Knowledge Presentation and Visualization

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Overview

Overview Knowledge Presentation and Visualization

- Background and Context
- Information Transmission Channels
- Cognitive Aspects
- Presentation and Visualization Methods
- Assessment and Evaluation
- Examples

Background

Background and Context

- emphasis on presentation and visualization of **knowledge**
  - concepts, relationships
- visualization is one way of presenting knowledge
  - possibly the most important, but not the only one
- only *explicit* knowledge can be presented
  - *tacit* knowledge must be circumscribed
  - many of the approaches presented are used in attempts to make tacit knowledge more explicit

Relevance of Knowledge Presentation

- better user experience
  - shorter time to locate, identify relevant knowledge
  - knowledge is easier to comprehend and utilize
- improved understanding
  - critical examination of existing bodies of knowledge
  - exploration and validation of relationships
  - suitable presentation of abstract concepts
- creation of new knowledge
  - integration of existing diverse bodies of knowledge
  - addition of relationships between knowledge items

Information Transmission Channels

- sensory equipment of humans and computers to send and receive information
  - knowledge has to be encoded in order to be transmitted
    - sender and receiver must have compatible encoding schemes

Main Human Information Channels

- visual
  - input via eyes; output via movement, gestures, manipulation of the environment
- auditory
  - input via ears; output via voice, gestures (clapping, stomping), manipulation of the environment
- tactile
  - input and output via touching (skin)
- olfactory and gustatory
  - smelling (nose), taste (mouth)

Main Computer Information Channels

- visual
  - almost exclusively for output (screen, printer)
  - some use for input (optical mouse, camera)
- tactile
  - mostly for input (keyboard, mouse)
- auditory
  - input (speech recognition) and output (alerts, messages)
- other channels for computer-computer communication
  - network, wireless, infrared

Evaluation Criteria

- capacity
  - amount of information that can be transferred
- selectivity
  - how difficult is it to concentrate on certain parts of the communication
    - focus, attention, noise
- dimensionality
  - how many dimensions can be perceived
- persistence
  - how long is the sensory signal available

Visual Communication

- heavily used
  - writing/reading, diagrams, images
- often relies on text (spoken language)
  - requires writing/reading skills
- some specialized functions
  - color, motion detection, resolution gradient
- limitations
  - range(distance, angle, frequency)
  - resolution (spatial, temporal)
  - sensitivity
  - fatigue

Evaluation Visual Communication

- capacity
  - high
- selectivity
  - good (close eyes, change direction, focus distance)
- dimensionality
  - 2+ (two dimensions, distance calculated)
- persistence
  - emphasis on changes (motion)
  - can be long-lived (writing, drawing, photos)

Auditory Communication

- heavily used
  - spoken language
- requires skills for knowledge presentation
  - speaking, understanding a language

Evaluation Auditory Communication

- capacity
  - medium (significantly lower than visual)
- selectivity
  - poor (closing ears difficult, changing direction requires head movements, focussing on specific auditory signals can be difficult)
- dimensionality
  - 1+ (all spatial information calculated)
- persistence
  - spoken language is transitory
  - can be long-lived (writing, drawing, photos)

Cognitive Aspects

- cognitive engineering
  - design principles for presentation techniques
  - based on cognitive processes in humans
    - information processing, attention, memory
  - main emphasis on the visual system
  - mental depiction can be as important as mental description

Perception

- interface between our mind and the world
- sensory information translates physical aspects of the world into neural encodings in our brain
  - visual and auditory systems are most relevant for knowledge-related perception
- many lower-level processing steps are encoded in "wetware" and happen sub-consciously

[Kowalski 1997]

Presentation and Visualization Methods

Information Visualization

- utilizes the human visual system to indicate important aspects of data and information
  - absence/presence, quantity, features
- basis for writing, drawing, art
  - long-distance communication
  - long-term preservation of knowledge
- graphical displays offer a much richer visual experience than text-based terminals
  - flexibility, resolution, color

[Kowalski 1997]

Cognitive Aspects of Vision

- proximity
  - nearby items are grouped together
- similarity
  - similar items are grouped together
- continuity
  - smooth continuous patterns vs. separate items
- closure
  - automatic filling of gaps in a figure
- connectedness
  - interpretation of related items as single units
- many of these aspects are performed at low levels of perception

[Kowalski 1997]

Visualization Primitives

- built-in, low level functions of our visual system
- orientation of shapes
  - easy detection of groupings
- color
  - preference for primary colors
- depth
  - cues to size, distance of objects
- arrangement of objects
  - deviation from regular arrangements are easily detected
- spatial frequency
  - construction of a coherent visual image is attempted

[Kowalski 1997]

Technology: Visual Computing

- computer presentation technology has some advantages over other media
  - modify representations of data and information
    - e.g. change color, scale
  - show changes in space and time through animation
  - use interaction with the user to optimize presentation
    - according to the user's preferences
  - show relationships between items
    - e.g. through hyperlinks

Visual Presentation Techniques

- text
  - mostly sequential
  - good for details, explanations
- diagrams
  - two-dimensional
  - good for structural aspects, relations between items, properties
- images
  - two-dimensional
  - (partial) reproduction of real-world objects
  - creation of imaginary objects
    - e.g. art

Visual Presentation Methods

- hierarchical structures (trees)
  - appropriate for items with relations such as
    - is-a, part-of, parent-child, dependencies, etc.
  - becomes difficult to use for large structures
- map
  - arranges items according to spatial proximity
    - useful for properties that map into space
  - with zooming, it can be used for large sets of items
- grid
  - visualization of tabular data
    - requires strong regularities in the overall information space

[Kowalski 1997]

Visual Presentation Methods cont.

- network (graph)
  - items are represented as nodes, and relationships as arcs
- clusters
  - related items are grouped together
- bar chart
  - indicates values of properties
- histogram
  - shows the distribution of items
- perspective wall
  - main focus on the centerpiece (front), with less relevant items arranged on the side panels

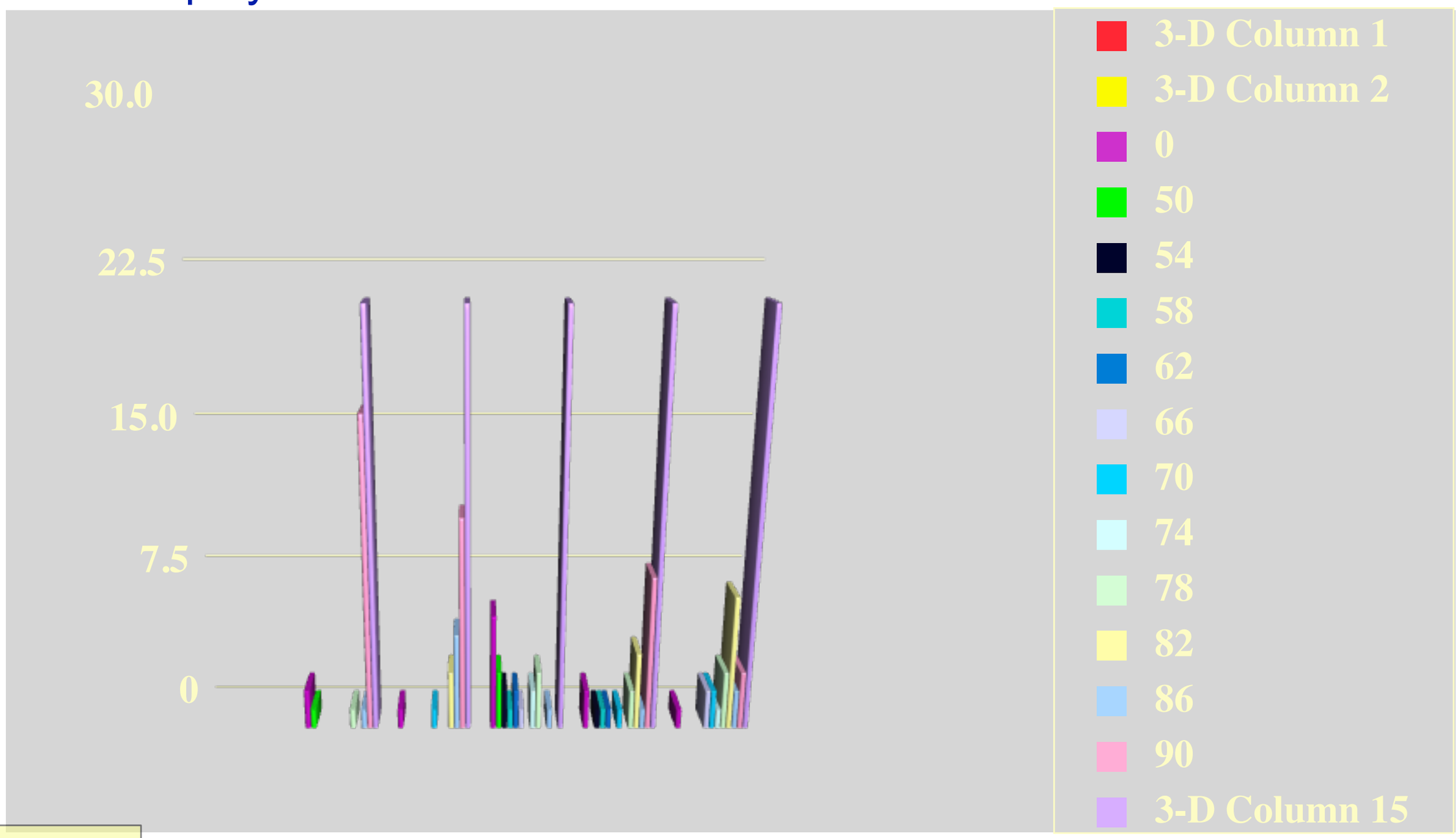
[Kowalski 1997]

Auditory Presentation Techniques

- language
  - sequential
  - similar to text
- sound
  - (partial) reproduction of real-world events
  - creation of new events
    - e.g. music

Data Visualization

- visual display of data values



Information Visualization

- display of relationships for structured data
  - e.g. entity-relationship diagrams
- document clustering
  - present the user with a visual representation of the document space constrained by the search criteria
  - group related documents together
    - requires a similarity measure
- search formulation analysis
  - display the relationships between various aspects of the search terms and the retrieved results
    - effects of expansion, relevance feedback, etc.
  - used to help the user formulate a better query

Knowledge Visualization

- link display
  - indicates relationships between items
  - color, patterns, thickness, arrows, labels, etc. can be used to differentiate types of relationships
- link analysis
  - correlates multiple documents that share certain aspects
  - helps with the identification of dependencies, trends, etc.

Alternatives to Visualization

- utilization of other senses for the presentation of knowledge
  - auditory
    - speech
    - signals
      - beeps
  - tactile
    - virtual reality
  - olfactory (smell)
  - gustatory (taste)

Sound

- speech
  - somewhat limited due to the sequential nature
  - helpful as alternative or additional method
- sounds
  - sometimes used for alerts, or to augment aspects of visual display
- music
  - primarily used for entertainment purposes
  - may be used to evoke emotional responses

Tactile Presentation

- Braille
  - as alternative to text input for visually impaired people
- virtual reality
  - mainly augmentation of visual input
- special-purpose devices
  - feedback mouse
    - special mouse/mouse pad combination that delivers some tactile feedback to the user
  - feedback joysticks, haptic gloves
    - force feedback
    - used for tele-manipulation, VR

Virtual Reality

- tries to provide a computer-based model of an environment
- relies mainly on 3D visual input
- feedback between user and system is critical
  - direct manipulation of virtual objects
- mostly used for modeling purposes, not so much for knowledge presentation

Immersion

- similar to VR, tele-presence
- the user has the impression of being in another environment

Assessment and Evaluation

- transmission capacity
  - more is not necessarily better
- effectiveness
  - does it enable the recipient to do something that wouldn't be possible otherwise
- efficiency
  - can a task be done with few resources
- user satisfaction
- expert evaluation
  - correct, complete, appropriate level of detail

Augmented Reality

- additional information is added to our perception of the real world
  - e.g. overlays with additional information on the windshield of a car or airplane
- requires matching of the real world with the virtual reality parts

Examples of Knowledge Presentation and Visualization

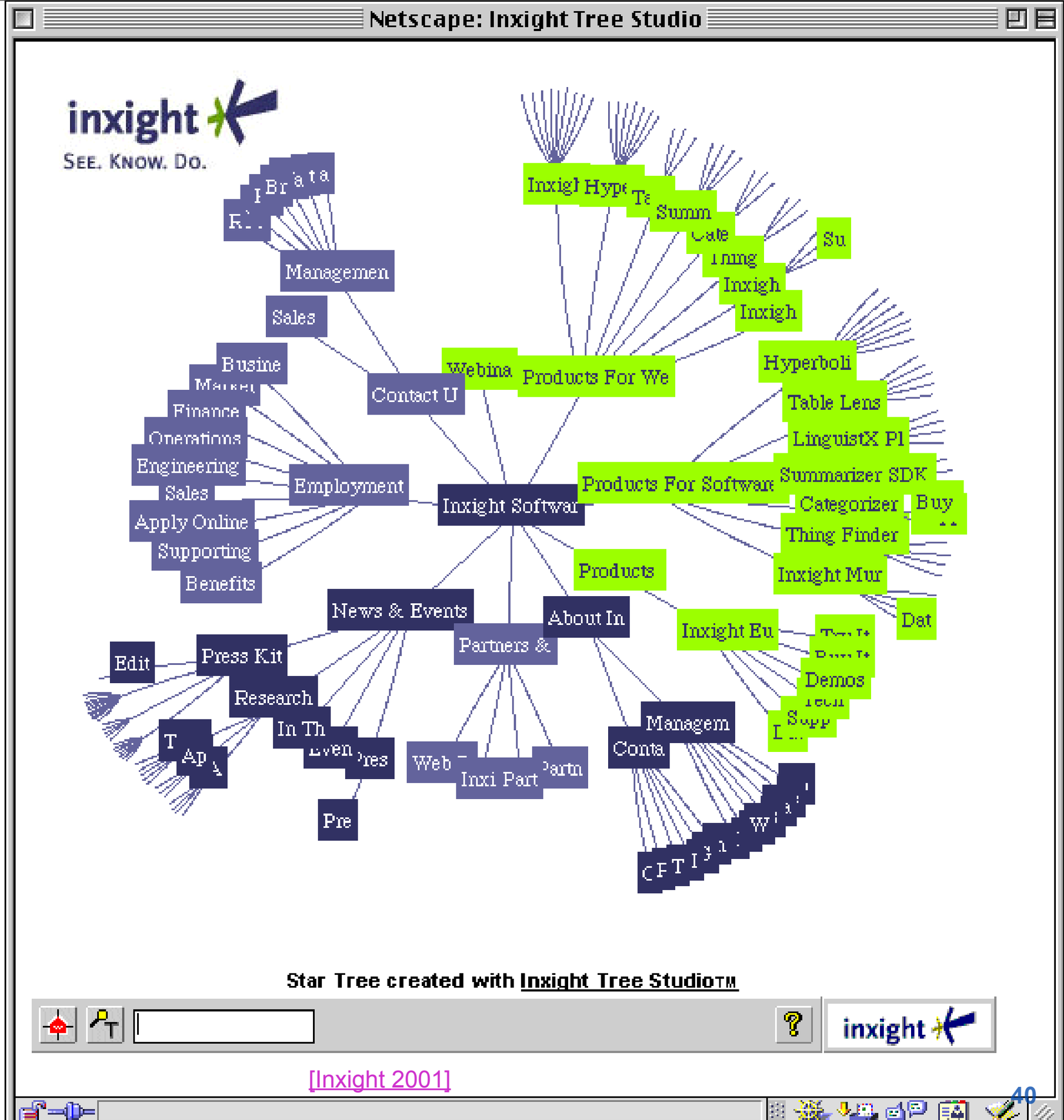
- hierarchical methods
  - trees
- graph-based methods
  - concept maps, mind maps, conceptual diagrams
- similes
  - the appearance of the proxy reflects the original
    - maps
- models
  - important functional properties are reproduced
- metaphors

Tree-Based Presentations

- hierarchical structure
- displayed visually, often as an upside-down tree
  - root node at the top, leaf nodes at the bottom
  - sometimes sideways
  - can also be arranged to optimize the utilization of available space

Inxight Tree

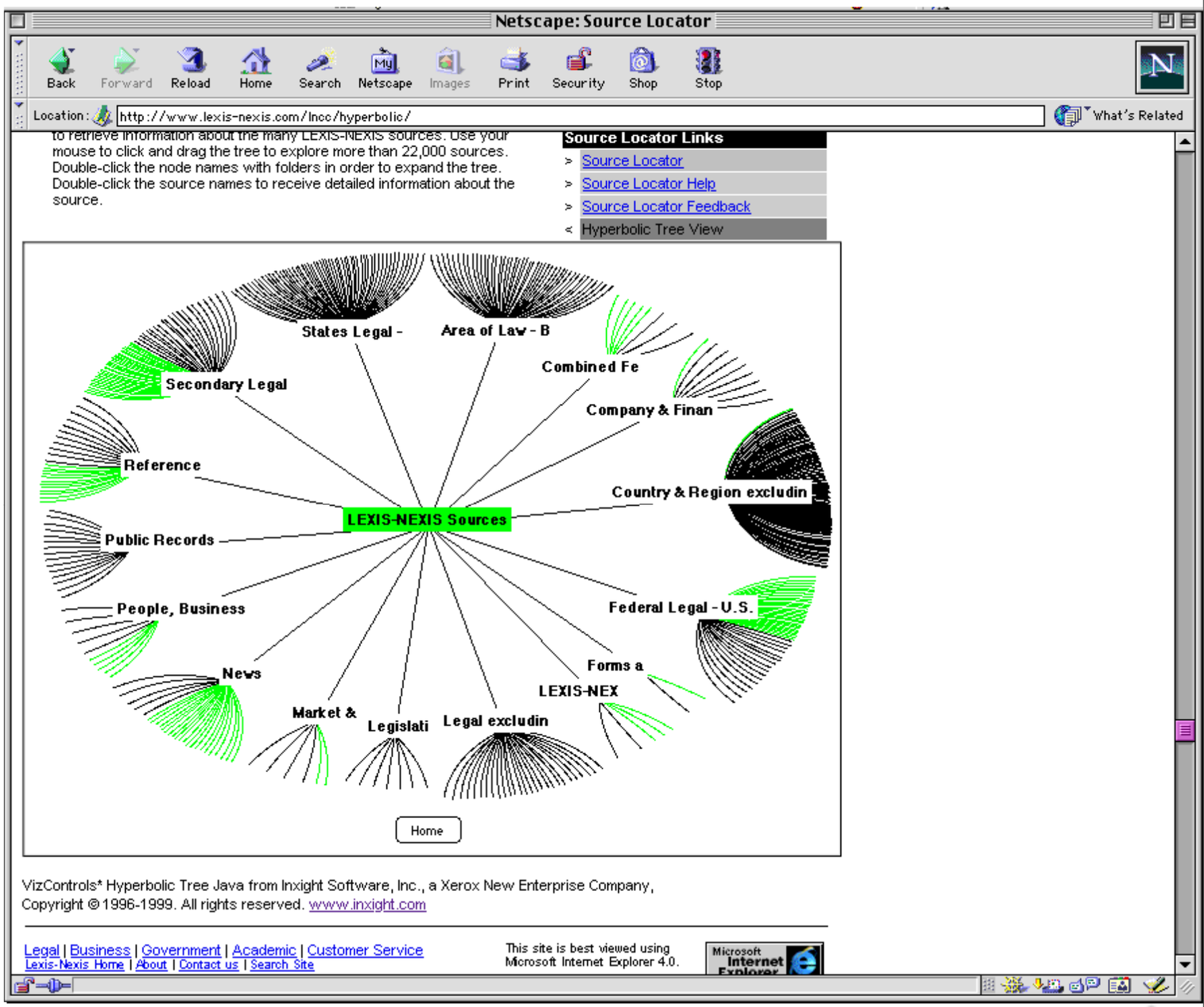
- tree displays the hierarchical structure of a Web site
- overview of available contents
- quick navigation
- no details



[Inxight 2001]

