From Trees to Rhizomes

Trees are associated with with:

- **Centralism**. The tree structure has a unique root node – the only node without a parent node higher in the hierarchy – from which all other nodes descend. This expresses a concentration of power and authority in a central actor of the system, and may also be related to, in its less reputable manifestations, to oppressive hierarchical systems.
- **Finalism.** It describes the unidirectional, linear courses of trees: any point in a tree is reachable from the root by a unique, linear, top-down path of intermediate nodes. Trees therefore embody an organization devoid of multilinearity or feedback loops.

The figurative tree in relisious and art

A1
Hans Sebald Beham
The Fall of Man
ca. 1525–27
Woodcut print of the fall of man with a forest in the background, showing Adam grabbing an apple out of Eve's left hand and Eve taking another apple from the leaning serpent. At the center of the tree's trunk, above the coiled serpent, is an oversize skull, a reminder of the consequences of disobedience to God. In a later version of this same scene, the German engraver Beham features the skull with a full-bodied skeleton intertwined with the tree of knowledge of good and evil.

A2
Anonymous
Marriage of Shiva and Parvati
ca. 1830
Watercolor painting of the marriage of Hindu deity Shiva and his wife, Parvati, under a sacred tree. The four-headed Brahma, seated, is performing a homa (a ritual fire sacrifice). The central tree could possibly be a bael or a Magnolia champaca, also known as Michelia champaca - an evergreen tree considered to be sacred to Shiva and whose flowers are employed in the worship and religious observance of other Hindu deities.

A3
Anonymous Painting of Buddha
ca. 701–750
A detail of a silk painting depicting Buddha seated under an adorned Bodhi tree, preaching to his disciples. The *Bodhi tree* was a large fig tree (or banyan tree) located in Bodh Gaya, northeastern India, under which Buddha (Siddhartha Gautama) is thought to have attained

enlightenment - the most common English translation of the original Sanskrit Bodhi, which stands for awakened.

A4
Anonymous
Yggdrasil tree
ca. 1680
Illustration of Yggdrasil, part of Edda oblongata, an Icelandic manuscript from 1680 containing several illustrations of Norse mythology. This particular drawing features the *world tree*, or cosmic ash tree, Yggdrasil, surrounded by the various animals that live in and on it. Of particular relevance is Ratatoskr, a green squirrel on the bottom left, who, according to Norse mythology (notably the thirteenth-century poem "Grímnismál"), runs up and down Yggdrasil to carry messages between the eagle, shown at the top of the tree, and the dragon, Níðhöggr, who gnaws at the roots.

A5
Gustav Klimt
The Tree of Life
1901
Detail of The Tree of Life, one of the most reproduced oil paintings in modern times. Painted during a productive period for Klimt, The Tree of Life respects the painter's obsession with this recurrent theme. The painting is organized in an enigmatic spiraling configuration, with branches forming a convoluted whirlwind enclosing various symbols, including geometric fruits and leaves, as well as animals such as birds and butterflies.

The tree as a knowledge representation structure

A6
Tree of virtues and tree of vices
From Lambert of Saint-Omer, Liber floridus
1121
A remarkable illustration featured in Liber floridus (Book of flowers), depicting two opposing arboreal schemes in the form of fig trees: a tree of virtues (arbor bona) on the left and a facing tree of vices (arbor mala) on the right. The
arbor bona sprouts from a trunk exhibiting a medallion with a personification of charity, while the arbor mala emerges from cupidity. Each contrasting tree bears twelve medallions, corresponding to twelve virtues and twelve vices.

A7
Ramon Llull
Porphyrian tree
From Logica Nova
1512
A representation of one of the oldest known tree archetypes, derived from the work of the Greek philosopher and logician Porphyry in the third century AD, based on ideas earlier

expressed by Aristotle in his Categories. The tree embodies Porphyry's scale of being through a treelike structure, composed of a central trunk containing the series of genus and species and two adjacent columns of succeeding dichotomous divisions. Although the original ontological structure by Porphyry hasn't survived, several interpretations were made during the Middle Ages. This figure is a literal arboreal translation of the Porphyrian tree, as drawn by the great thirteenth-century Spanish poet, mystic, and philosopher Ramon Llull.

