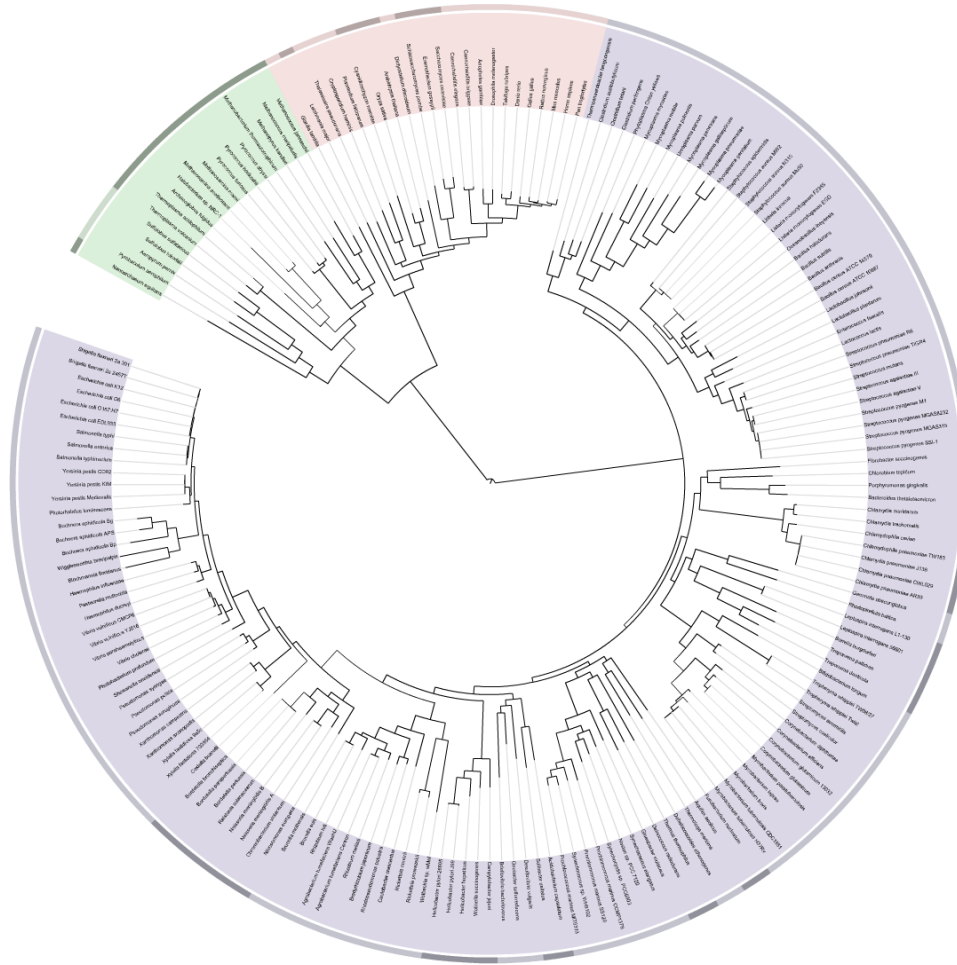
<http://www.phylowidget.org/>

# Interactive ToL



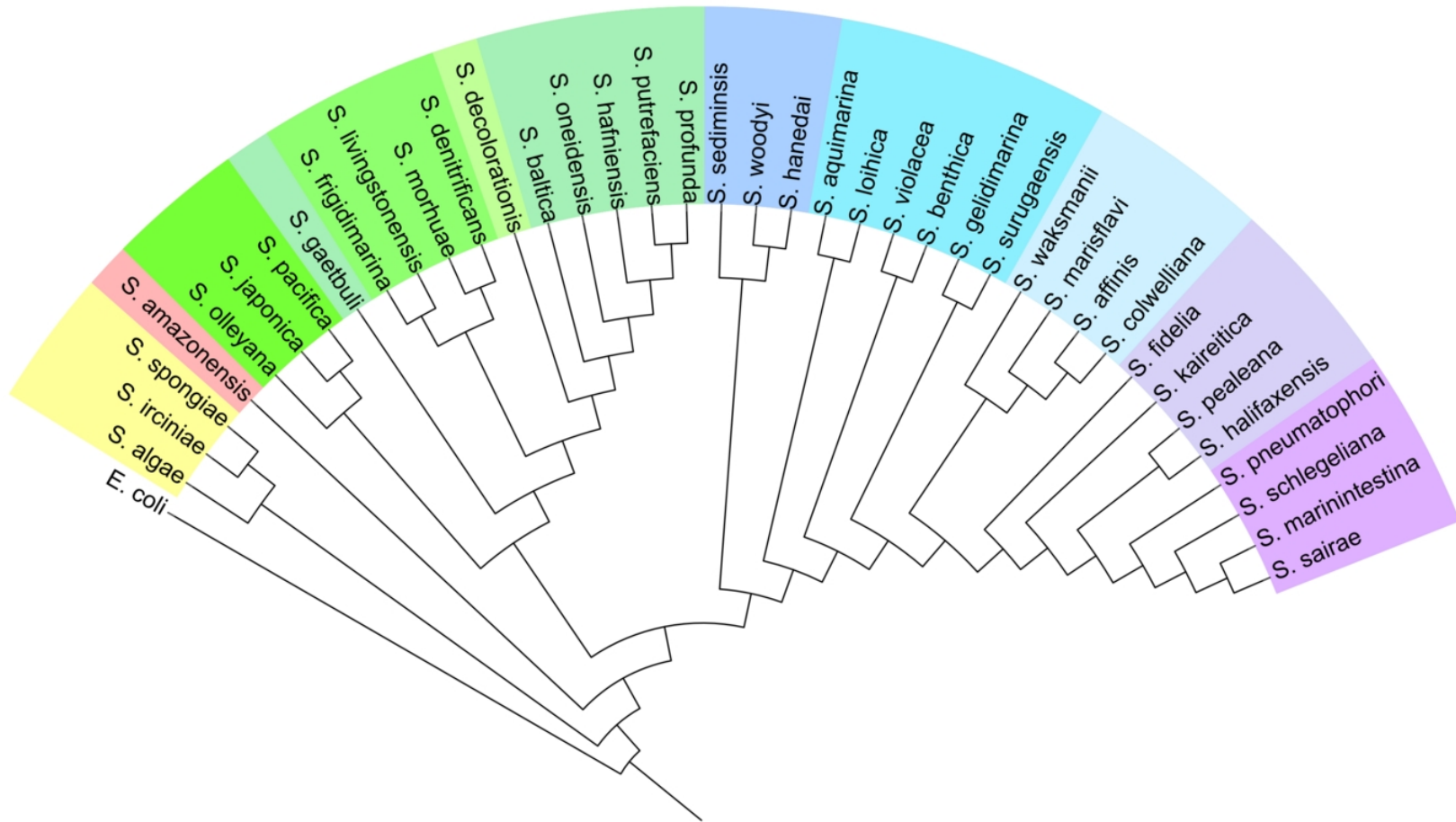
<http://itol.embl.de/>

