



Knowledge Presentation and Visualization

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Acknowledgements

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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

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

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

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

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

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

Visual Presentation Methods cont.

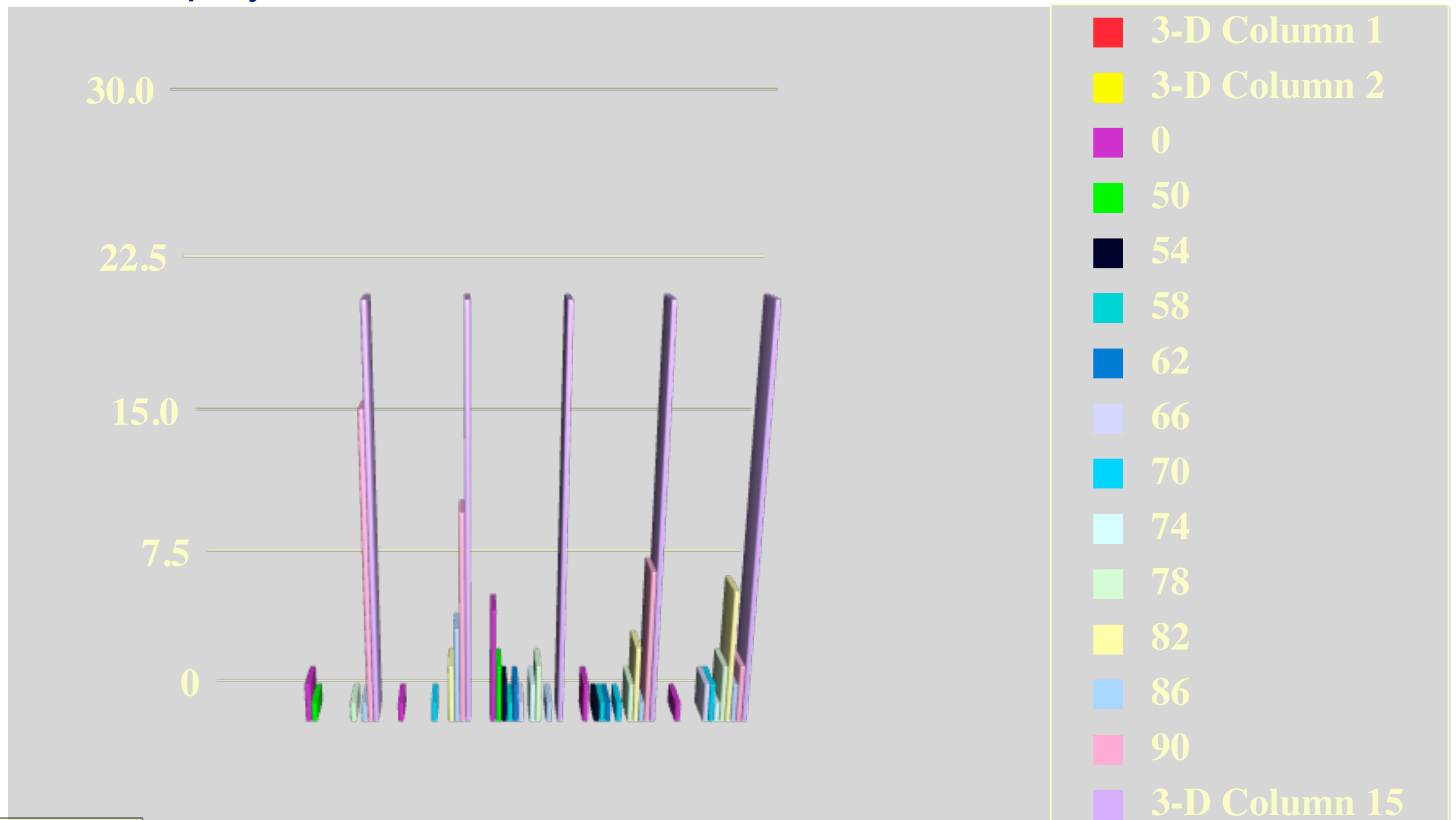
- ❖ network (graph)
 - ❖ items are represented as nodes, and relationships as arcs
- ❖ clusters
 - ❖ related items are grouped together
- ❖ bar chart
 - ❖ indicates values of properties
- ❖ histogram
 - ❖ shows the distribution of items
- ❖ perspective wall

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.