Lexis-Nexis Tree

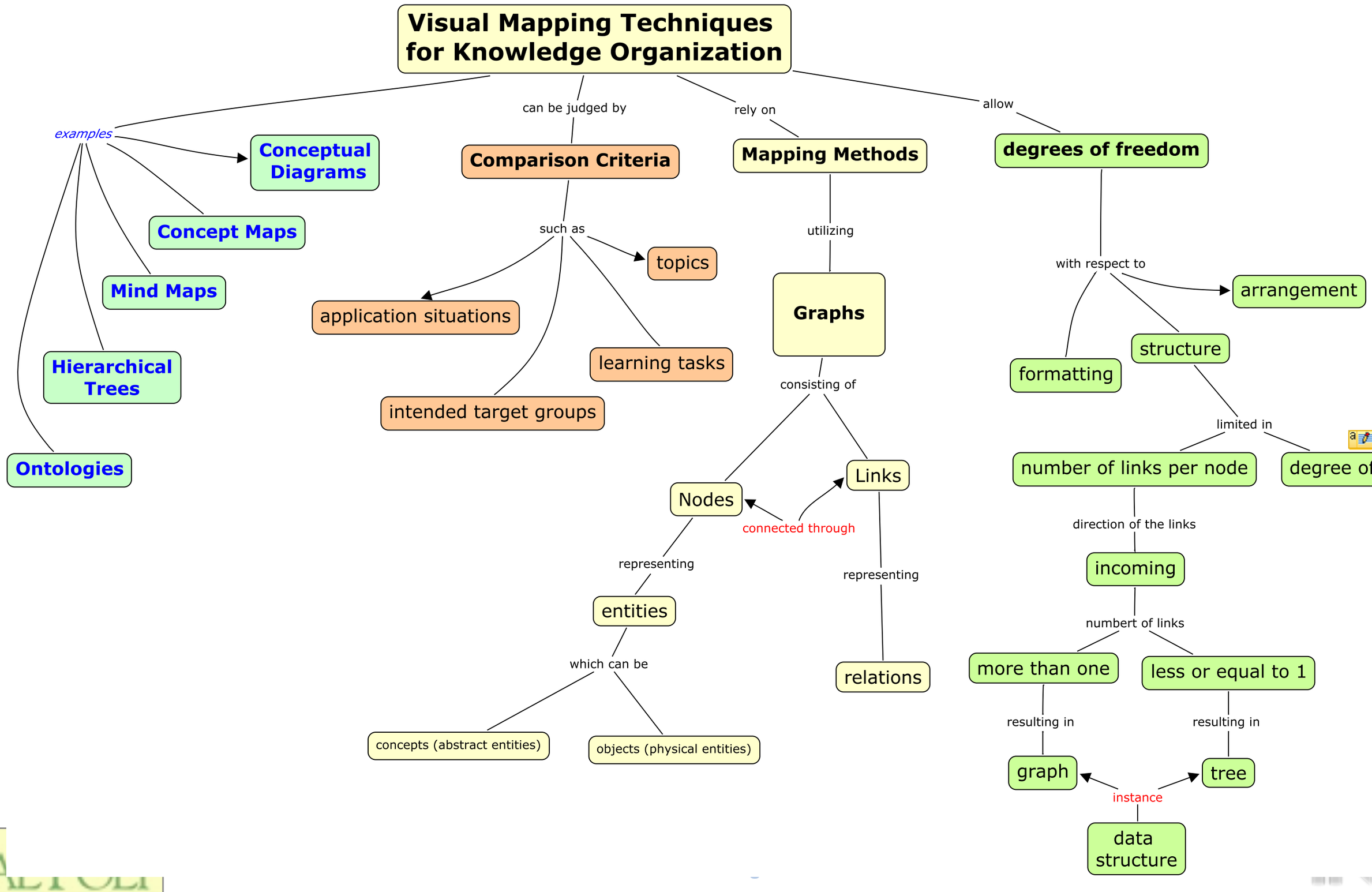
- built with Inxight Tree Studio



Graph-Based Presentations

- arbitrary links between nodes are allowed
- nodes often stand for concepts, links for relationships

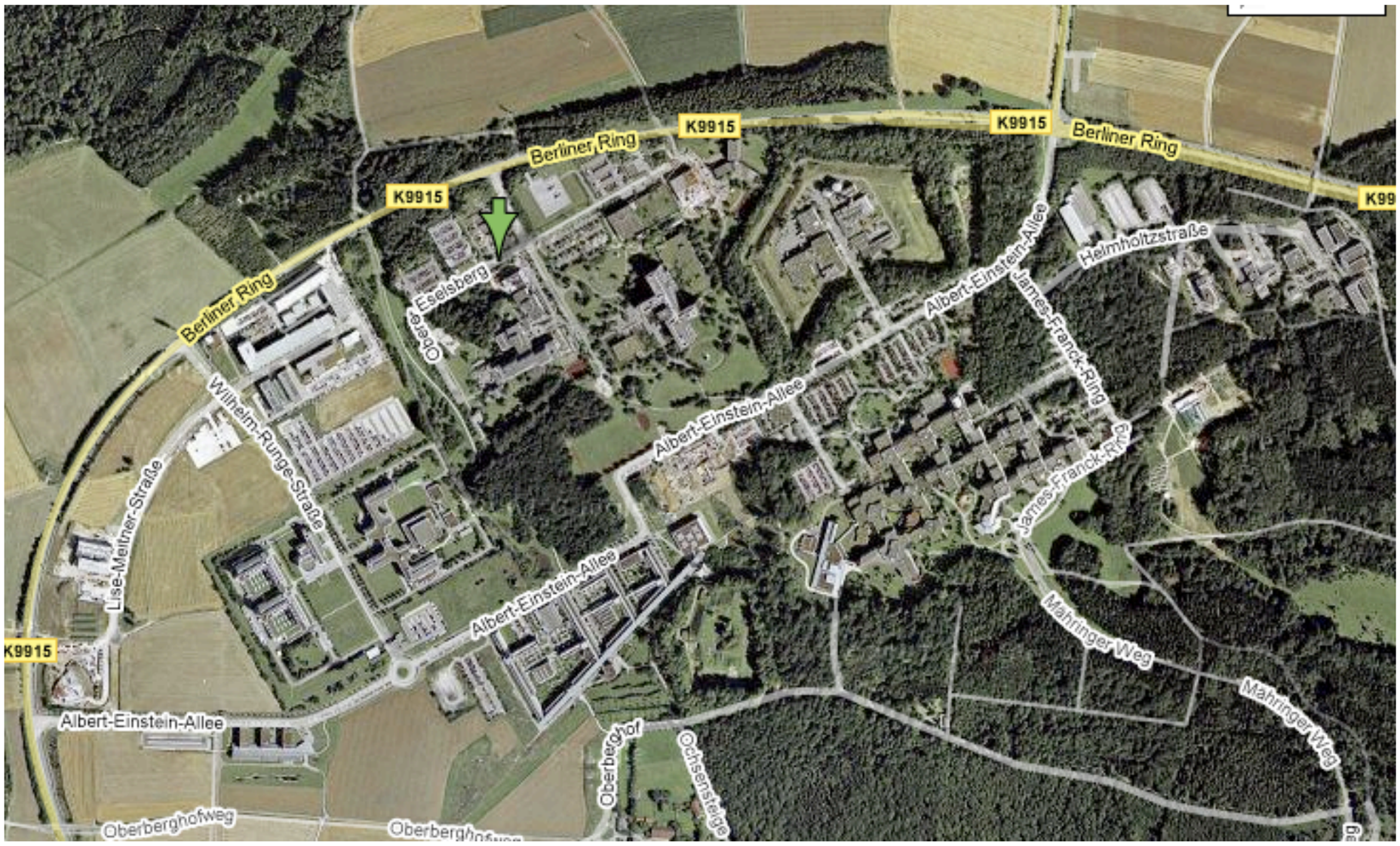
Example Concept Map



Similes

- representations that capture the appearance of the original
  - reproductions of sensory inputs using different technologies
    - paintings, photographs
    - audio recordings
- often used to increase the persistence of sensory impressions

Example Simile



http://maps.google.com/maps?f=q&hl=en&geocode=&q=Universit%C3%A4t+Ulm,+Germany&sll=37.0625,-95.677068&sspn=44.339735,73.212891&ie=UTF8&ll=48.412853,9.94606&spn=0.036461,0.071497&t=h&z=14

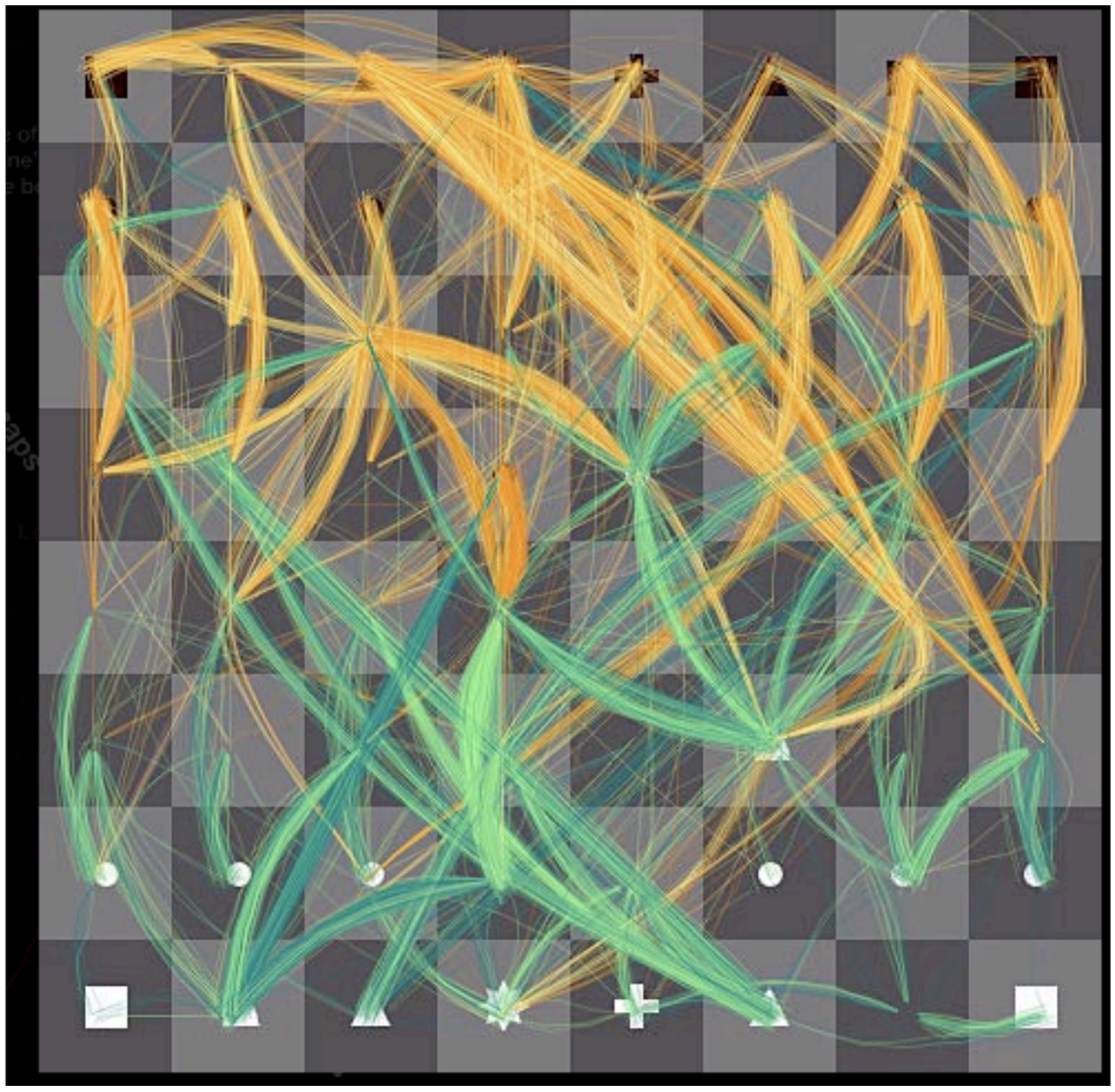
Simile or Graph?

Models

- capture important functional aspects
- conceptual models, theories, hypotheses
  - abstract descriptions, often in formal languages like mathematics, logic
- simulations
  - implementations of models in a different technology or scale
    - nowadays often computers, electronic devices
    - sometimes at a more practical scale

Modeling Chess

- visualization of the computer's possible moves as it plays
- makes the machine's evolving "thought process" visible
- play the game at http://www.turbulence.org/spotlight/thinking/chess.html



http://www.moma.org/exhibitions/2008/elasticmind/#/283/
http://www.turbulence.org/spotlight/thinking/index.html

Visualization for the Masses

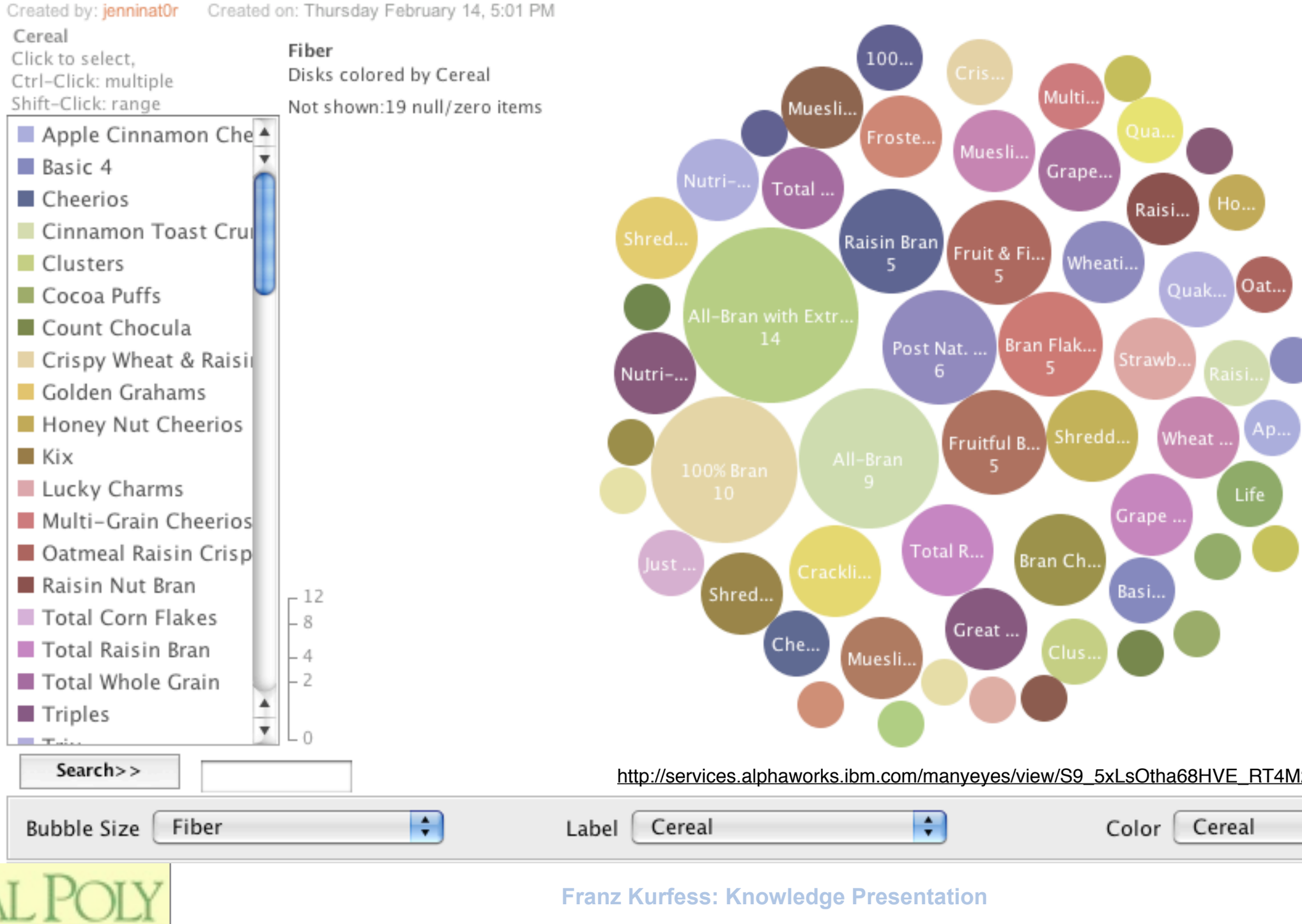
- Web site as service for the general public to visualize data sets
  - http://www.many-eyes.com/
  - http://services.alphaworks.ibm.com/manyeyes/
    - not only for academics
- various types of frequently used visualizations
  - arranged by purpose
  - explanations with examples and guidelines for usage

ManyEyes Example Visualization

Visualizations : Amount of Fibre (g) in various brands of North American Breakfast Cereal

Can't see the visualization? Download the latest Java plugin here. On Macs: best viewed in Safari.

Created by: jenninat0r Created on: Thursday February 14, 5:01 PM



Hybrid Presentations

- combinations of several techniques are used

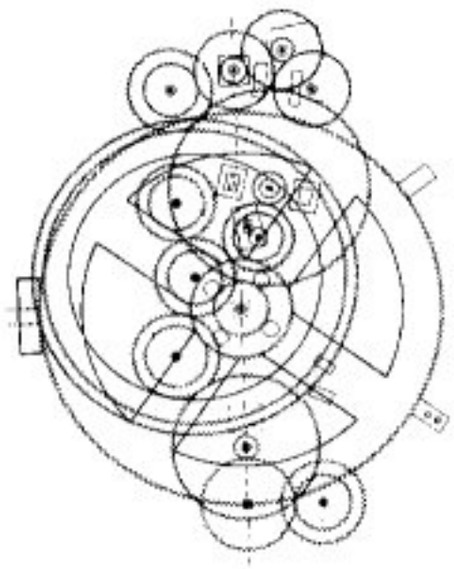
Embodiment of Knowledge

- creation of artifacts that represent important aspects of knowledge
  - replication of physical systems
  - demonstration of processes
  - simulation for experiments