# Interactive ToL



<http://itol.embl.de/>

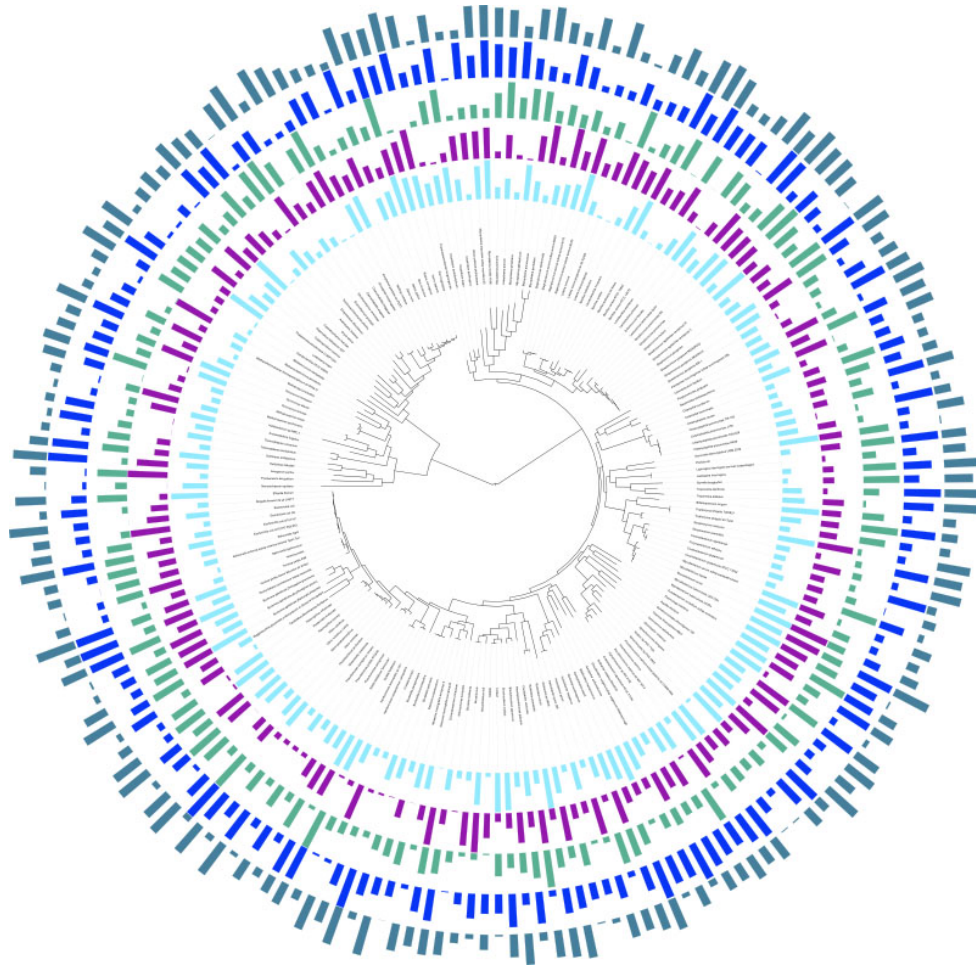
# Iterative ToL



<http://itol.embl.de/>



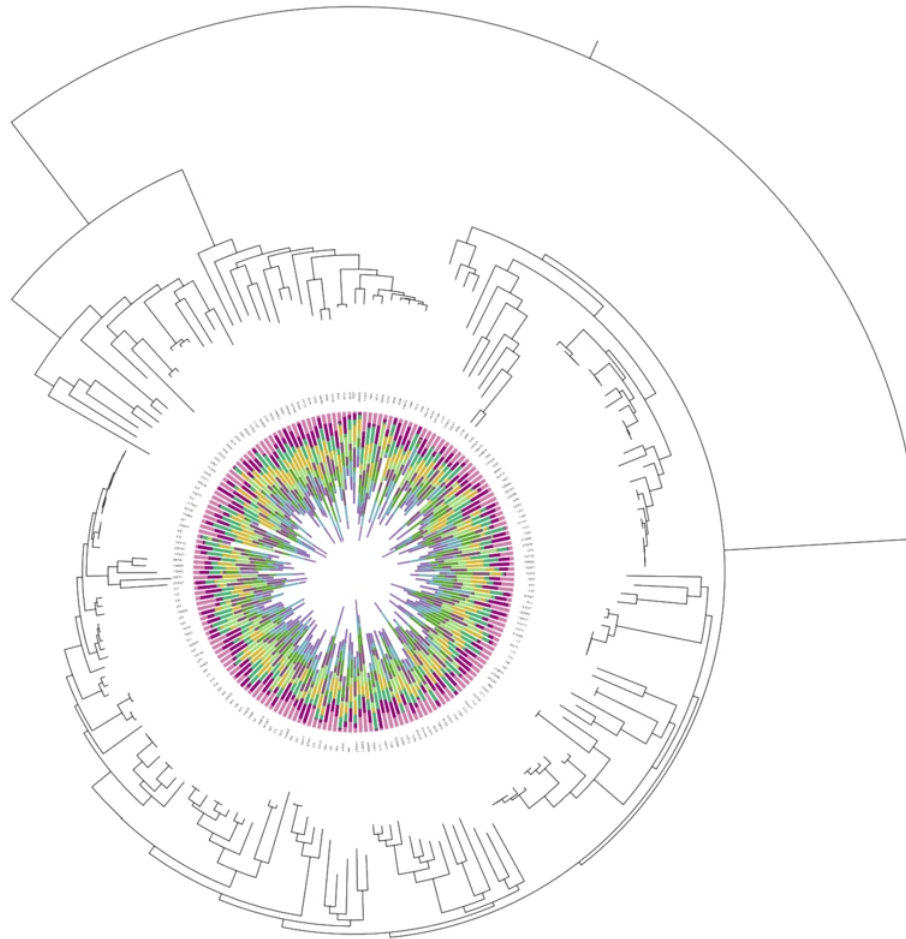