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

Examples of Knowledge Presentation and Visualization

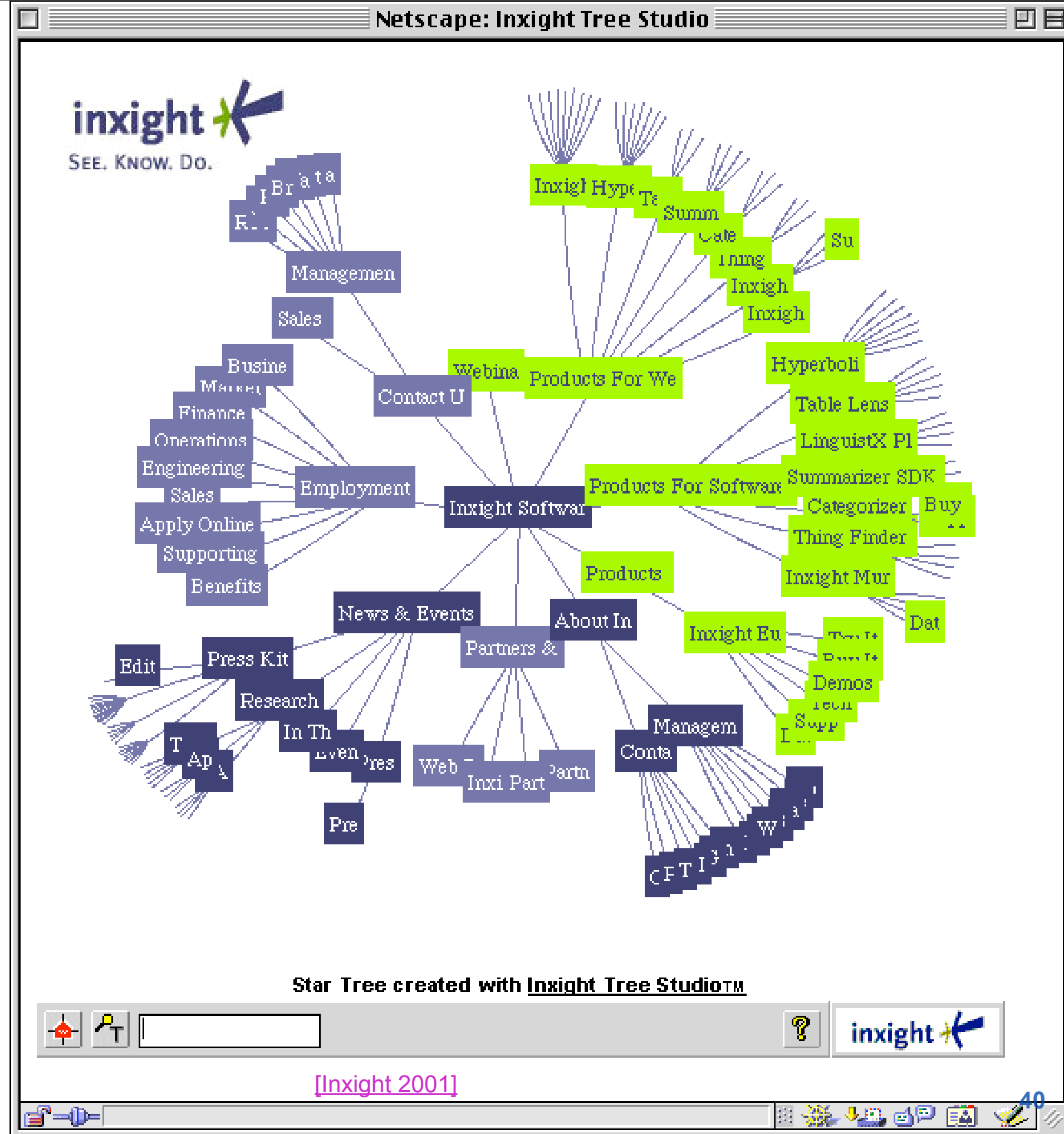
- ❖ hierarchical methods
 - ❖ trees
- ❖ graph-based methods
 - ❖ concept maps, mind maps, conceptual diagrams
- ❖ similes
 - ❖ the appearance of the proxy reflects the original
 - ❖ maps
- ❖ models
 - ❖ important functional properties are reproduced
- ❖ metaphors