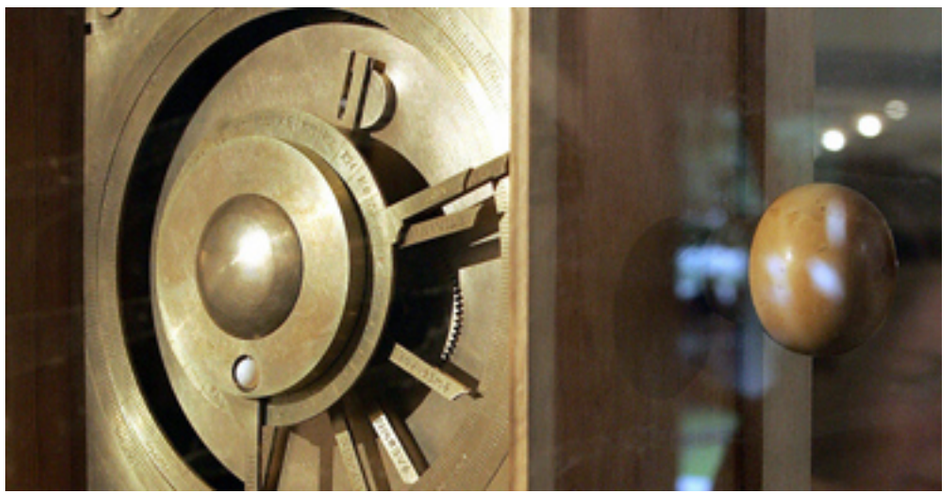
Knowledge Embodiment Examples

- Antikythera Mechanism
  - astronomical calendar capable of tracking
    - position of the sun
    - several heavenly bodies
    - phases of the moon
  - earliest known mechanism to use gear wheels
    - not observed again until about 1600 years later

http://commons.wikimedia.org/wiki/Image:NAMA_Machine_d%27Anticyth%C3%A8re_1.jpg



http://commons.wikimedia.org/wiki/Image:Meccanismo_di_Antikytera.jpg



A reconstruction of the Antikythera mechanism.
Photograph: Louisa Gouliamaki/AFP/Getty

http://www.guardian.co.uk/science/2006/nov/30/uknews

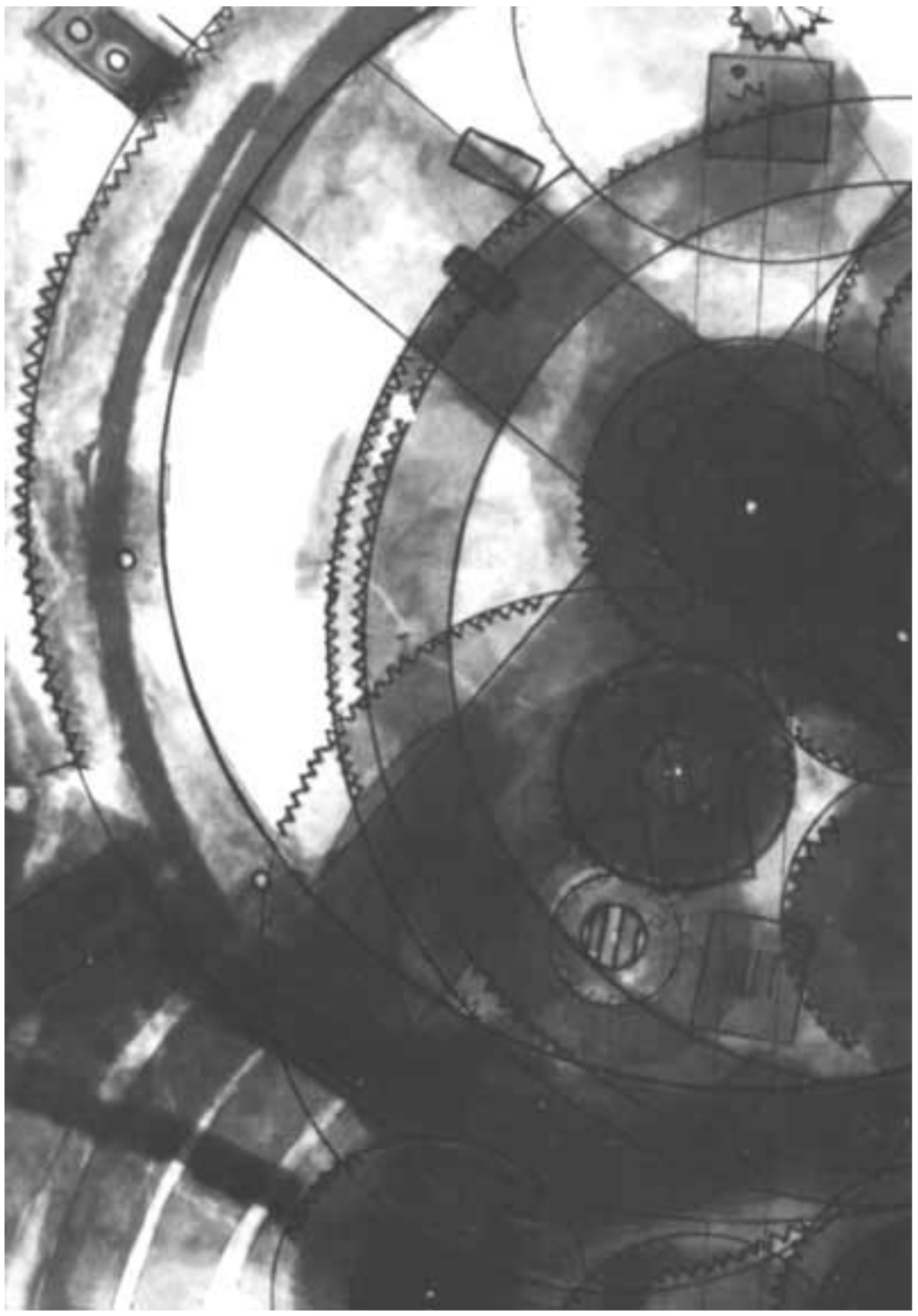
Antikythera Original

http://www.crystalinks.com/antikythera.jpg

http://news.bbc.co.uk/nol/shared/spl/hi/pop_ups/06/technology_enl_1164817474/img/1.jpg

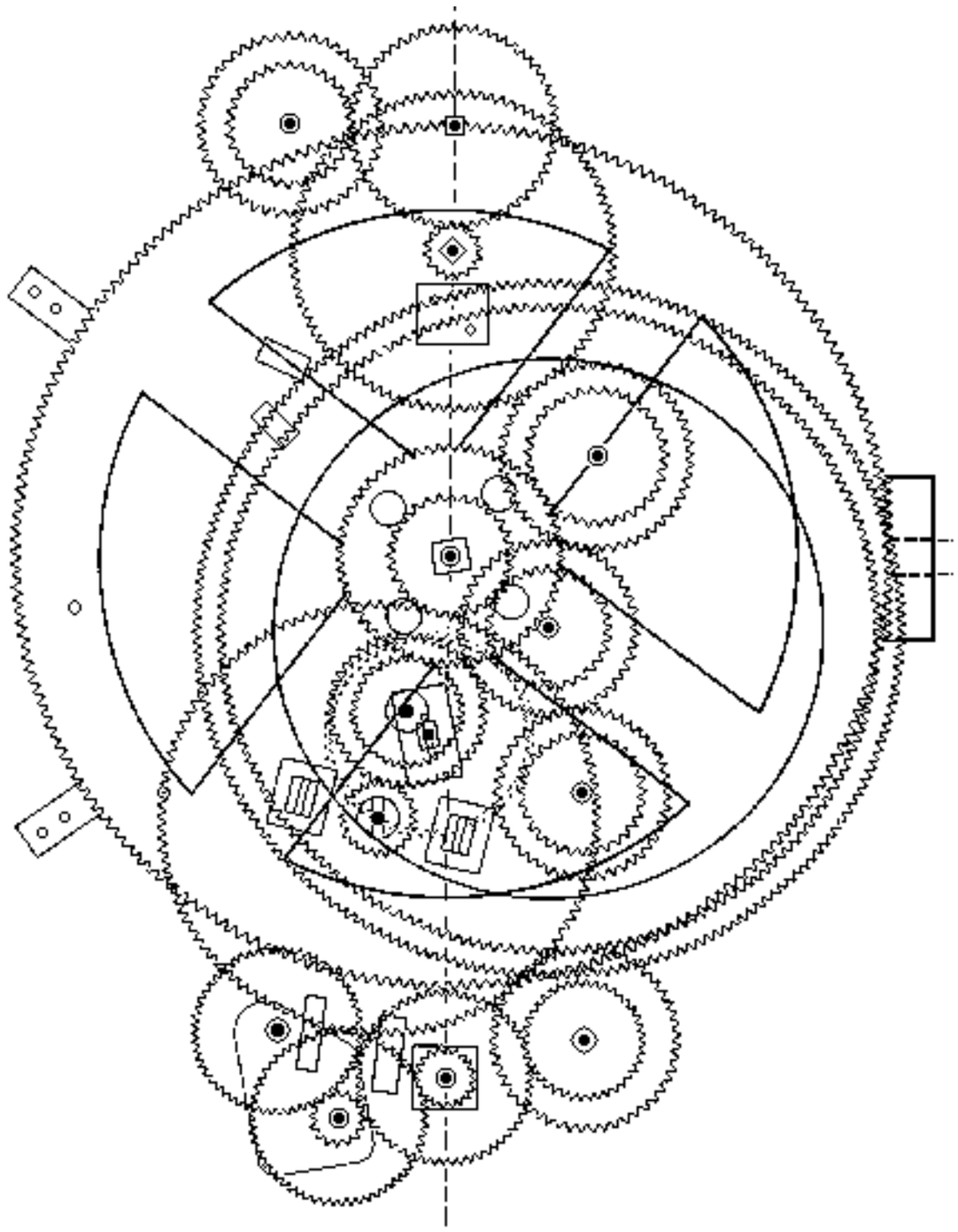
Antikythera Analysis

- trying to decipher the purpose and function of the mechanism
  - only partially preserved
  - some faint inscriptions
  - impractical to take apart



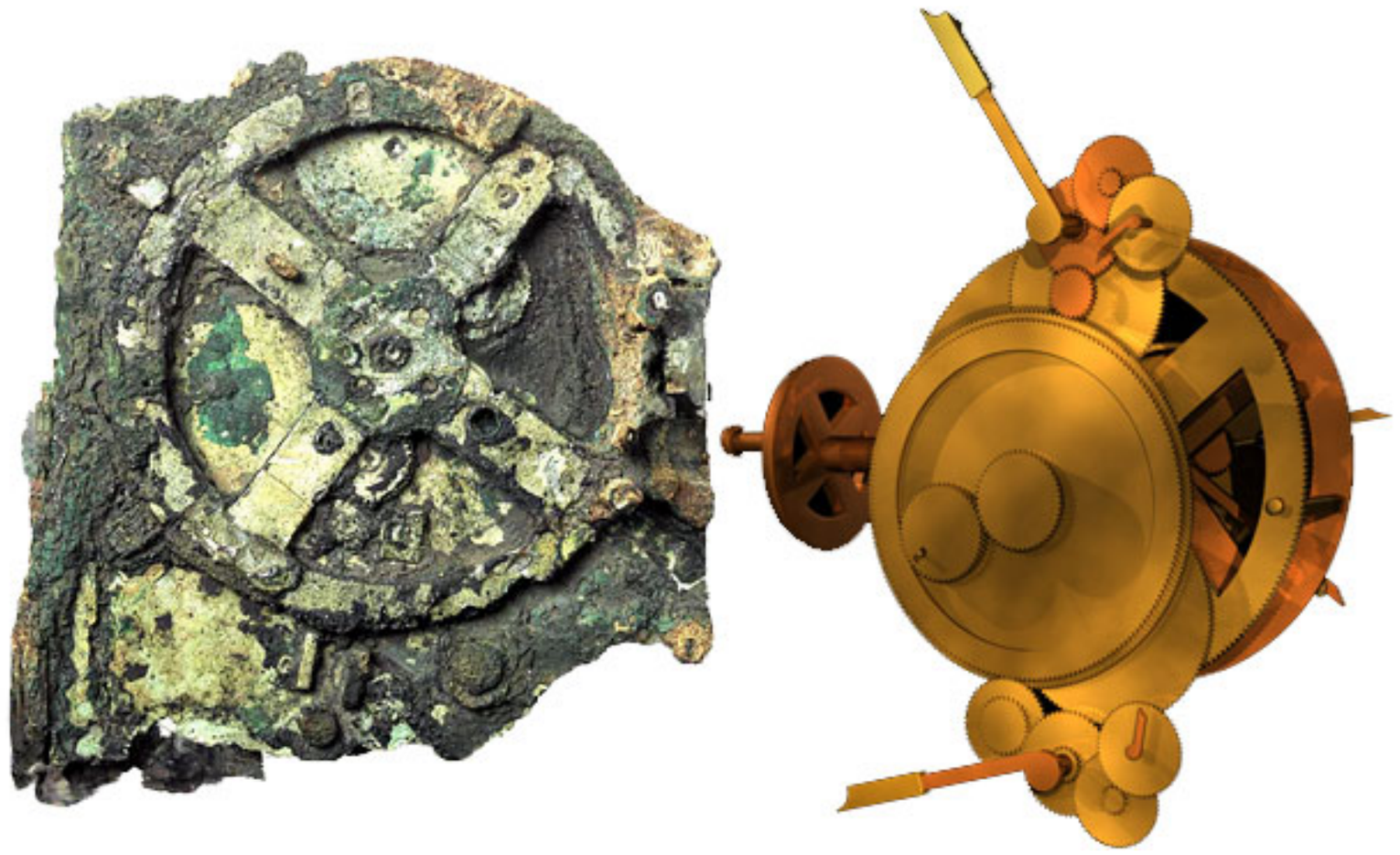
http://www.virtuescience.com/antikythera.jpg

Antikythera Schematics



http://www.cs.uwaterloo.ca/~shallit/Courses/134/antik3.gif

Antikythera Virtual Model



http://asymptotia.com/wp-images/2006/11/29comput650.jpg

Antikythera Reconstruction

http://www.grand-illusions.com/images/antik1.jpg

http://www.grand-illusions.com/images/antik2.jpg

Astrolabe

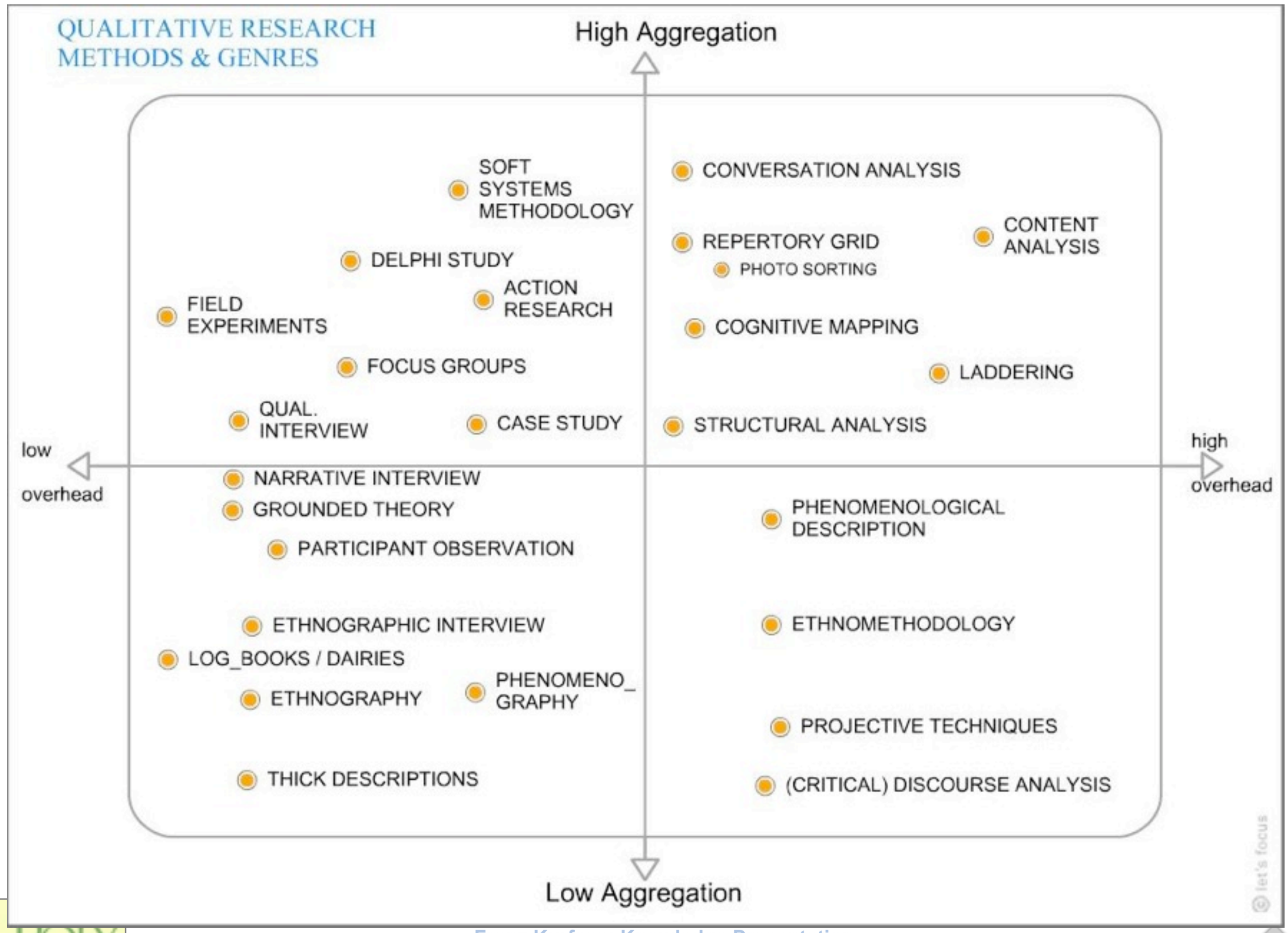
- later development
  - possibly influenced by the Antikythera mechanism

New York Metropolitan Museum of Art, April 2003.
en.wikipedia.org/wiki/Astrolabe, if you are interested in how they are used.

Photo by Charles Tilford, http://www.flickr.com/photos/charlestilford/189670488/

via http://iscience.wordpress.com/2006/11/29/the-antikythera-mechanism/

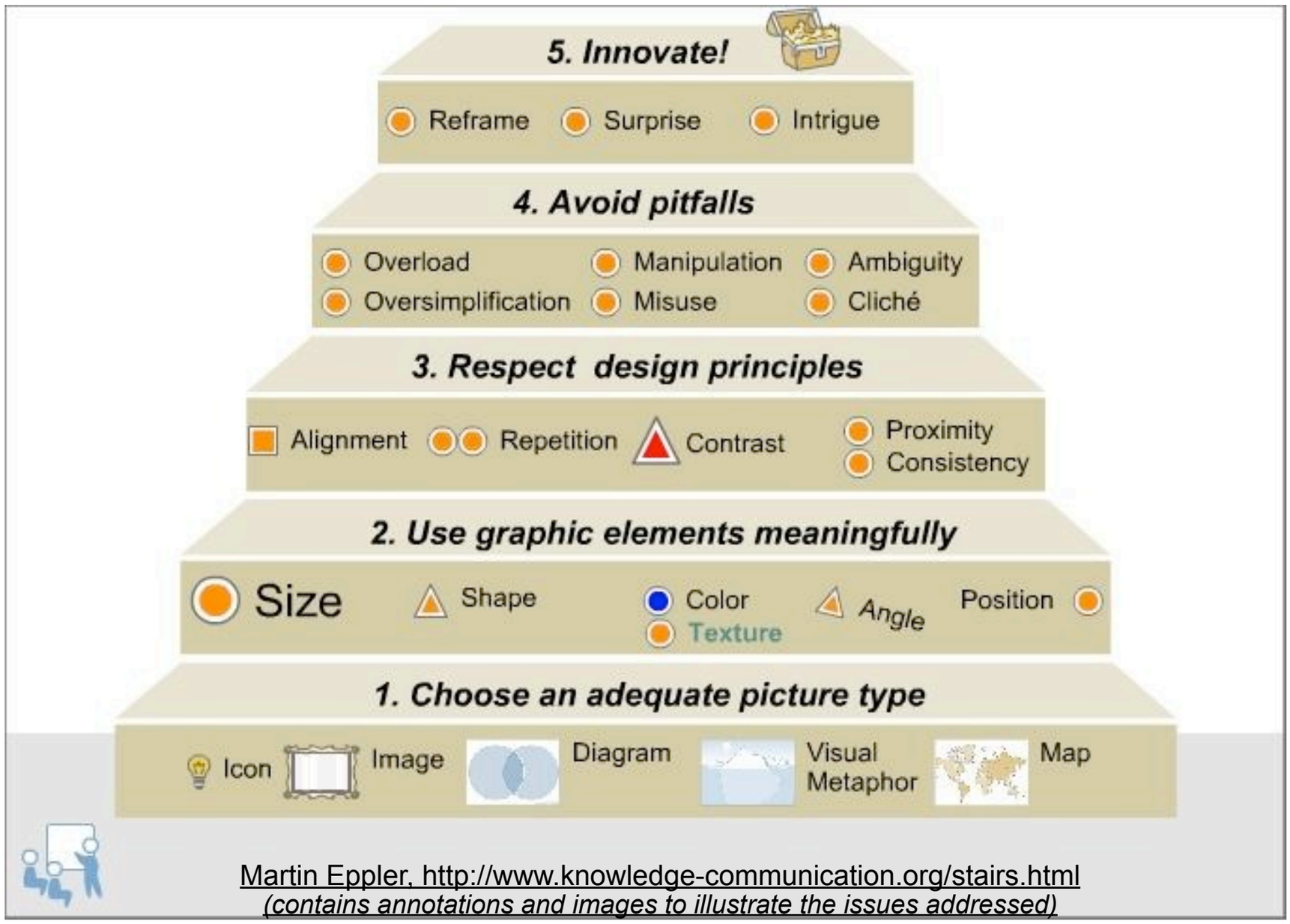
Qualitative Research Methods



Martin Eppler, http://www.knowledge-communication.org/images/qualitative_methods_final.jpg