# Interactive ToL



<http://itol.embl.de/>

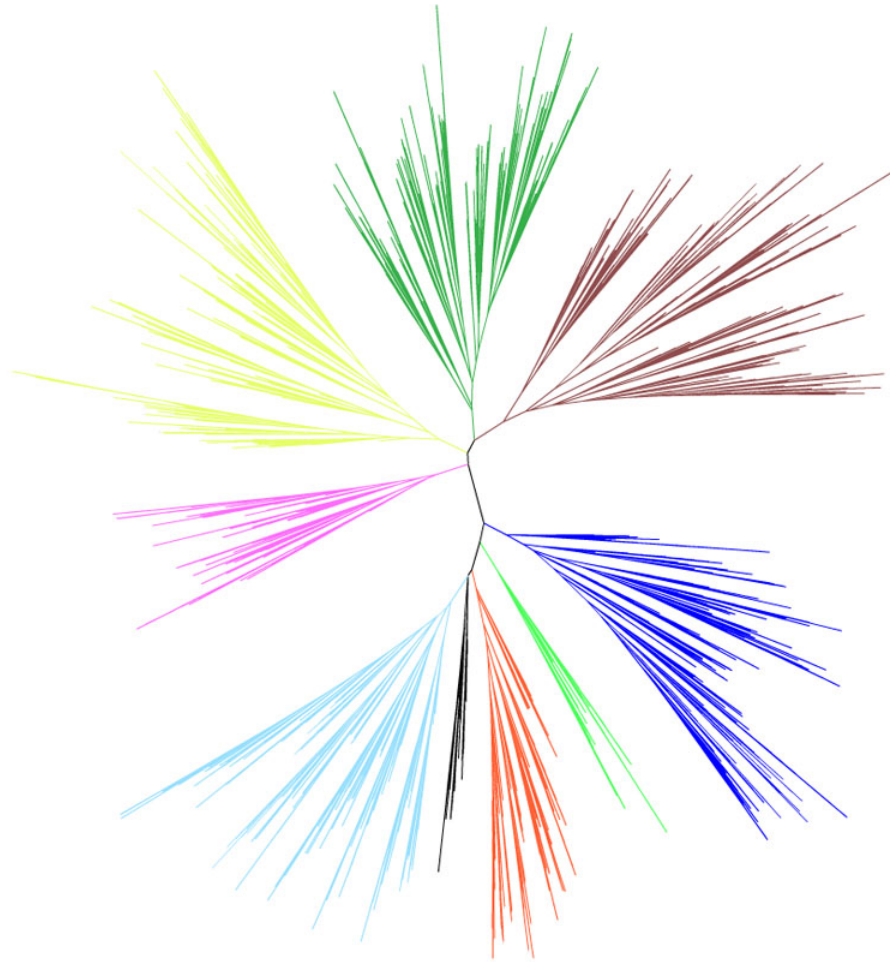


# Interactive ToL



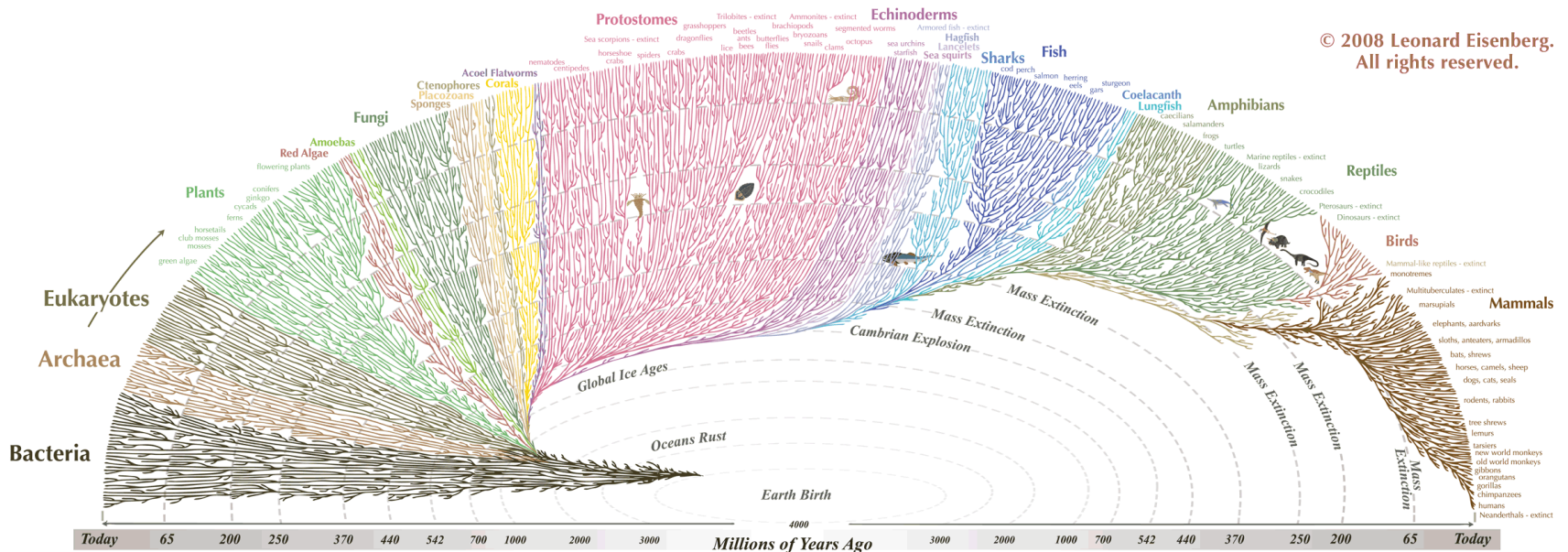