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

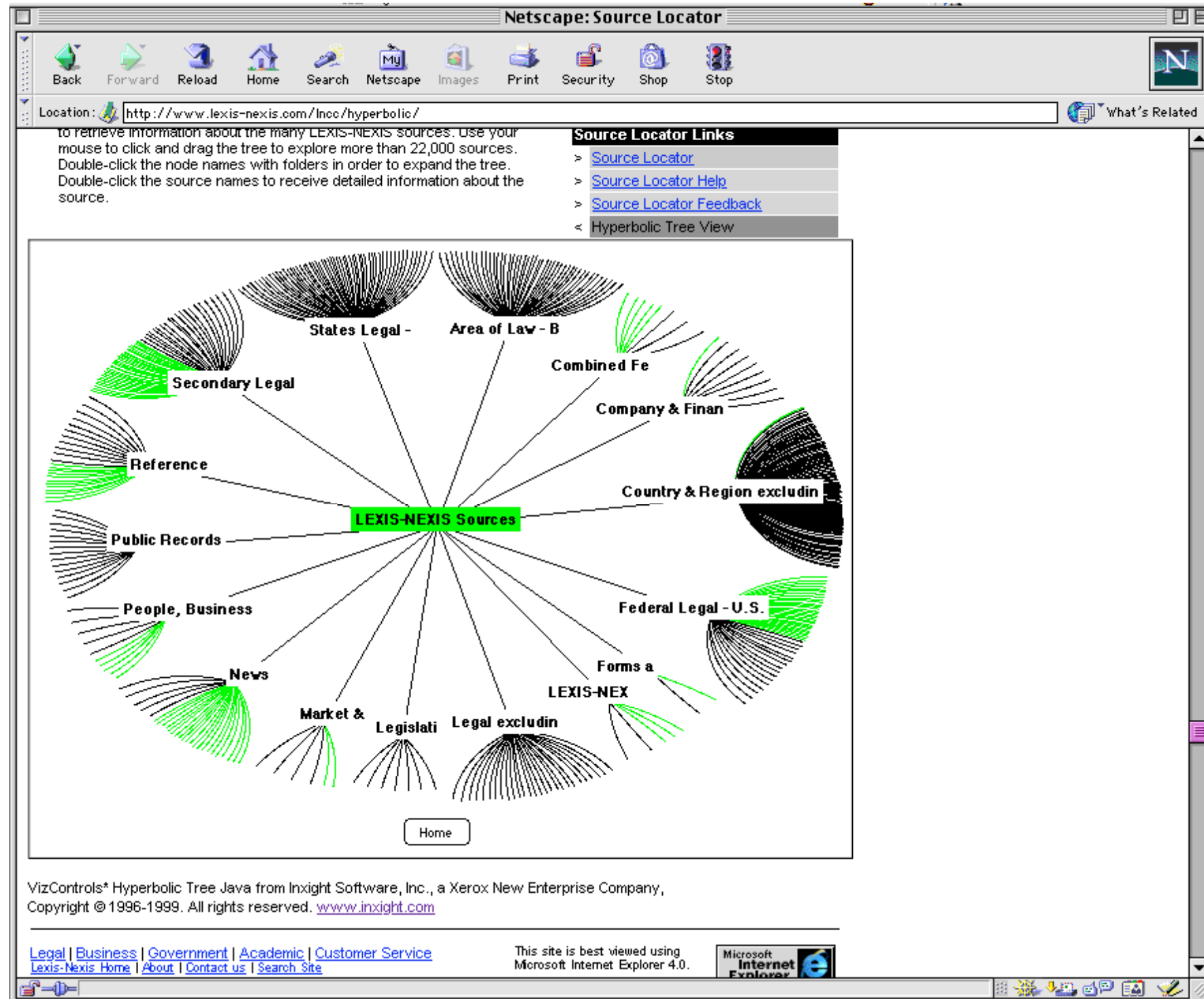
Inxight Tree

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