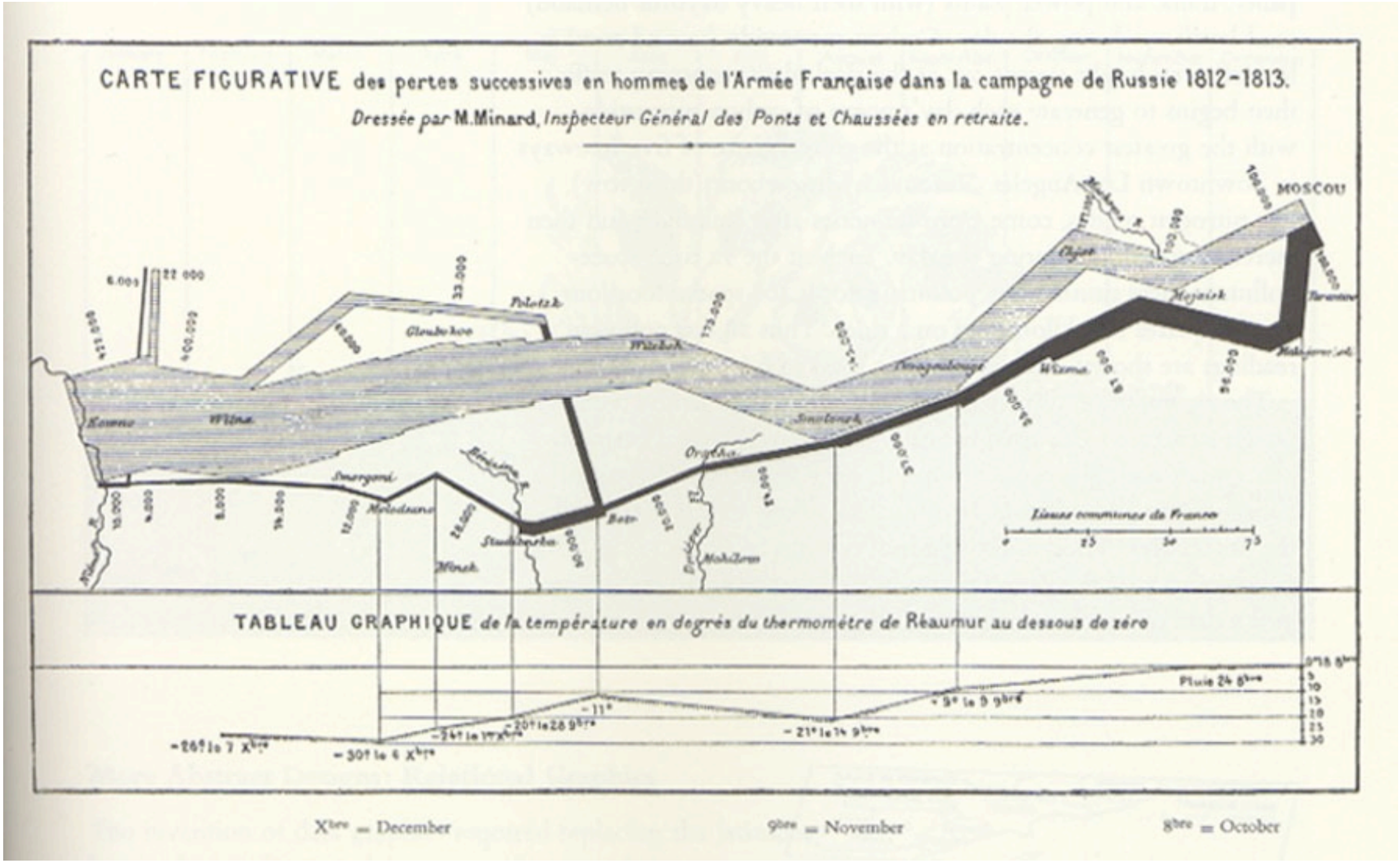
Knowledge Types

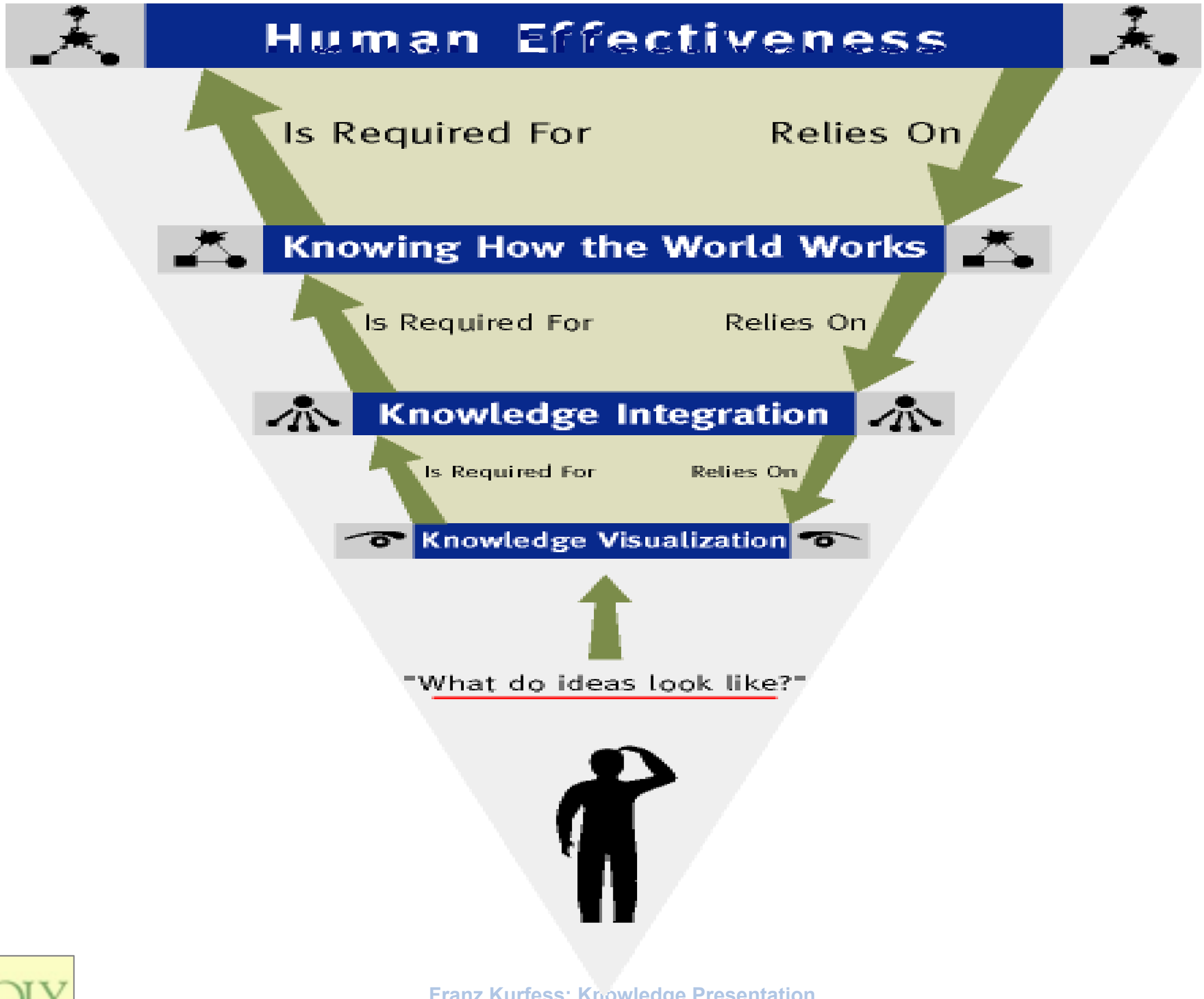
Stairs of Visualization



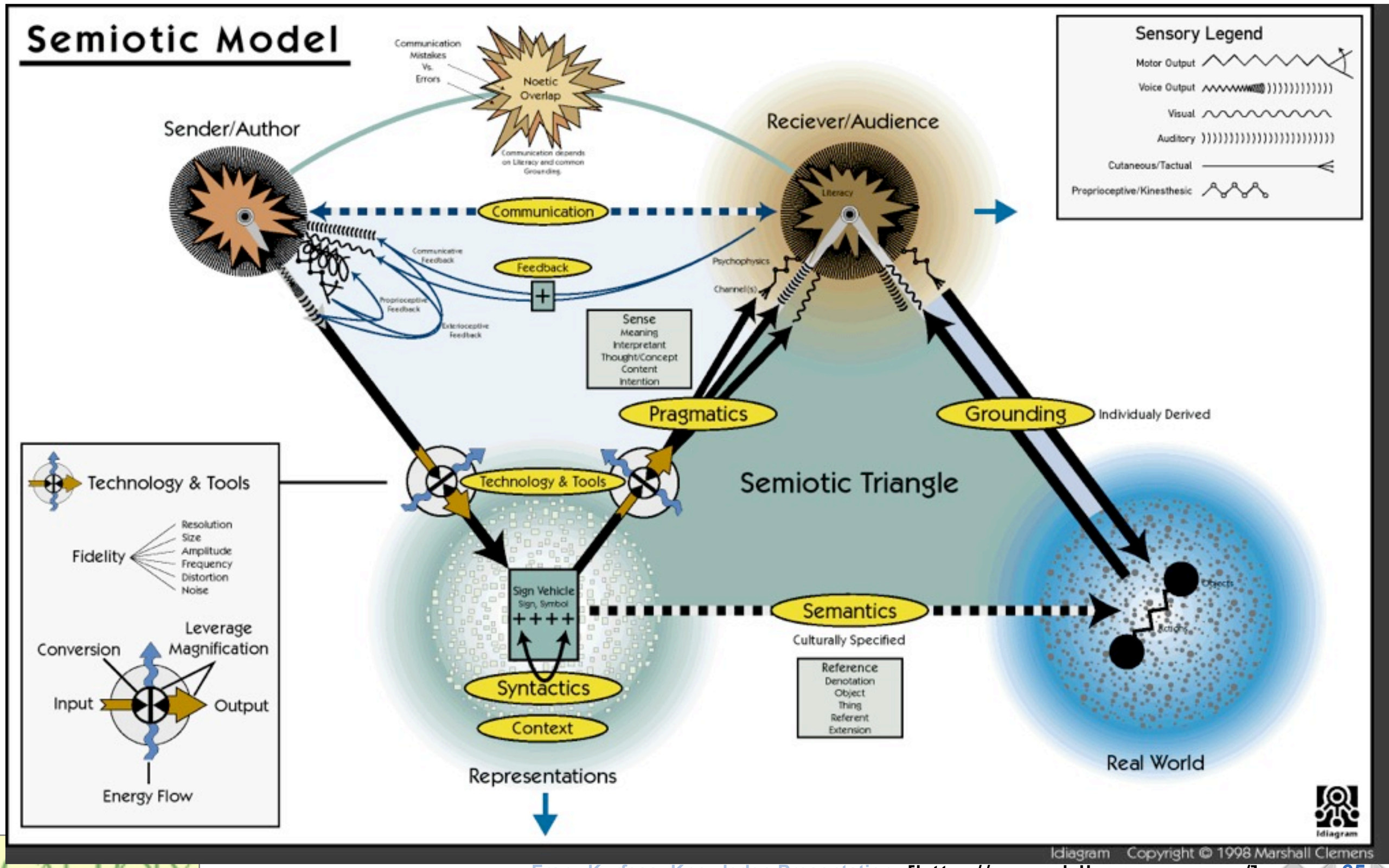
Martin Eppler, http://www.knowledge-communication.org/stairs.html
(contains annotations and images to illustrate the issues addressed)

Minard: Napoleon's Russia Campaign

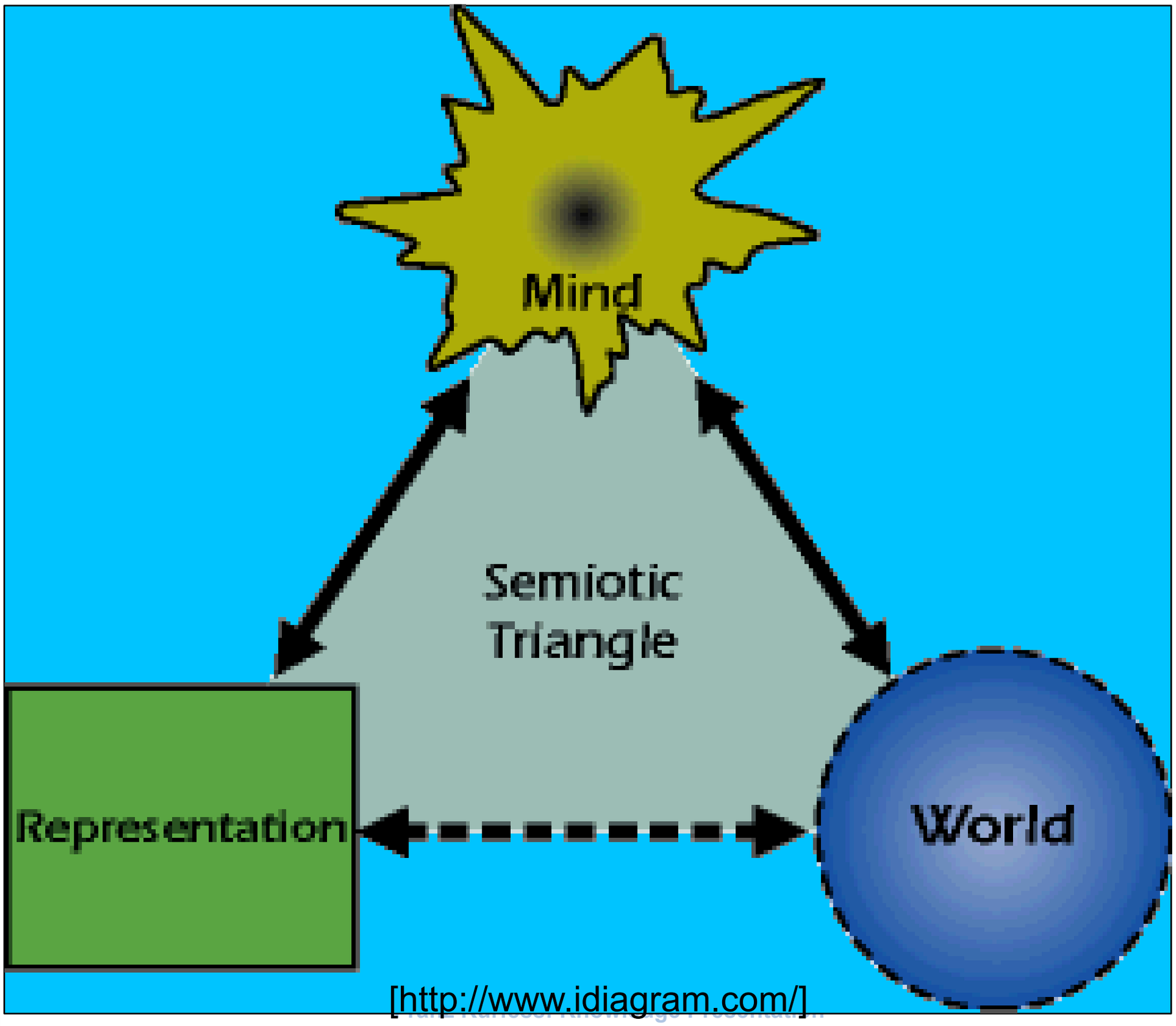



Human Effectiveness
Is Required For
Relies On
Knowing How the World Works
Is Required For
Relies On
Knowledge Integration
Is Required For
Relies On
Knowledge Visualization
"What do ideas look like?"

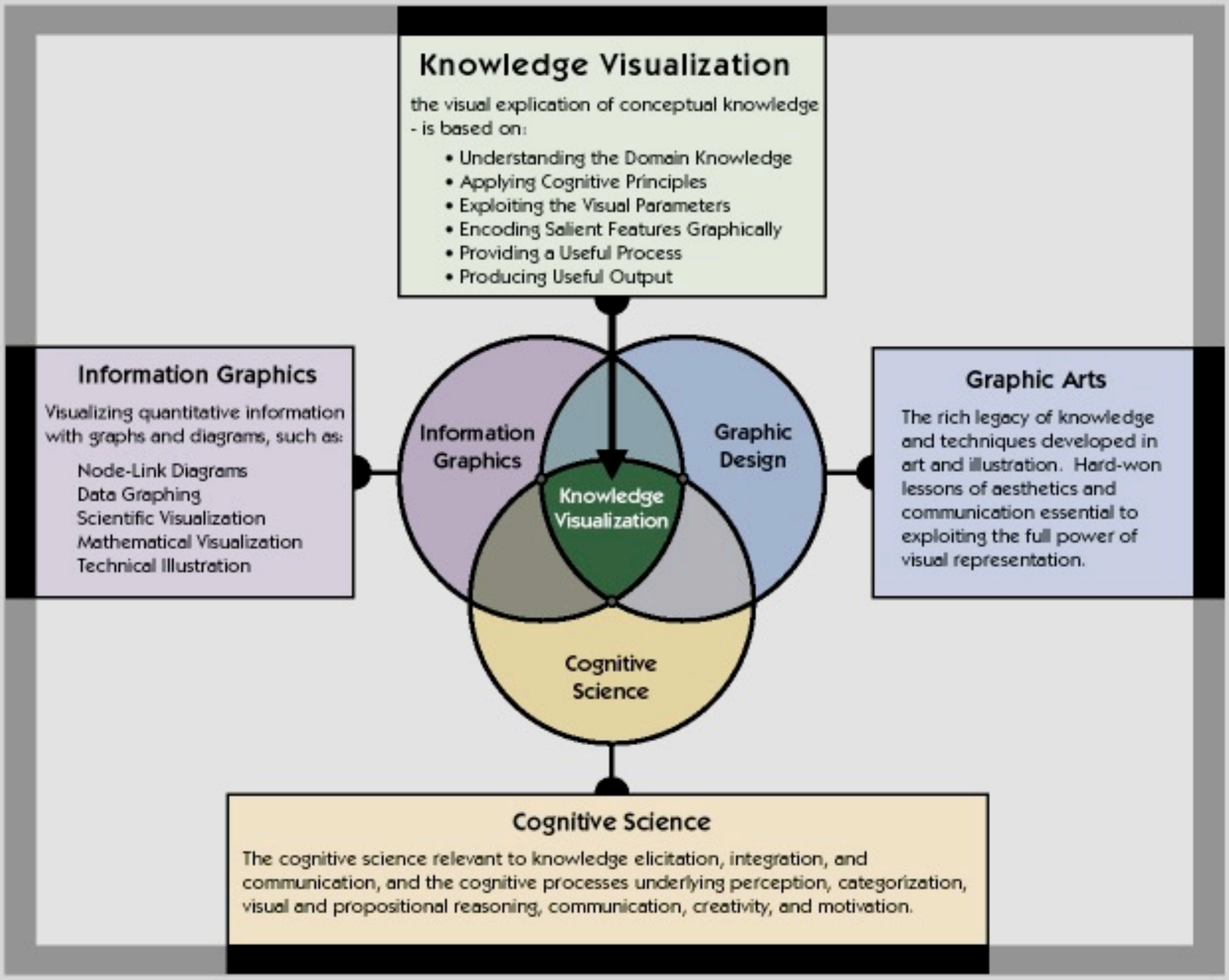
Semiotic Model



Semiotic Triangle

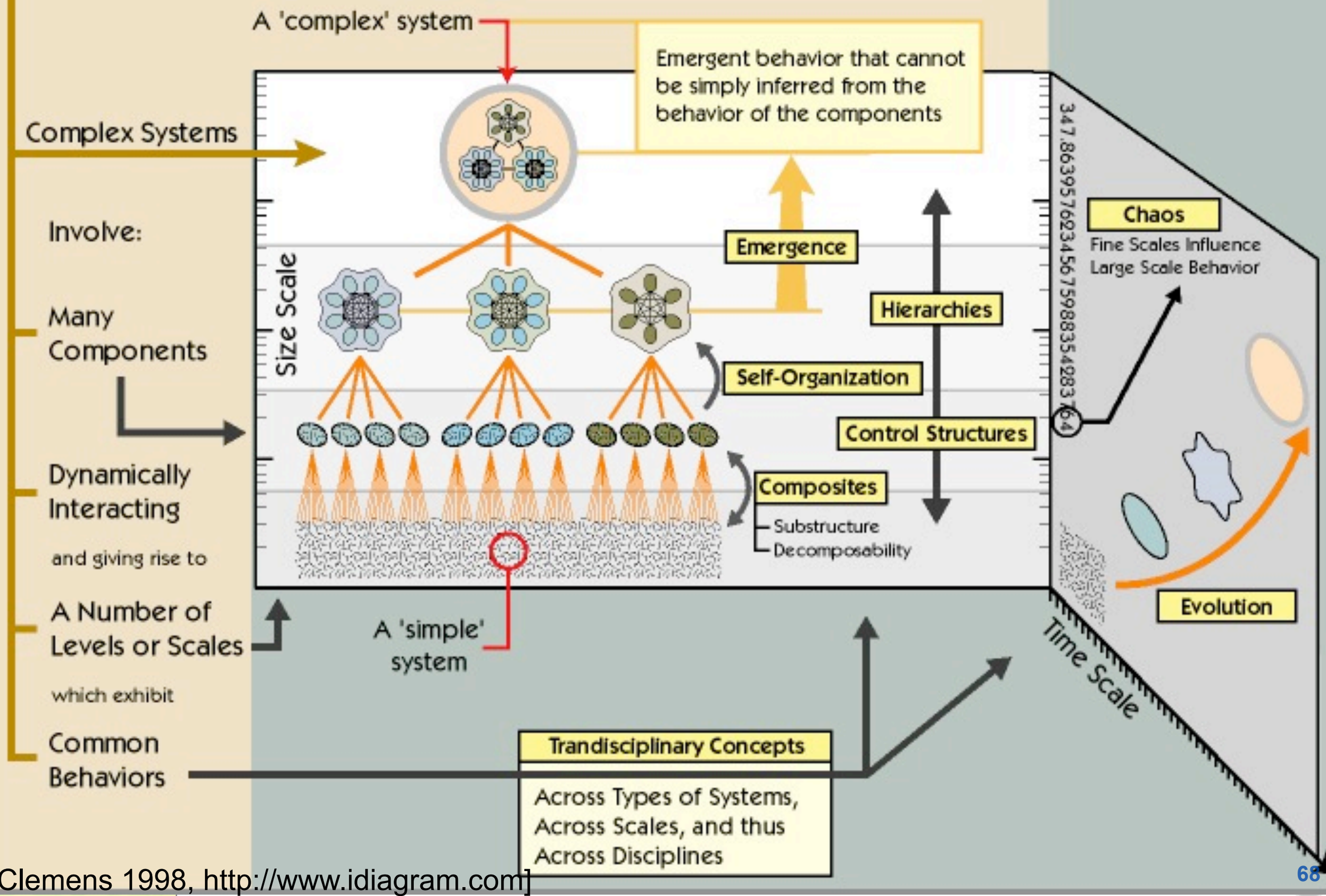


[http://www.idiagram.com/]