<http://itol.embl.de/>


# Interactive ToL



<http://itol.embl.de/>

# Illustration

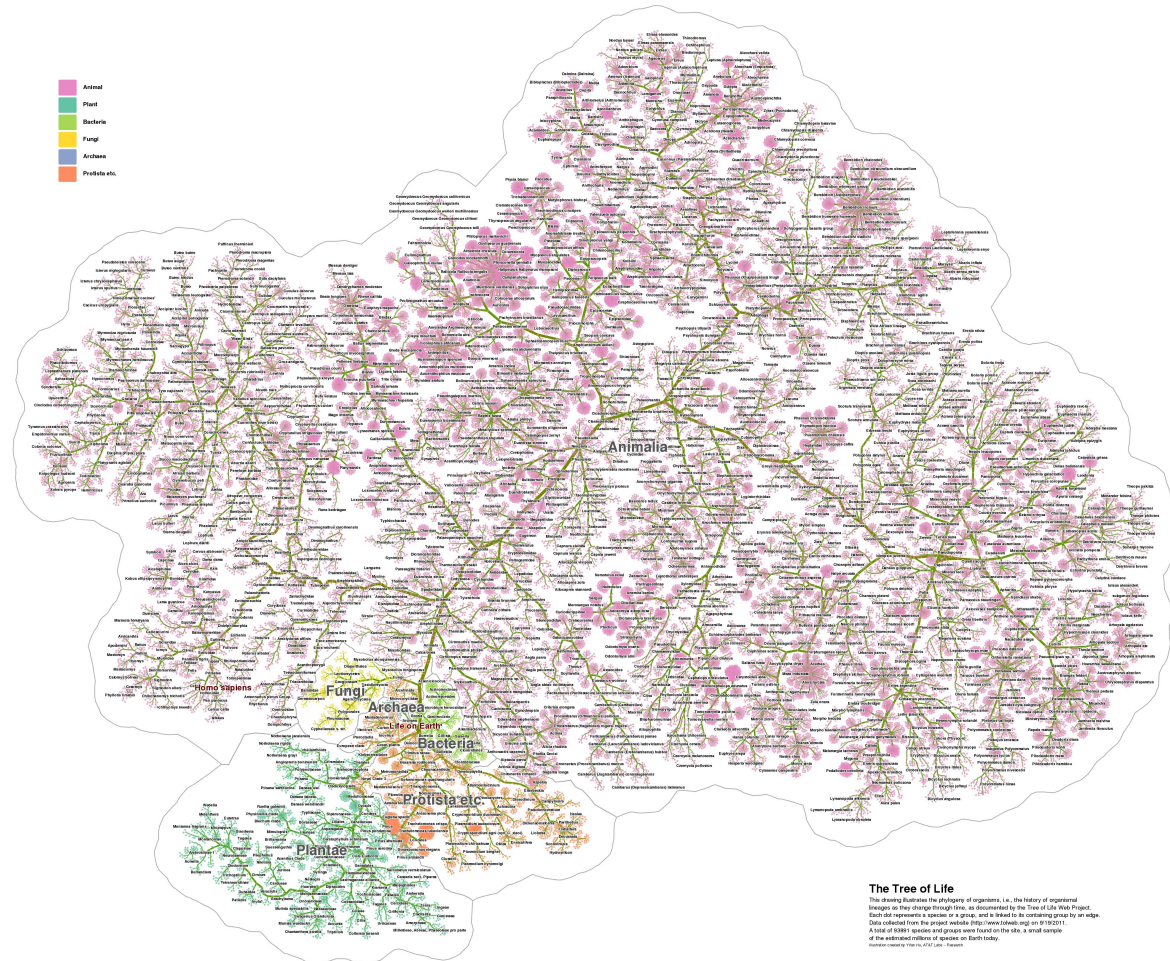


All the major and many of the minor living branches of life are shown on this diagram, but only a few of those that have gone extinct are shown. Example: Dinosaurs - extinct 