A8
Charles Darwin
Tree of life
From On the Origin of Species by Means of Natural Selection
1859
The only illustration featured in the first edition of Darwin's On the Origin of Species. The tree is an essential demonstration of his evolutionary thinking and the theory of universal common descent. In the base of the diagram, Darwin lists a series of hypothetical ancestral species spaced irregularly, from A to L, in order to emphasize their distinction, while above them are various branching schemes indicating subsequent varieties and subspecies. Each division along the vertical axis, from I to XIV, represents one thousand generations. Even though other trees of life tying species together had been created before by figures such as Jean-Baptiste Lamarck, Edward Hitchcock, and Heinrich Georg Bronn, Darwin was the first to introduce a mechanism of change over time, making this the first evolutionary tree of life.

A9
Chrétien Frederic Guillaume Roth
Essai d'une distribution généalogique des sciences et des arts principaux (Genealogical distribution of arts and sciences)
From Denis Diderot and Jean le Rond d'Alembert, Encyclopédie
1780
A remarkable tree featured as a foldout frontispiece in a later 1780 edition of the French Encyclopédie, by Denis Diderot and Jean le Rond d'Alembert, first published in 1751. The Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers (Encyclopedia, or a systematic dictionary of the sciences, arts, and crafts) was a bastion of the French Enlightenment and one of the largest encyclopedias produced at that time. It consisted of 3,129 illustrations and twenty million words in 71,818 articles over 35 volumes. The tree depicts a genealogical structure of knowledge, with its three prominent branches following the classification set forth by Francis Bacon in The Advancement of Learning (1605): memory and history (left), reason and philosophy (center), and imagination and poetry (right). The tree bears fruit in the form of roundels of varying sizes, representing the domains of science known to man and featured in the encyclopedia.

B1
Joe Stone
X-Men Family Tree
2011
An enticing and playful family tree charting the many convoluted relationships - whether they be romantic, genetic, or otherwise - of the X-Men characters from Marvel Comics.

B2
Leslie Bradshaw, Jesse Thomas, Tiany Farrant-Gonzalez, Joe Chernov, and Jesse Noyes
The Blog Tree: New Growth
2012
A tree of connections among a group of popular, recently launched blogs. The marketing firm Eloqua, partnering with the creative agency JESS3, took a holistic look at the dynamic marketing blogosphere in this colorful diagram, evocative of earlier medieval executions. Each blog is represented as a leaf, its color indicating a specific ranking determined by trafic to the site, from orange (high score) to dark green (low score). Blogs are grouped on different branches by categories depicted as red fruits, including "start-up" and "design/data".

B3
Minna Sundberg
The Language Tree
When linguists talk about the historical relationship between languages, they use a tree metaphor. An ancient source (say, Indo-European) has various branches (e.g., Romance, Germanic), which themselves have branches (West Germanic, North Germanic), which feed into specific languages (Swedish, Danish, Norwegian). Lessons on language families are often illustrated with a simple tree diagram that has all the information but lacks imagination. There's no reason linguistics has to be so visually uninspiring. Minna Sundberg, creator of the webcomic Stand Still. Stay Silent, a story set in a lushly imagined post-apocalyptic Nordic world, has drawn the antidote to the boring linguistic tree diagram.

Structure and visualization: a one-to-many relationship

B4
Organization chart
From William Henry Smith,
Graphic Statistics in Management
1924
Radial organization chart highlighting the centralized decision-making process of most companies, with the president in the very core of the chart, followed by successive levels of managers and workers represented by sequential concentric rings. The fundamental process of rationalization effected
by the Industrial Revolution was a central impetus for the solidification of bureaucracy, corporate ranking, and management models based on centralized, hierarchical control. The second half of the nineteenth century and the beginning of the twentieth witnessed the emergence of numerous similar charts that embraced the tree model to portray an increasingly complex corporate structure.