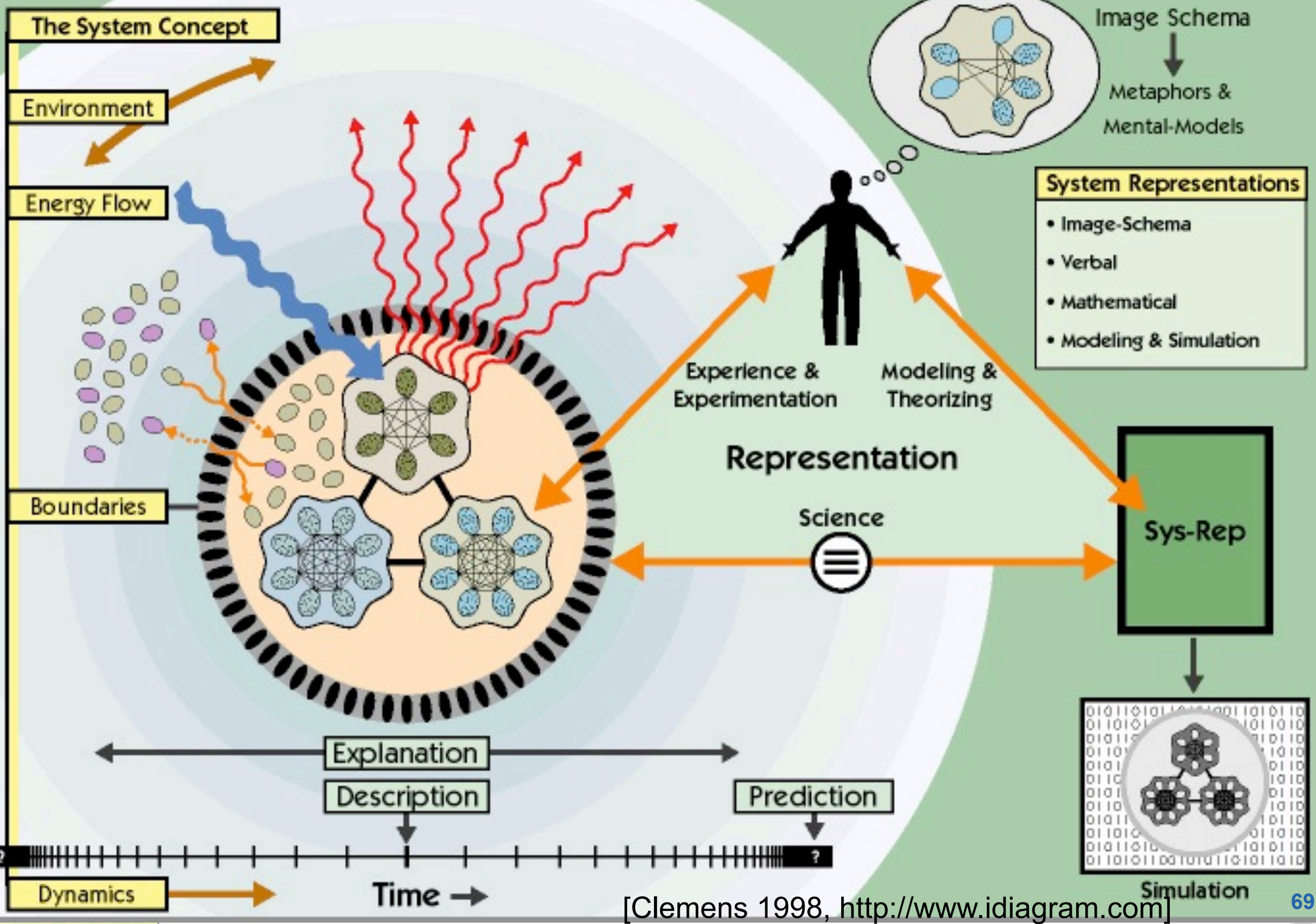
[Clemens 1998, http://www.idiagram.com/kv_venn.html]

Characteristics of Complex Systems



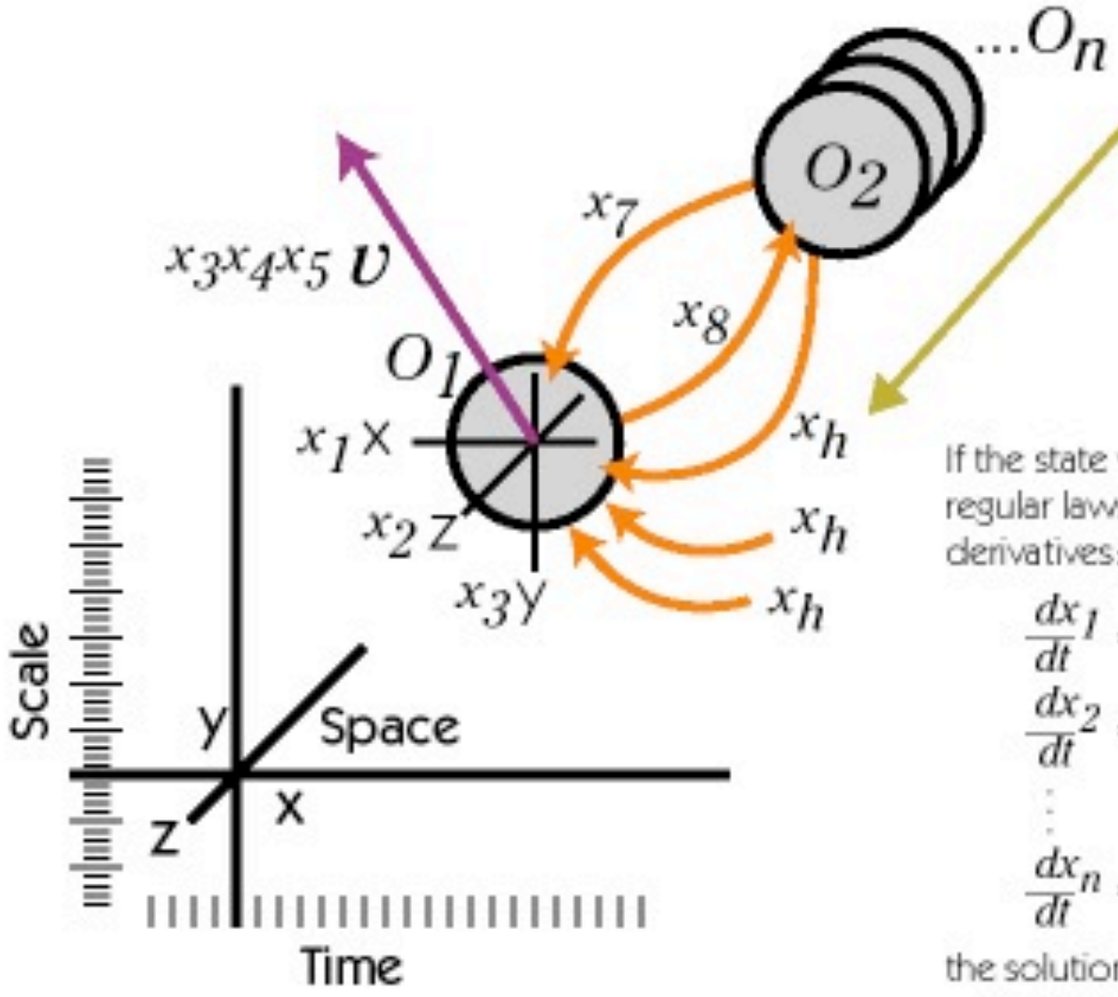
[Clemens 1998, http://www.idiagram.com]

Systems .....and their..... Representation

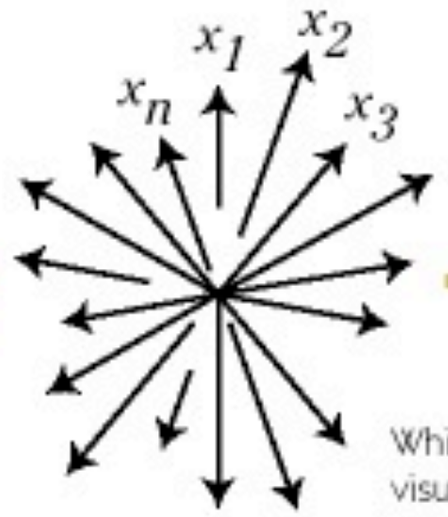


[Clemens 1998, http://www.idiagram.com]

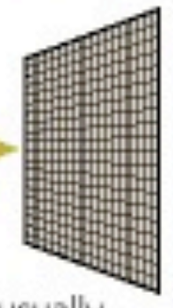
System Dynamics: State & Phase Space



For each of N objects, O, we define n **State Variables** $\{x_1, x_2, x_3 \ldots x_n\}$ sufficient to describe the state of the system. The Nn-dimensional **State Space** of the system is described by the Nn-dimensions and their ranges.



State or Design Space



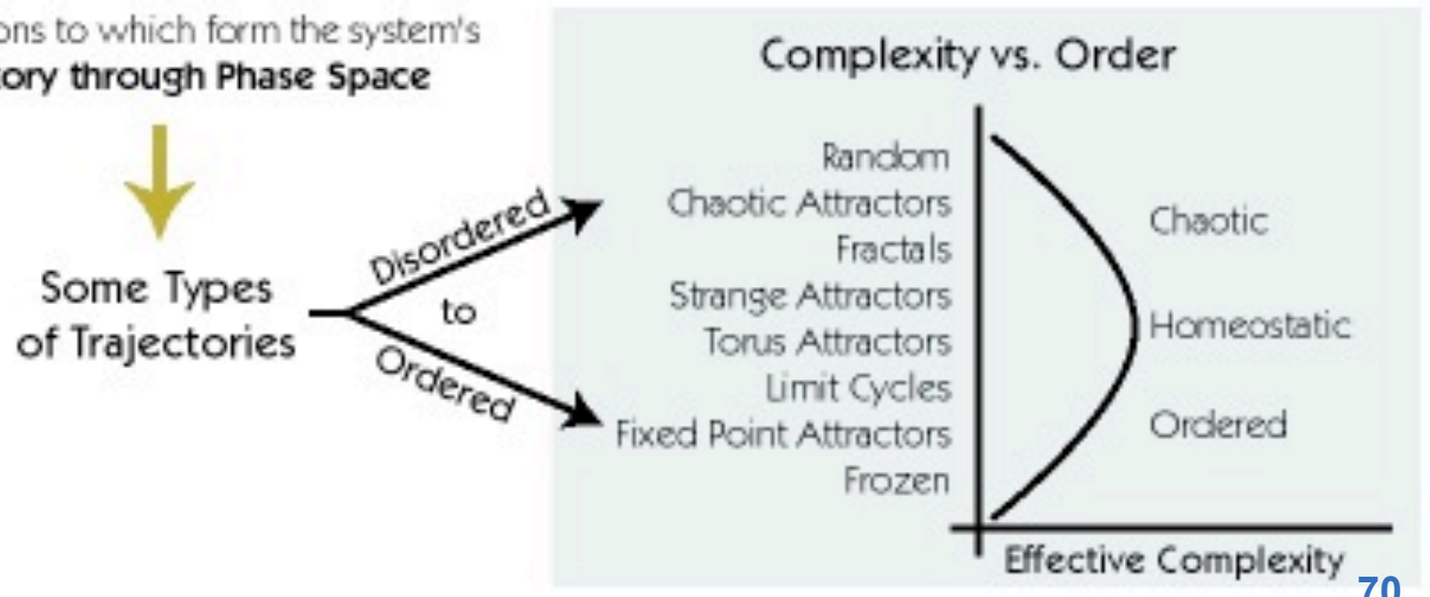
Which we usually visualize in 2 or 3 dimensions.

If the state variables behave according to regular laws, we can describe their derivatives:

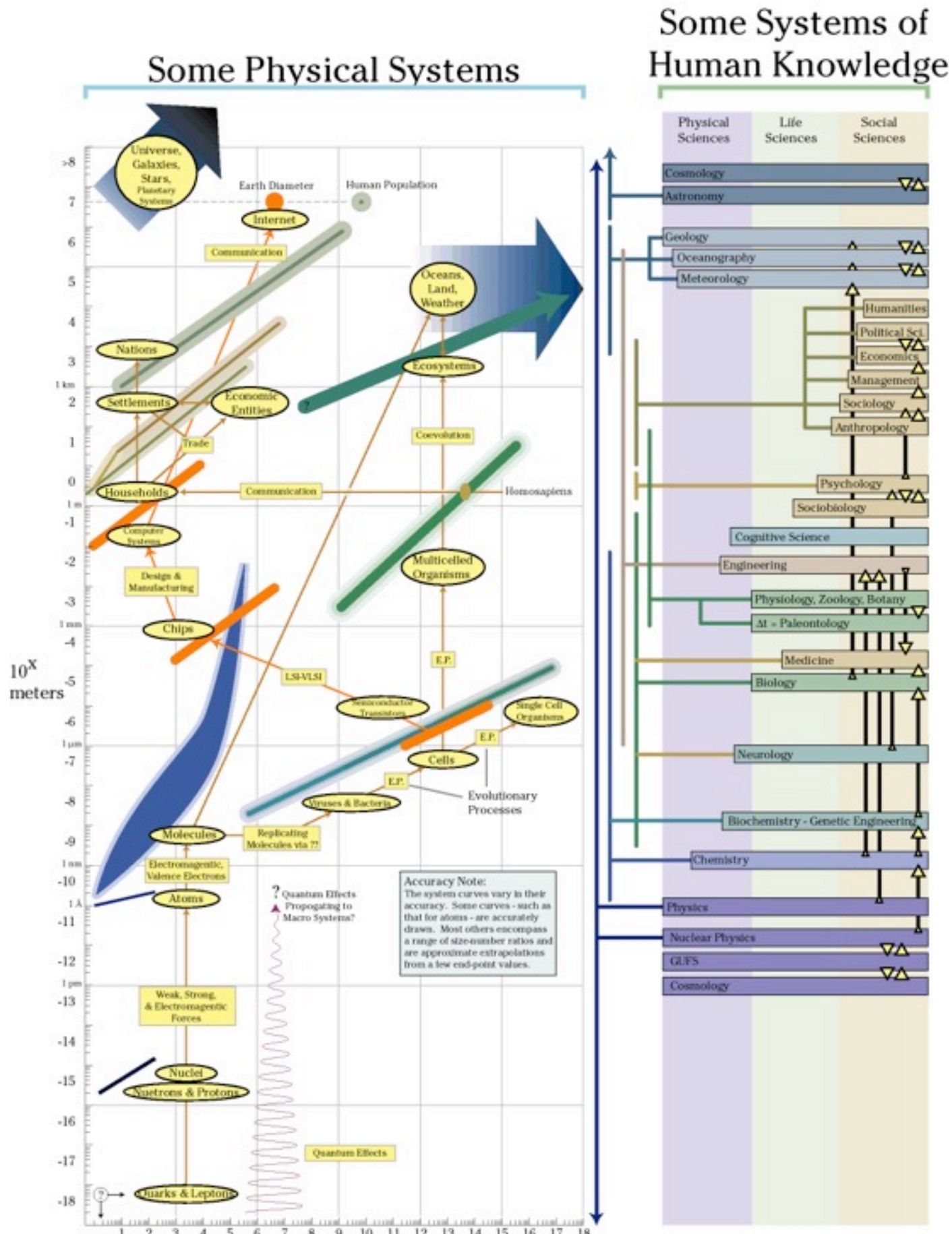
$$\frac{dx_1}{dt} = f_1(x_1, x_2, x_3 \ldots x_{Nn})$$
$$\frac{dx_2}{dt} = f_2(x_1, x_2, x_3 \ldots x_{Nn})$$
$$\vdots$$
$$\frac{dx_n}{dt} = f_n(x_1, x_2, x_3 \ldots x_{Nn})$$

the solutions to which form the system's **Trajectory through Phase Space**

Statistical Approaches:
When there are too many units to keep track of individually, and the units all exhibit identical or similar behavior, the systems can be modeled using statistical methods.