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evogeneao.com

<http://www.evogeneao.com/>

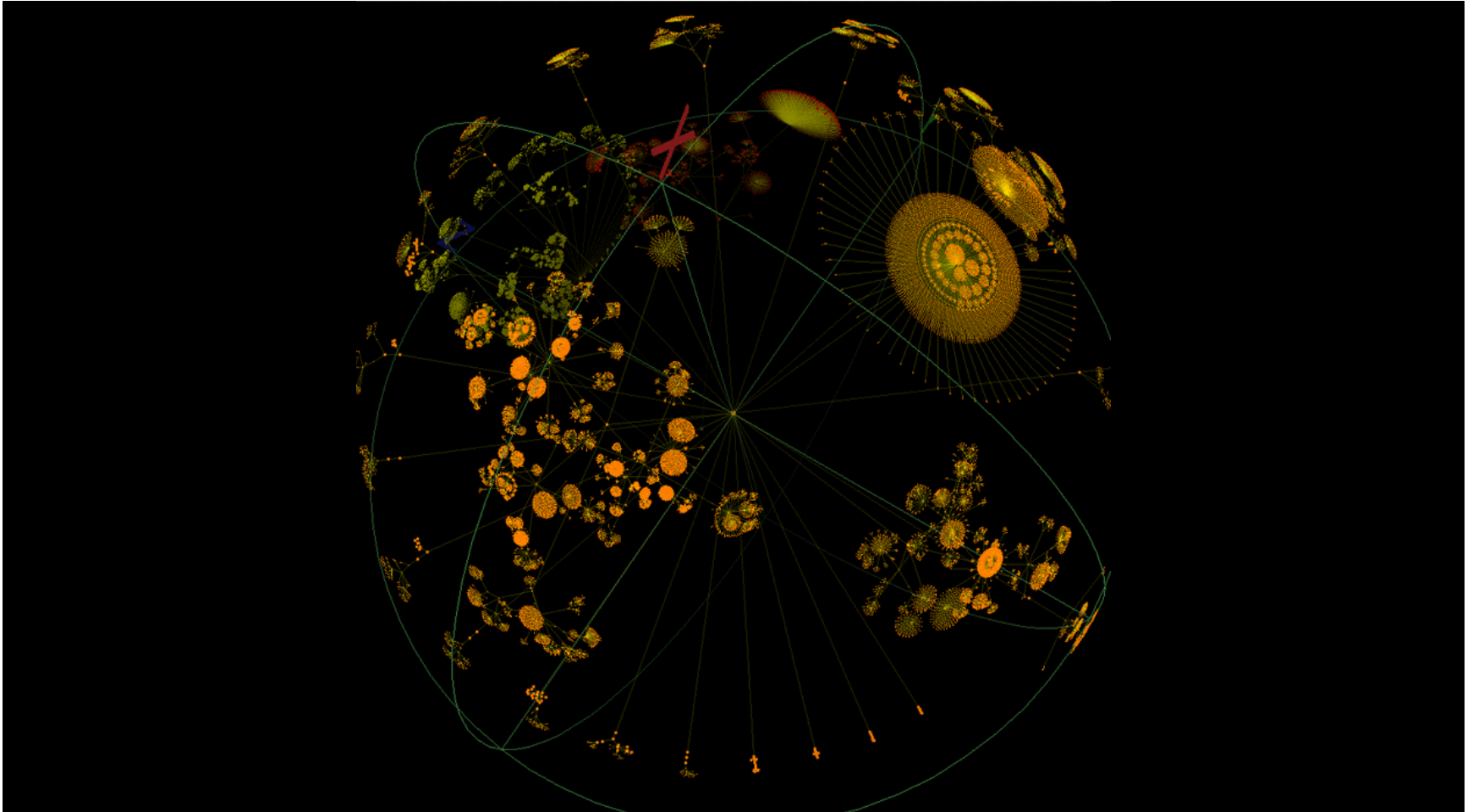
# Interactive ToL (2)



<http://www2.research.att.com/~yifanhu/TOL/>



# ToL Using Walrus



<http://digitised.info/content/view/20/51/>

# QUESTIONS?