B5
Oli Laruelle
Invisible Commitments
2009
An attempt at visualizing the data and amount of effort behind an open-source software development project, in this case the Processing source code. The branching structure of this diagram mirrors that of the folders and code used by the developer team. A branch's thickness conveys the frequency with which the developers worked in a given folder, and its length is proportional to the number of subfolders. At the end of the branches are fruits symbolizing files, organized by extension. Every dot of a fruit represents a letter of the file extension and is placed according to alphabetical order: a and z are the farthest apart, a and b the closest.

B6
Jevin West and Carl Bergstrom
Well-formed Eigenfactor
2007
Well-Formed Eigenfactor is an collaborative experiment in visualizing citation patterns among scholarly journals based on data from the Thomson-Reueters Journal Citation Reports. Moritz Stefaner, in collaboration with the Eigenfactor team, drew upon the Eigenfactor metrics (a bibliometric measure based on PageRank idea) to develop novel interactive visualizations to illustrate the structure of science. This visualization displays a hierarchical clustering of journals in the form of a treemap. The size of a journal marker corresponds to its Eigenfactor Score. An interactive version is available at http://www.eigenfactor.org/projects/well-formed/treemap.html

B7
Richard Wettel and Michele Lanza
CodeCity
2006
Image from CodeCity: Software Systems as Cities, a research project on software visualization revolving around a city metaphor. With this approach, industrial-size software systems are visualized in a 3-D treemap environment that resembles an urban layout. The districts of the city represent the system's packages, and the buildings represent its classes. The visible properties of the city's elements reflect a configurable set of software metrics: the building height is proportional to the number of methods of the class, the base size shows the number of attributes, and the color reflects the number of lines of code (the more lines of code, the more intense the shade of blue).

B8
Oliver Deussen
Eclipse Voronoi treemap

2010
A Voronoi treemap of the hierarchical file structure of the multilanguage software development system Eclipse, showing fifteen thousand classes.

B8a
Jörg Bernhardt, Juliane Siebourg, Julia Schüler, and Henry Mehlan
Vortices (Omics data visualization using treemaps)
2011
A Voronoi treemap where cells represent Bacillus subtilis genes. Following the human genome sequencing, "omics" is a recent neologism that refers to a variety of areas in systems biology that end in "-omics", such as genomics, proteomics, transcriptomics, metabolomics, and metallomics. Most omics studies focus on the functions, behaviors, and interactions of genes, molecules, and proteins. This diagram shows the difference in gene expression between a Bacillus subtilis culture grown under optimal conditions and one where cells suffered from glucose starvation. Jörg Bernhardt and his team have become strong advocates of the use of Voronoi treemaps in bioinformatics, specifically for mapping and analyzing proteomes (sets of proteins expressed by a genome, tissue, cell, or organism).

Adding feedback loops: rhizomes

Networks are associated with:

- **Decentralization**. Networks are webs without a spider: there exist no central authority (root) that regulates their growth, but they evolve in a **self-organized** way.
- **Multilinearity**. Networks allows feedback loops, that are paths that come back on their feet. This means that any actor of the system can be reached through multiple paths.

B8b
Rhizome
In botany and dendrology, a rhizome is a modified subterranean stem of a plant that is usually found underground, often sending out roots and shoots from its nodes. Networks are often called by philosophers rhizomatic structures.

B9
Leonhard Euler
Solution of a problem relating to the geometry of positon
1736
The original sketch of the seven bridges of Köningsberg

C1
Köningsberg's bridges abstract graph

Graph theory was born thanks to Leonhard Euler's deconstruction of the mathematical problem of the seven bridges in an abstract graph. In it, the land areas are represented by four nodes connected by seven links, which correspond to the bridges.

C2
Jacob Moreno
Who shall survive?
1934
This early hand-drawn image of a social network, taken from the work of psychiatrist Jacob Moreno, depicts friendship patterns between the boys (triangles) and girls (circles) in a class of schoolchildren in the 1930s.

C2a
A. Davis, B. B. Gardner, and M. R. Gardner
Deep South
1941
The affiliation network of the Southern Women Study. This network (like all affiliation networks) has two types of vertex, the open circles at the bottom representing the 18 women who were the subjects of the study and the shaded circles at the top representing the social events they attended. The edges connect each woman to the events she attended, as deduced from newspaper reports.