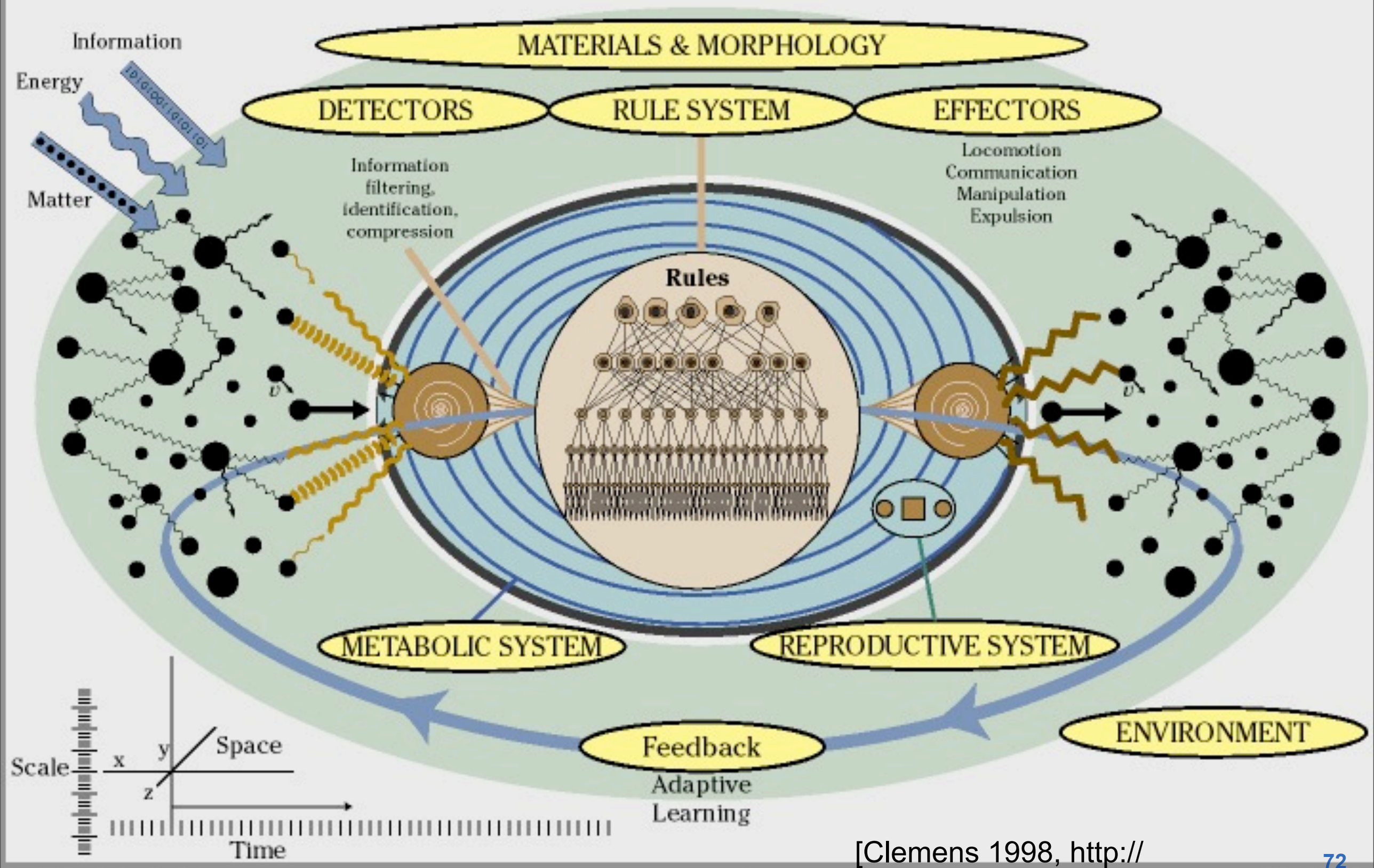


[Clemens 1998, http://www.idiagram.com]



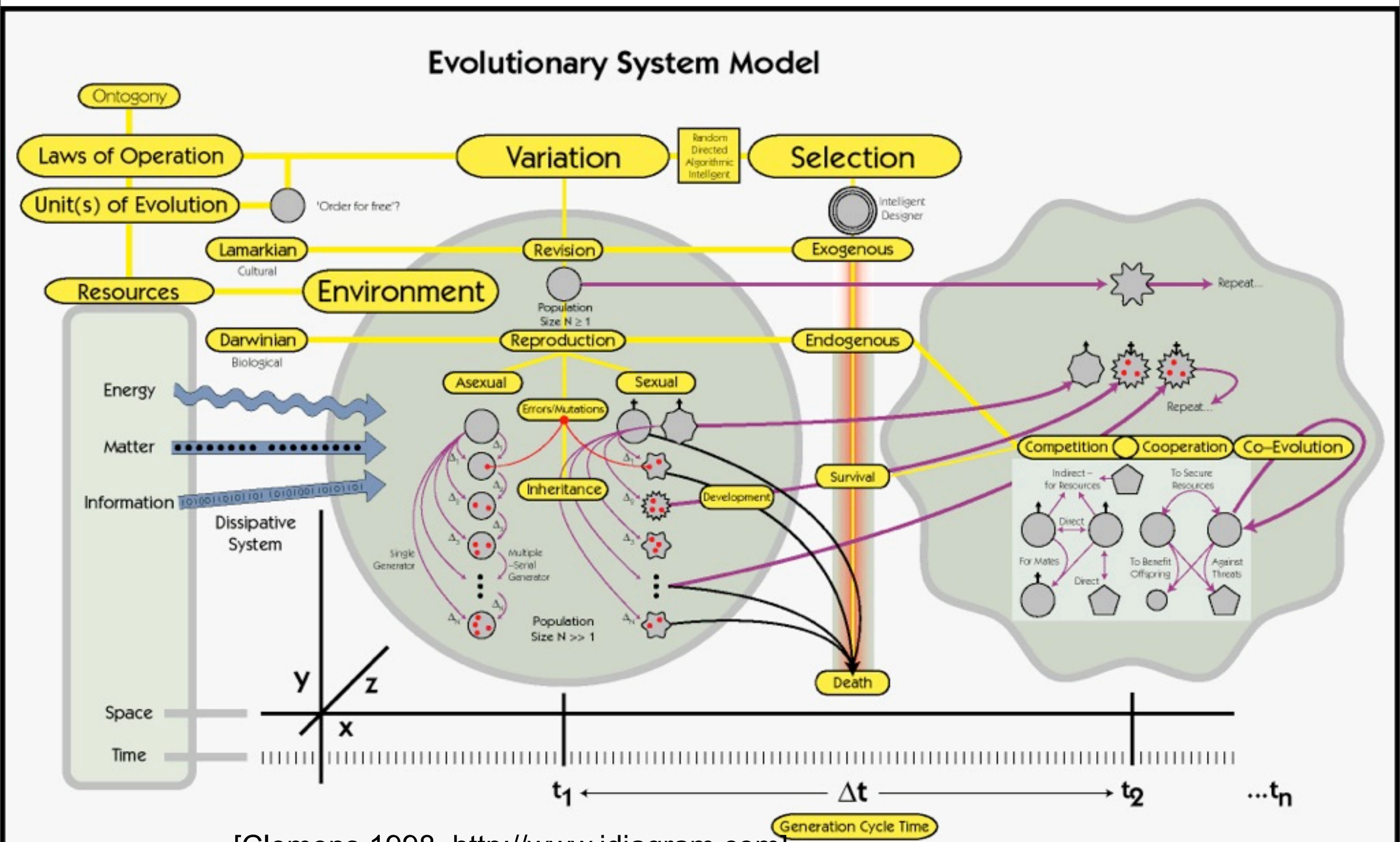
[Clemens 1998, http://www.idiagram.com]

Complex Adaptive System Model



[Clemens 1998, http://www.idiagram.com]

Evolutionary System Model

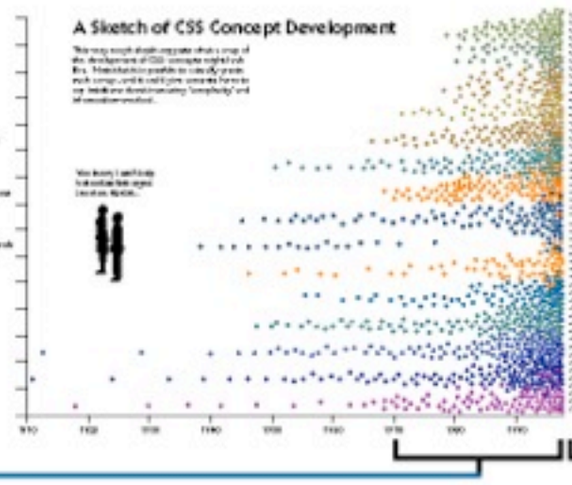


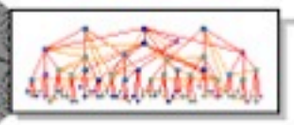
[Clemens 1998, http://www.idiagram.com]

Visualizing Complex Systems Science (CSS)

Why is Complexity Complicated?

Abstract





Because it is:

- Transdisciplinary
- New
- Conceptually Difficult
  - What is CSS anyway?
  - CSS is conceptually complex
  - Complex Systems are invisible

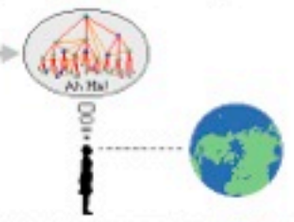
Integration

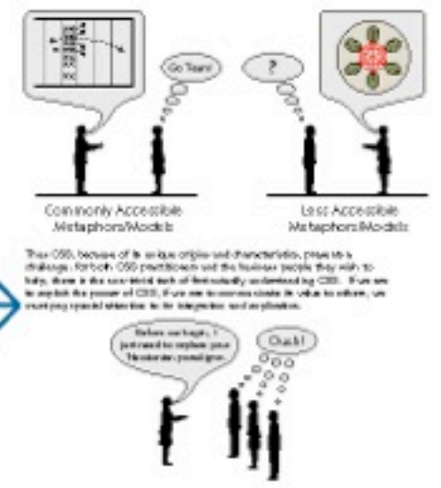
Integration & Diagrams

Conceptual Complexity & Diagrams

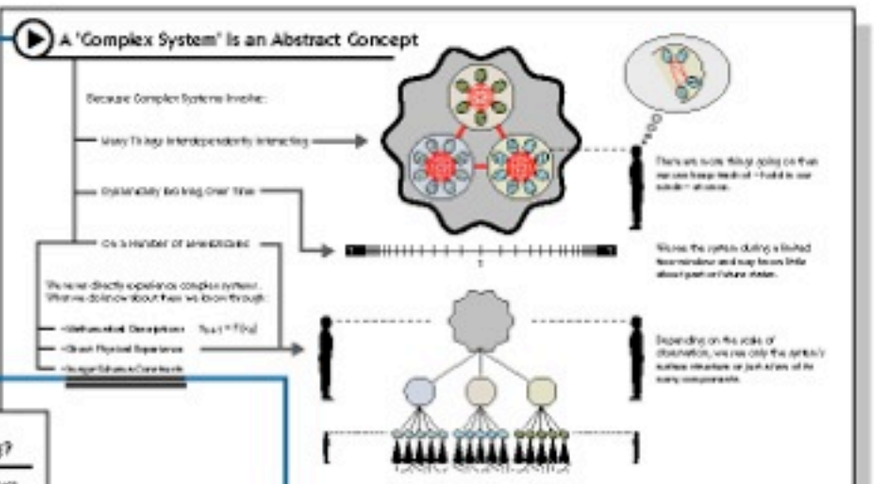
For example, even a simple model of evolution is more than a mind full.

Visualizing CSS & Management

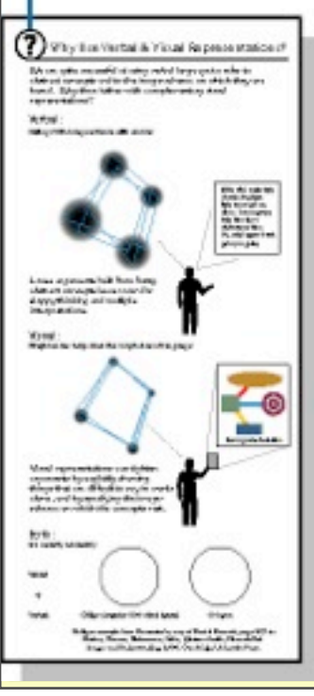




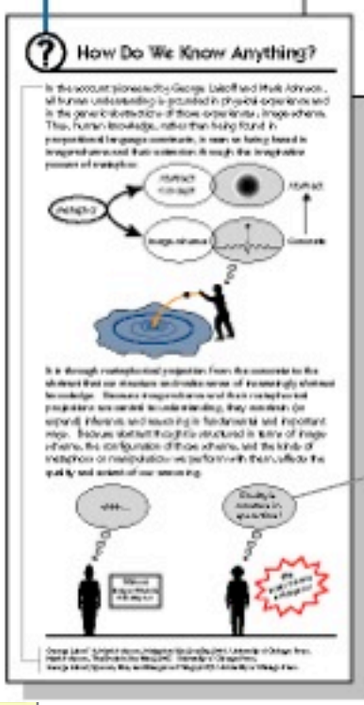
A 'Complex System' Is an Abstract Concept



Why Are Verbal & Visual Representations?



How Do We Know Anything?

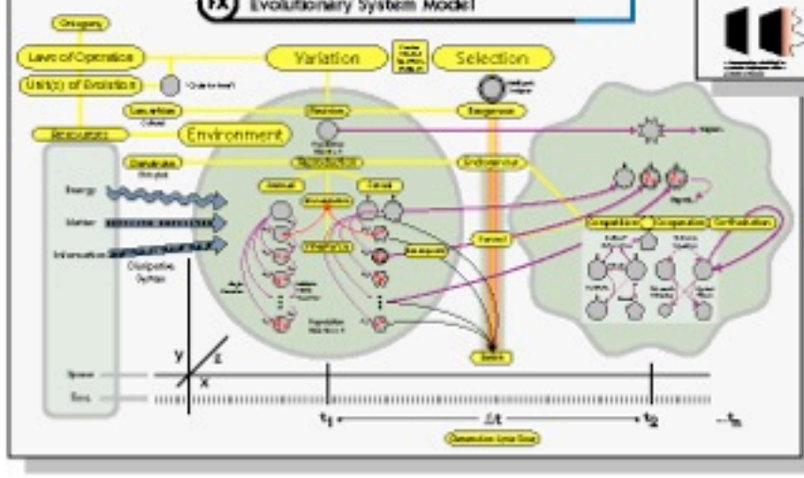


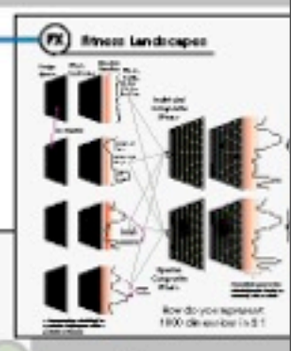
This is the Point:

Because complex systems are **abstract**, visual models and visual metaphors – whether in our heads or on paper – are not just useful analogies or an interesting way to think about such things, **they ARE the things**. Other than mathematical models, and very limited direct experience, we simply have no direct way we understand about such systems.

Visual models and metaphors of complex systems – how we imagine them, how we draw them – matter because to us they are the systems. If we are to understand complex systems, talk about them, use them to model the world, then we should be careful that our conceptions of them – our distinctly visual conceptions – are accurate and productive.

Evolutionary System Model





Brain Images

- visualizations of structures and activities in the brain
  - e.g. neurons, cerebellum, visual cortex,
  - functions such as connections (wires)
- electrical and chemical activities

Ramón y Cahal's Neuron Diagram

- drawing of a Purkinje cell
  - large neurons in the cerebellum
- based on tissue stained with silver nitrate
  - viewed through a microscope

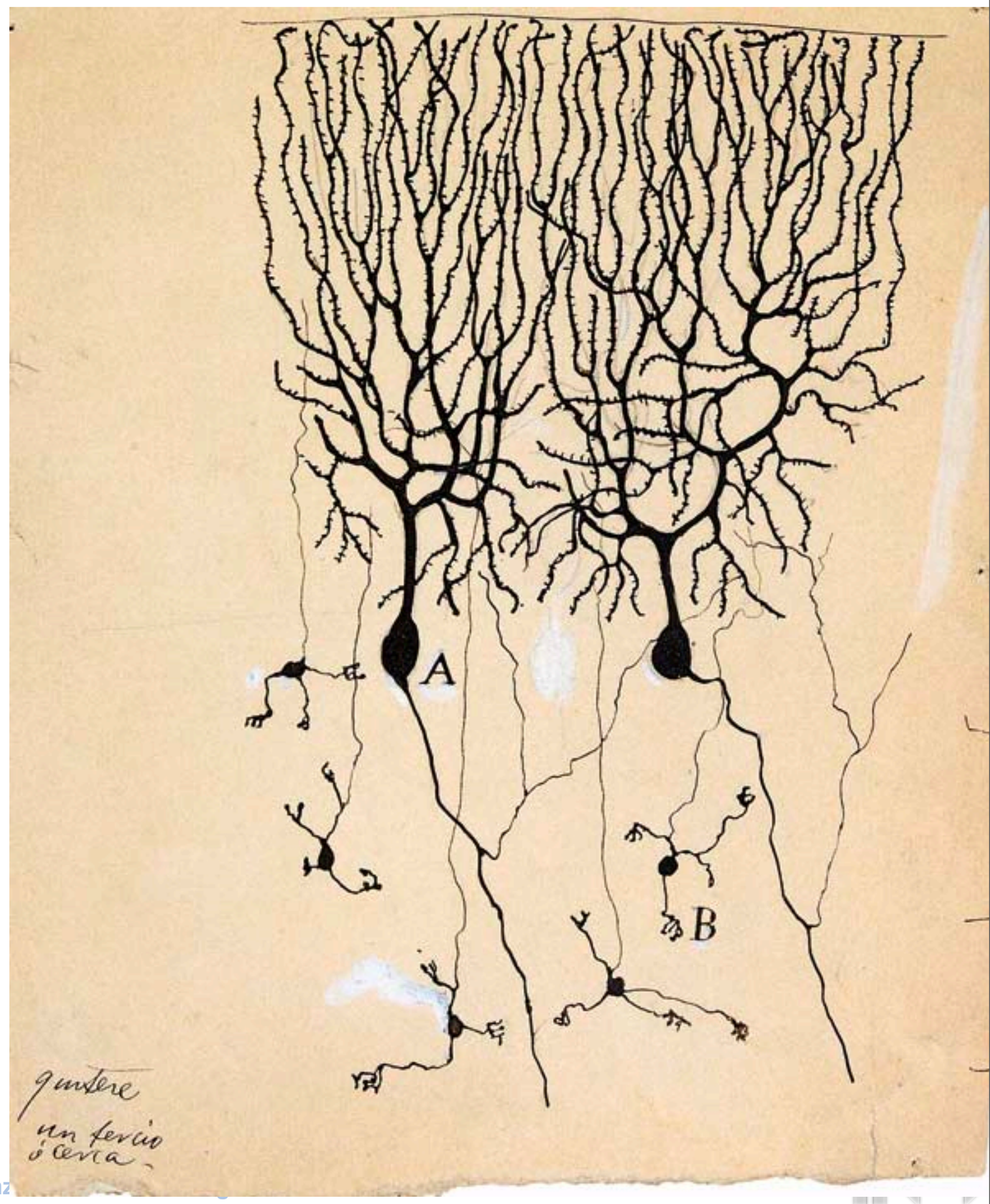


Photo Credit: Herederos de Santiago Ramón y Cajal, via MIT Technology Review "Time Travel Through the Brain" http://www.technologyreview.com/biomedicine/23758/

Mouse Cerebellum

- two-photon microscopic image
- allows images of live tissue
- uses infrared light

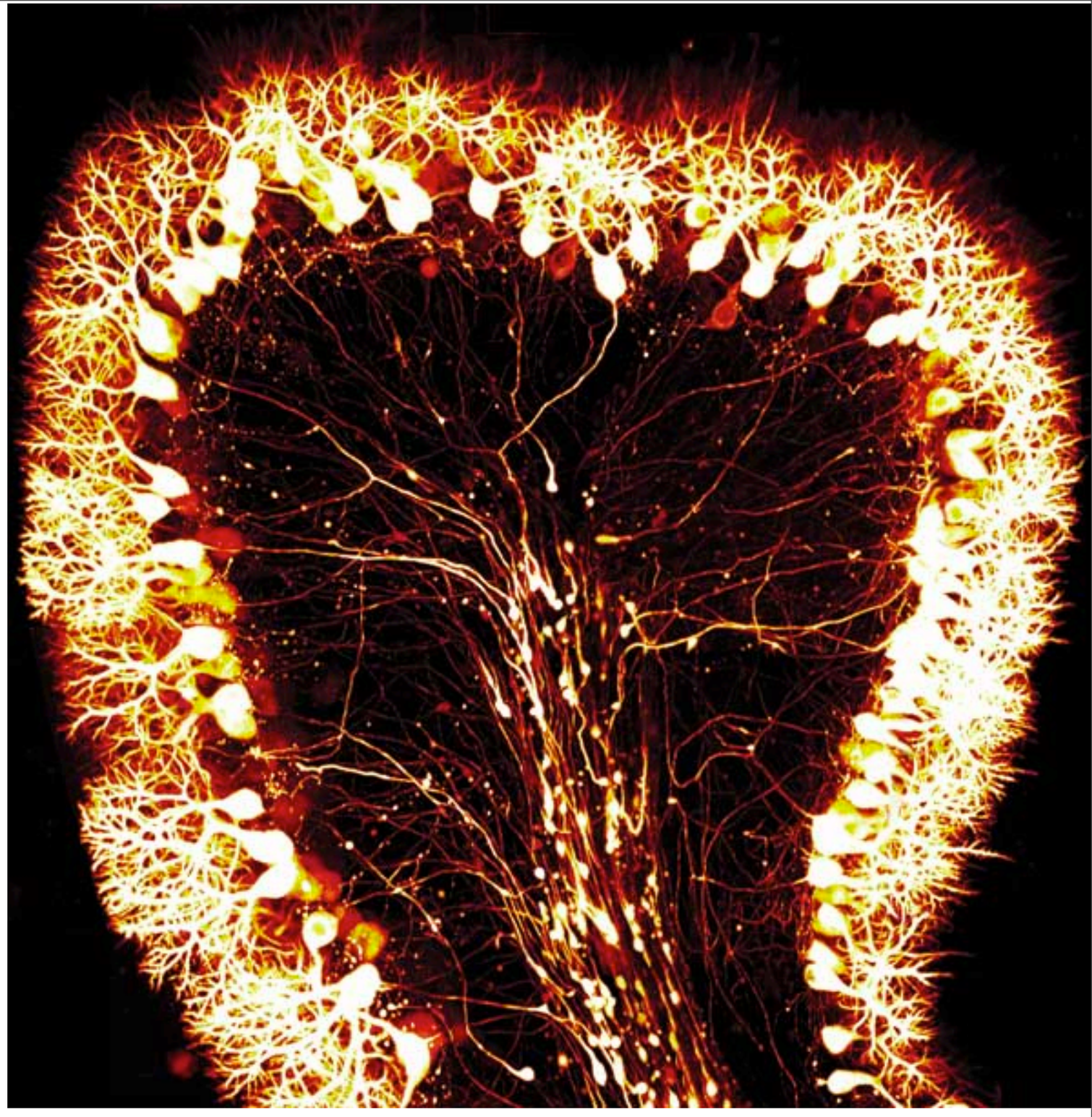
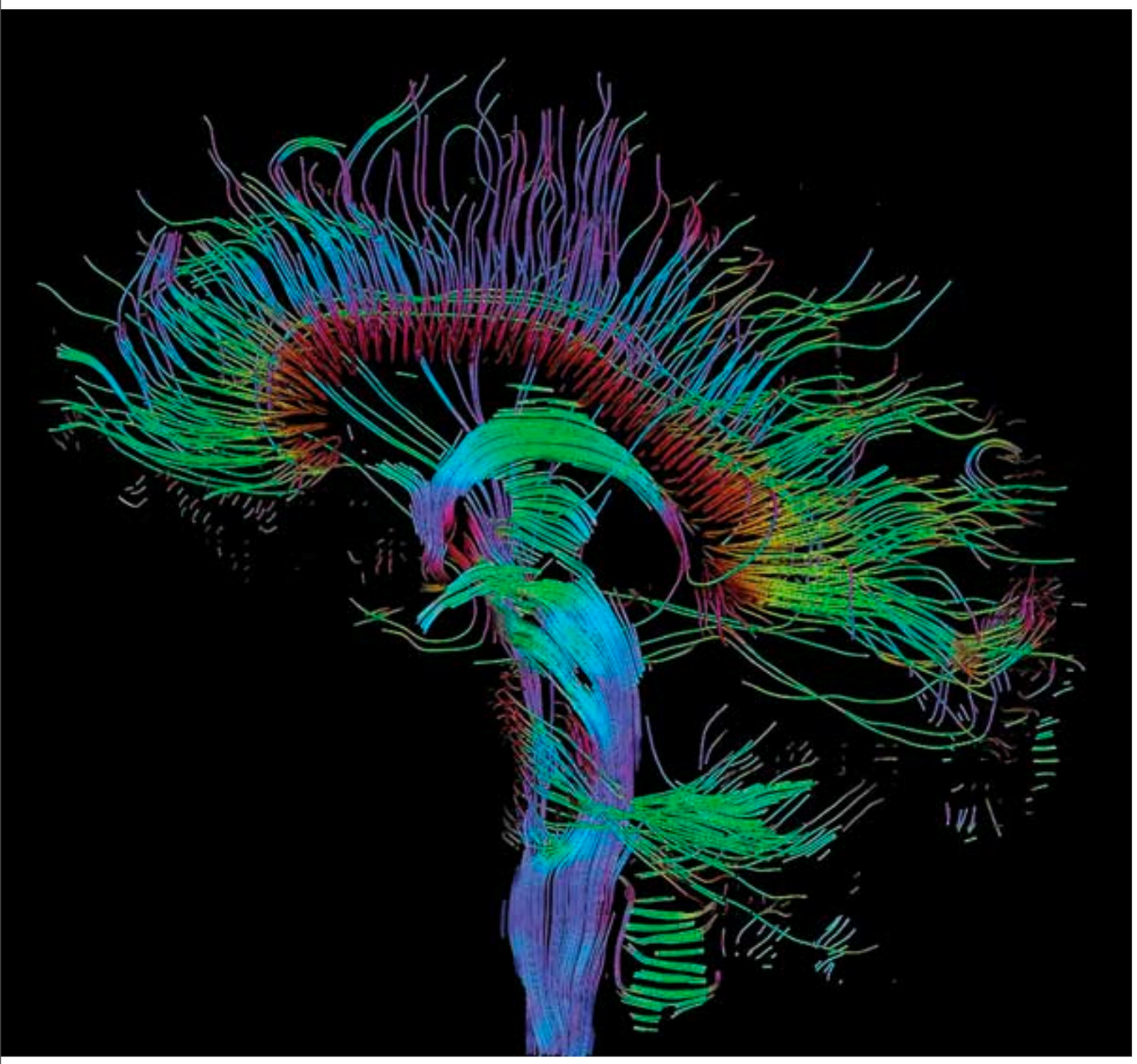


Photo Credit: Alanna Watt and Michael Häusser, UCL,
via MIT Technology Review “Time Travel Through the Brain” http://www.technologyreview.com/biomedicine/23758/

Human Thalamus



- fibers radiating from the thalamus in the human brain
- diffusion tensor image
  - variation of magnetic resonance imaging (MRI)

Photo Credit: Thomas Schultz/University of Chicago, via MIT Technology Review "Time Travel Through the Brain"
http://www.technologyreview.com/biomedicine/23758/

Fluorescent Purkinje Cells

- Purkinje cell (red)
- nerve fiber from another cell (green)
- injection of fluorescent dye into individual cells

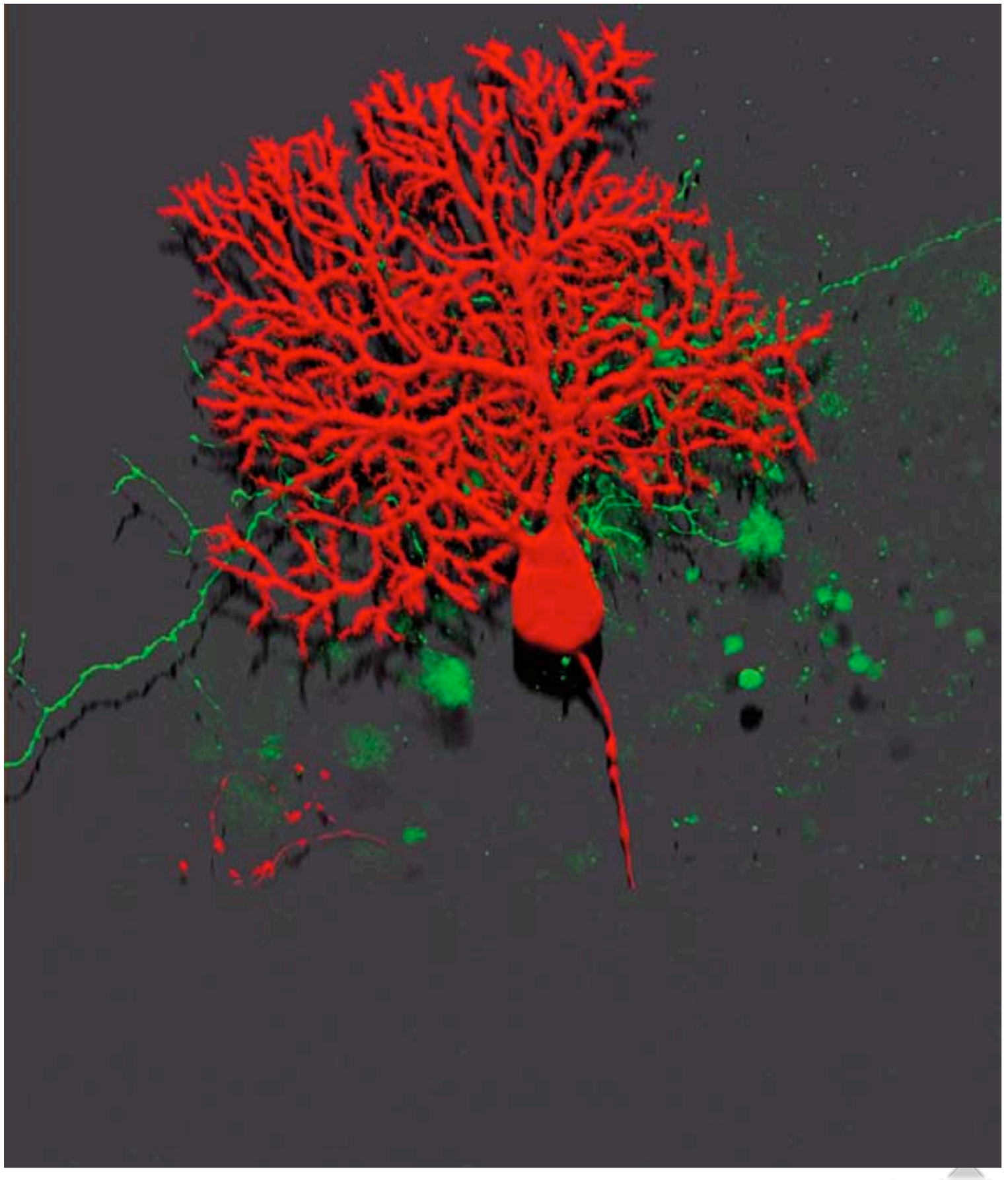
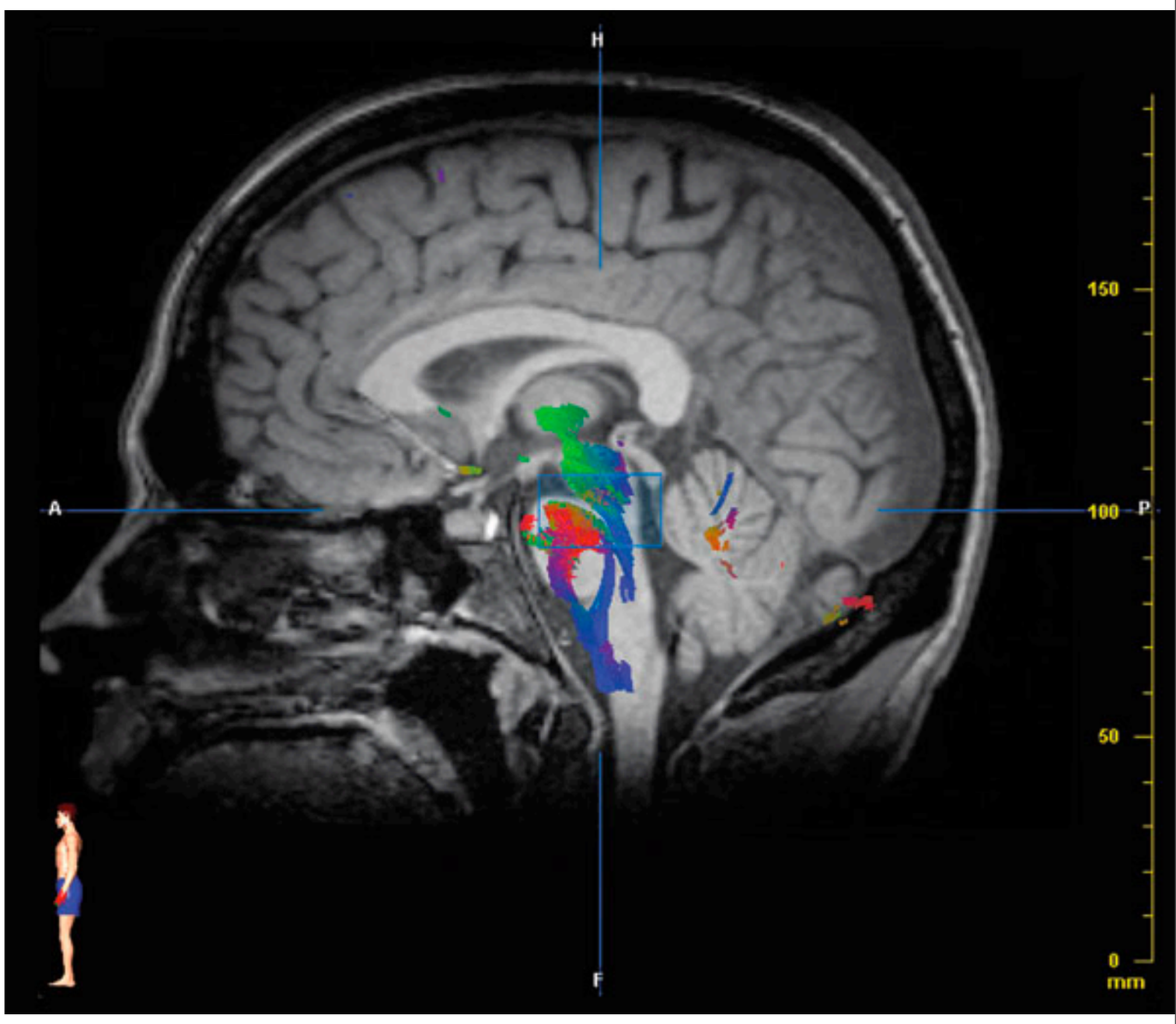


Photo Credit: Michael Häusser, University College London
via MIT Technology Review "Time Travel Through the Brain"
http://www.technologyreview.com/biomedicine/23758/

Neural Wiring Map 1

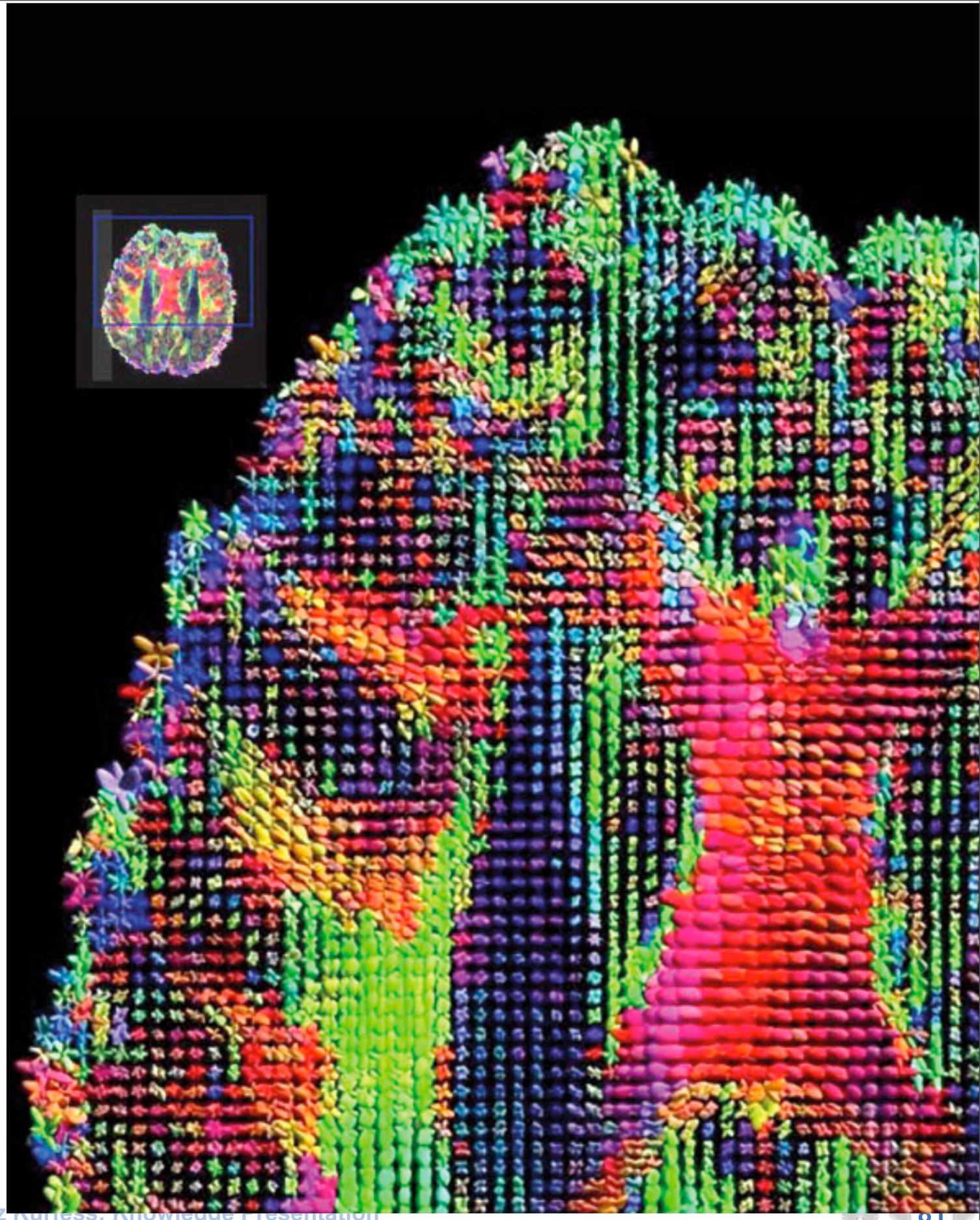
- created via BrainLab software from an MRI scan
- subsets of wires are highlighted
  - colors indicate the directions of the wires



Intelligence Explained, MIT Technology Review, November/December 2009
http://www.technologyreview.com/biomedicine/23695/

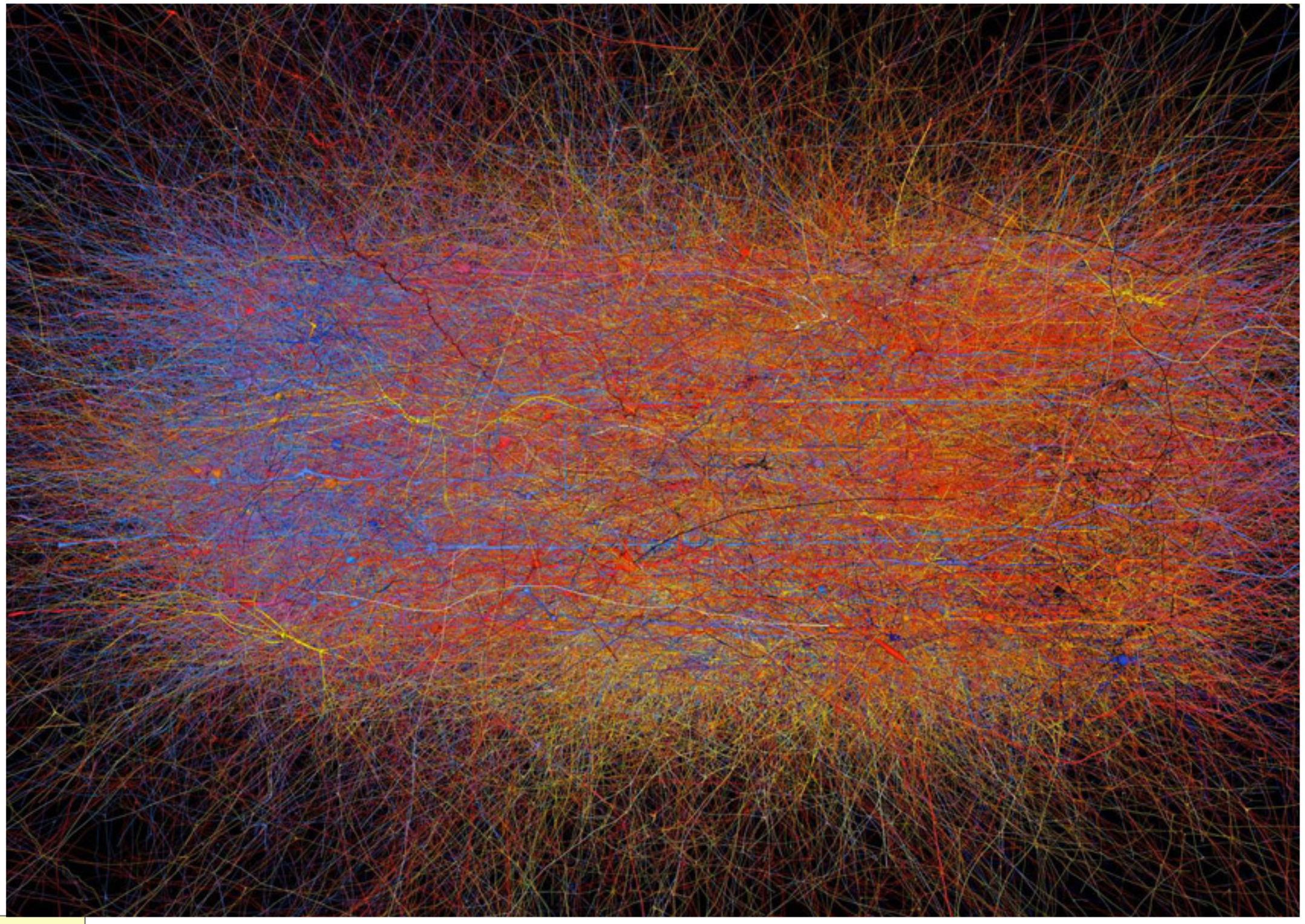
Neural Wiring Map 2

- circuit diagrams derived from the diffusion of water molecules in the brain
- software calculates the most likely paths of neural wires