C3
Opte Project
The Internet
The vertices in this representation of the Internet are class C subnets - groups of computers with similar Internet addresses that are usually under the management of a single organization - and the connections between them represent the routes taken by Internet data packets as they hop between subnets. The geometric positions of the vertices in the picture have no special meaning; they are chosen simply to give a pleasing layout and are not related, for instance, to geographic position of the vertices.

C3a
R. Carvalho, L. Buzna, F. Bono, E. Gutierrez, W. Just, and D. Arrowsmith
The network of natural gas pipelines in Europe
2009
The transmission network (dark gray pipelines) overlaid with the distribution network (light gray pipelines). Link thickness is proportional to the pipeline diameter.

C3b
J. D. Pelletier
Drainage basin of the Loess Plateau
1999

The network of rivers and streams on the Loess Plateau in the Shanxi province of China. The tree-like structure of the network is clearly visible - there are no loops in the network, so water at any point in the network drains off the plateau via a single path.

C3c
Matthew Hurst
Mapping The Blogosphere
2006
The graph is only showing the links between the blogs, which as argued by the author gives us a far better look at the structure than if we include all the nodes. In this image, we are looking at the core of the blogosphere. The dark edges show the reciprocal links (where A has cited B and B has cited A), the lighter edges indicate a-reciprocal links. The larger, denser area of the graph is that part of the blogosphere generally characterised by socio-political discussion (the periphery contains some topical groupings). Above and to the left is that area of the blogosphere concerned with technical discussion and gadgetry.

C4
Jevin West and Carl Bergstrom
Eigenfactor (www.eigenfactor.org)
2004
Orange circles represent fields, with larger, darker circles indicating larger field size as measured by Eigenfactor score. Blue arrows represent citation flow between fields. An arrow from field A to field B indicates citation traffic from A to B, with larger, darker arrows indicating higher citation volume.

C4a
H. Jeong, S. Mason, A.-L. Barabási, and Z. N. Oltvai
Protein interaction network
2001
A protein-protein interaction network for yeast. A network of interactions between proteins in the single-celled organism Saccharomyces cerevisiae (baker's yeast).

C4b
Mark Newman
A food web of species in Antarctica
2010
Vertices in a food web represent species or sometimes, as with some of the vertices in this diagram, groups of related species, such as fish or birds. Directed edges represent predator-prey interactions and run in the direction of energy flow, i.e., from prey to predator. In common parlance, one refers to a food chain. Only a moment's reflection, however, is enough to convince us that real ecosystems cannot be represented by single chains, and a complete network of interactions is needed in most cases.

Networks as artworks

C5
EPFL (Politecnico di Losanna)
Blue brain project (bluebrain.epfl.ch)
2008
A computer-generated of the 30 million connections between 10 thousand neurons in a single neocortical column - the most complex part of mammal's brain. The different colors indicate different levels of electrical activity.

C6
Jackson Pollock
Convergence
1952

C7
Chris Harrison and Christoph Römhild
Bible cross-references
The bar graph that runs along the bottom represents all of the chapters in the Bible. Books alternate in color between white and light gray. The length of each bar denotes the number of verses in the chapter. Each of the 63779 cross references found in the Bible is depicted by a single arc - the color corresponds to the distance between the two chapters, creating a rainbow-like effect.

C8
Lee Jang Sub
ComplexCity Paris.
This project is an exploration to find a concealed aesthetic by using the pattern formed by the roads of the city which have been growing and evolving randomly through time, thus composing the complex configuration we experience today.

C9
Keith Peters
Art From Code (www.artfromcode.com)

D1
Keith Peters
Art From Code (www.artfromcode.com)

D3
Keith Peters
Art From Code (www.artfromcode.com)

D4

Sharon Molloy
Transient structures and unstable networks
2008

D5
Tim Rollins and K.O.S
On the Origin of Species - Variations IV (after Darwin) (detail)
2013

D6
Tomás Saraceno
14 Billions (Working Title)
2010

D7
Chiharu Shiota
In Silence
2011

D8
Chiharu Shiota
The Key in the Hand
2015