Intelligence Explained, MIT Technology Review, November/December 2009
http://www.technologyreview.com/biomedicine/23695/

Mammalian Neocortical Column

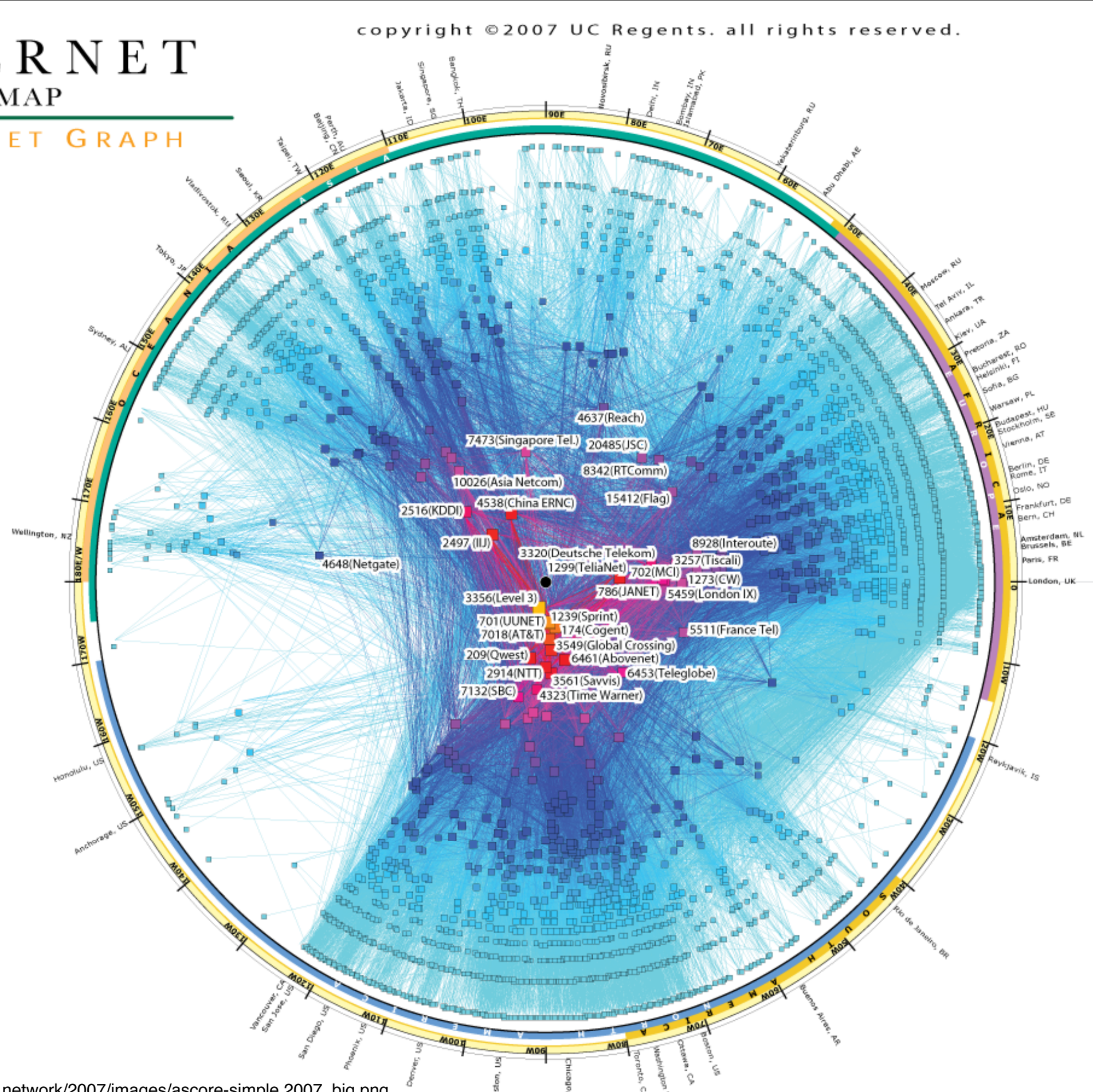


Tuesday, May 4, 2010

Connect the dots: A representation of a mammalian neocortical column, the basic building block of the cortex. The representation shows the complexity of this part of the brain, which has now been modeled using a supercomputer.
Credit: BBP/EPFL

- http://www.technologyreview.com/files/13733/bluebrain_x600.jpg
- http://www.technologyreview.com/Biotech/19767/

IPv4 INTERNET
TOPOLOGY MAP
AS-level INTERNET GRAPH



http://www.caida.org/research/topology/as_core_network/2007/images/ascore-simple.2007_big.png

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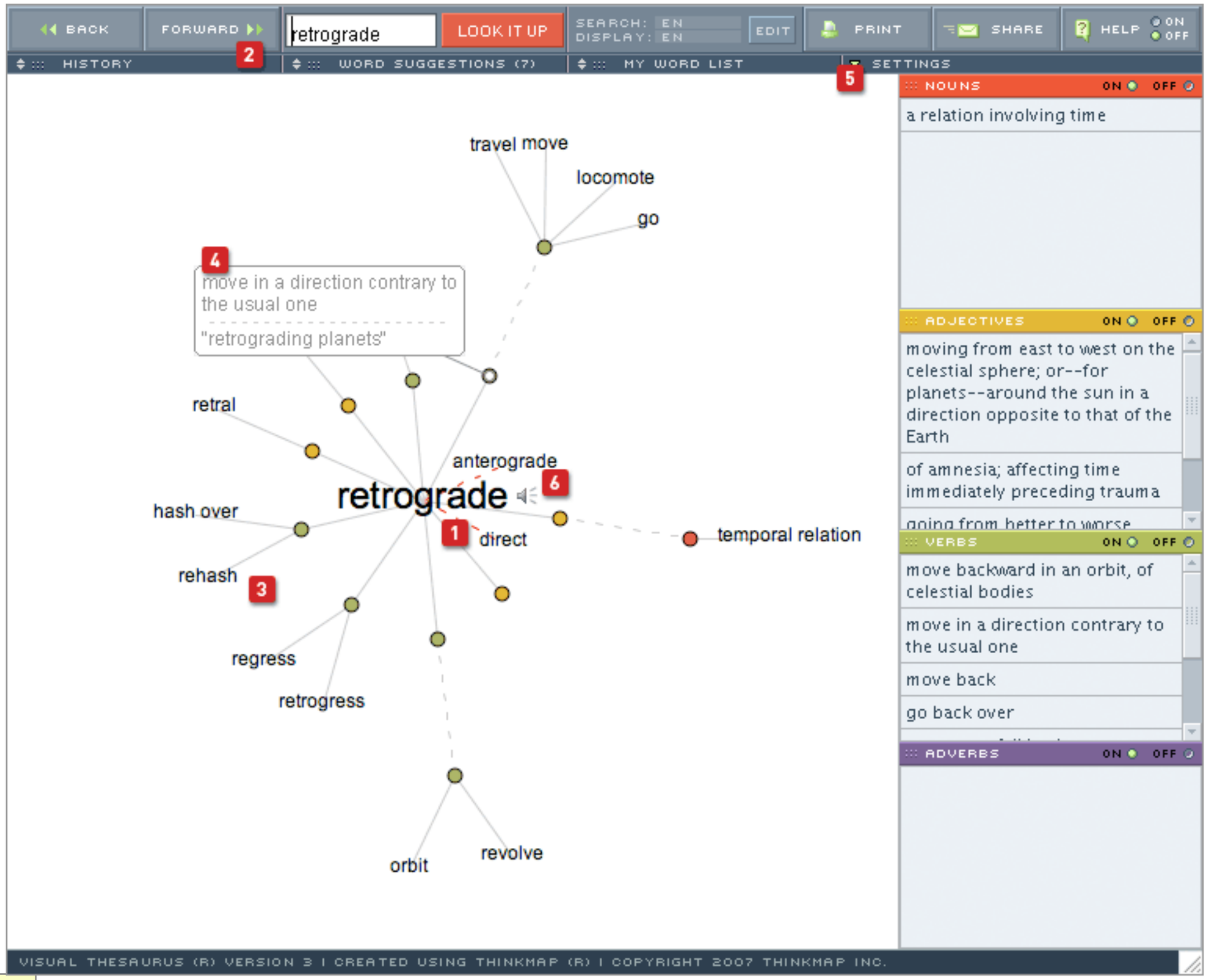
see also http://discovermagazine.com/2006/oct/map-internet-servers/

Visual Thesaurus



http://www.visualthesaurus.com/howitworks/images/screen.gif

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- Here are 6 basic steps on how to use the Visual Thesaurus. If you'd like to see a more thorough introduction, click here for the interactive product tour, or click here to read the entire manual.
  - The Center. The Visual Thesaurus displays words and meanings that are related to the item in the center of the display.
  - The Toolbar. Search for words, view word suggestions, see search history, and change preferences settings from the toolbar. Forward/Back buttons provide easy navigation. Help tips are always available.
  - Words. Click on a word to bring it to the center. Click on the speaker icon to hear the word spoken. Surrounding the word are words and meanings that are related to it.
  - Meanings. Roll your mouse over a meaning to learn more about it. Click on a meaning to bring it to the center.
  - Settings. Click on the Settings menu to personalize font size, types of relationships shown, content filtering, special keyboard shortcuts, and more.
  - Special Features. Printing, spell checking, Internet image and web page search are all available.

Visible Body Overview

- complete, fully interactive, 3D human anatomy model
- developed by Argosy Publishing
  - http://www.visiblebody.com/
- highly detailed, anatomically accurate, 3D models of all human body systems
- includes content covered in an undergraduate-level Anatomy and Physiology course

Tuesday, May 4, 2010

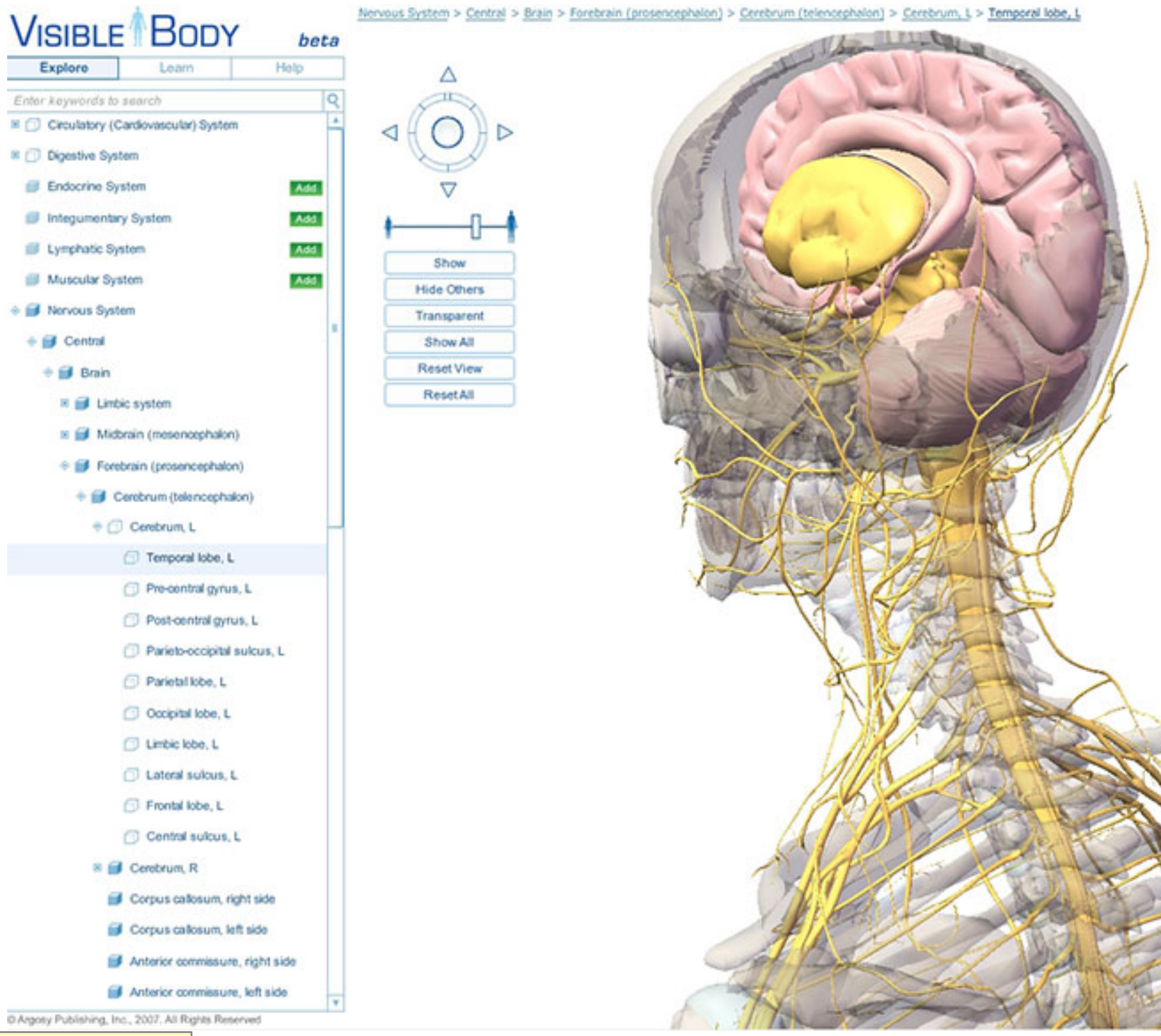
Overview
Argosy's Visible Body is the best human anatomy visualization tool available today.

The Visible Body features:

* Complete, fully interactive, 3D human anatomy model
* Detailed models of all body systems
* Dynamic search capability
* Easy-to-use, 3D controls
* Seamless compatibility with Internet Explorer

This entirely Web-delivered application offers an unparalleled understanding of human anatomy. The Visible Body includes 3D models of over 1,700 anatomical structures, including all major organs and systems of the human body.
The Model
The Visible Body consists of highly detailed, anatomically accurate, 3D models of all human body systems. The models were developed by an extensively trained team with decades of experience in medical illustration and biomedical visualization. All anatomical content has been reviewed for accuracy by our panel of experts, including physicians and anatomists. The beta release includes content covered in an undergraduate-level Anatomy and Physiology course. Years of modeling and enhancement make it the most sophisticated and complete 3D model of the human body available.

Visible Body Example: Brain



http://www.visiblebody.com/nervous_system2.html

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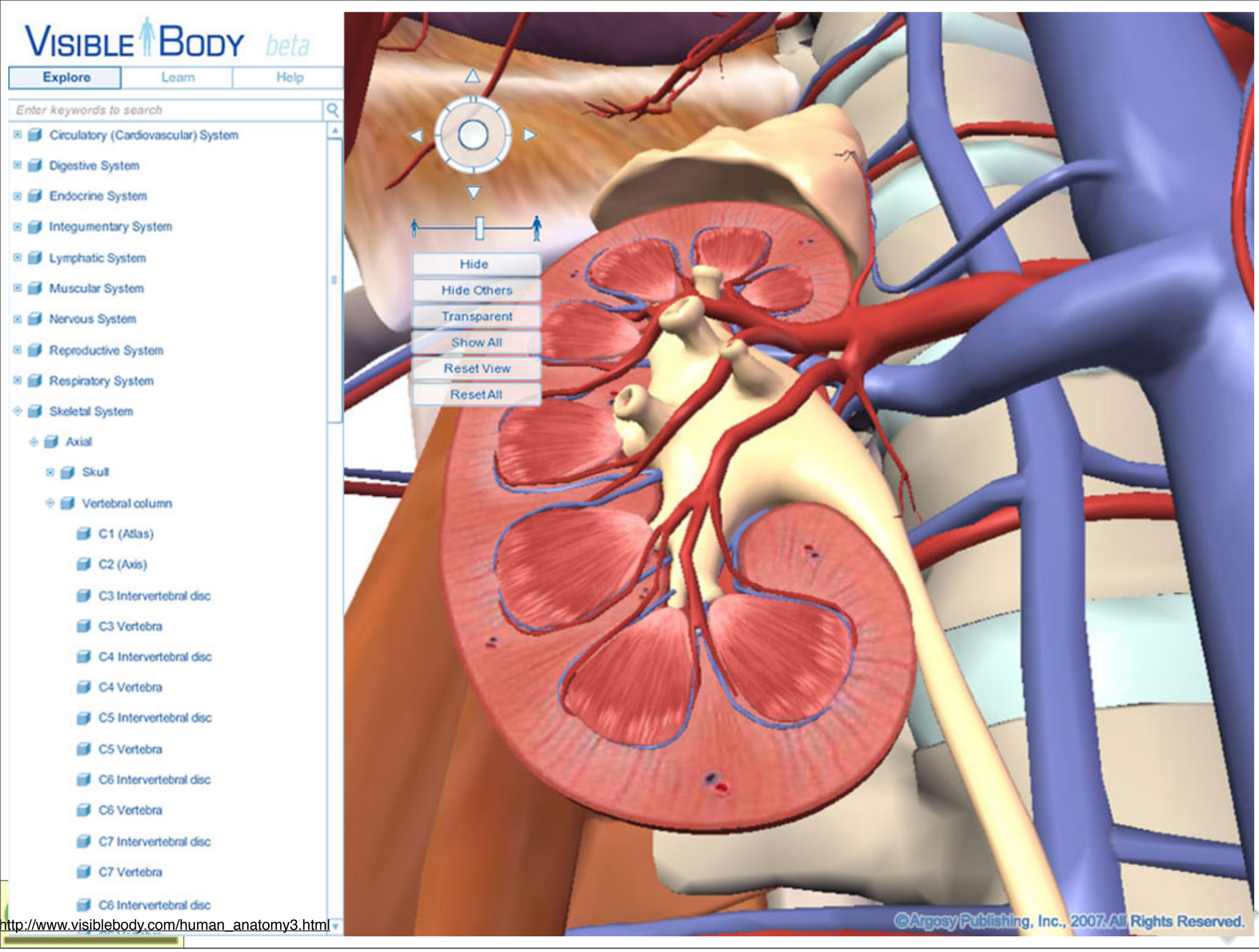
Visible Body Example: Kidney



Visible Body Operations

- With the Visible Body, you can:
  - Search for and locate anatomical structures by name.
  - Hide, rotate, see through, and explore parts of human anatomy.
  - Move the model in three-dimensional space
    - clicking directly on the model or using the virtual joystick.
  - Zoom in and out, using either the on-screen zoom slider or a mouse scroll wheel.
  - Click on systems or structures to make them transparent or hide them entirely.
  - Click on anatomical structures to reveal names.