Lexis-Nexis Tree

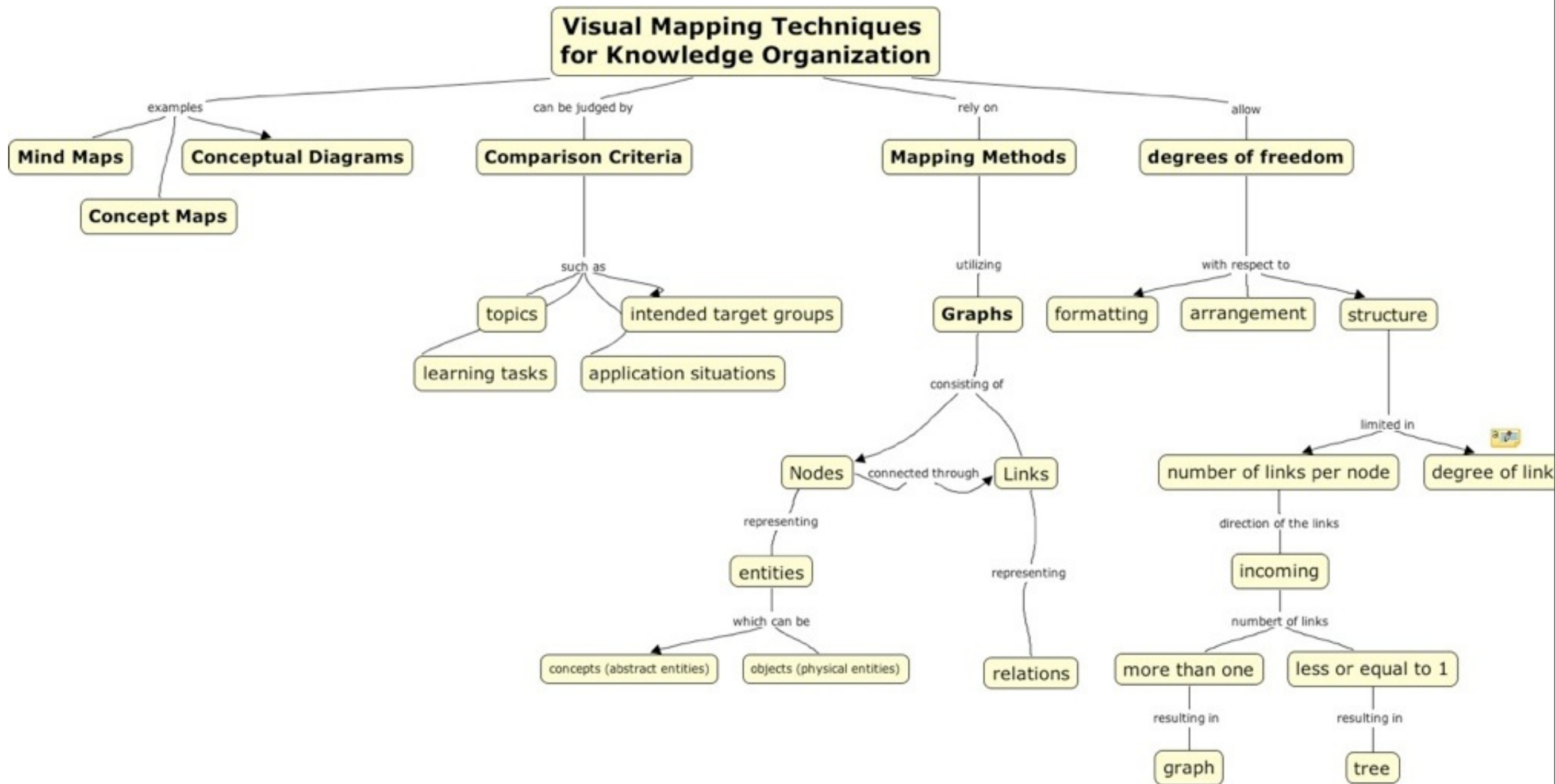
- ❖ built with Inxight Tree Studio



Graph-Based Presentations

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

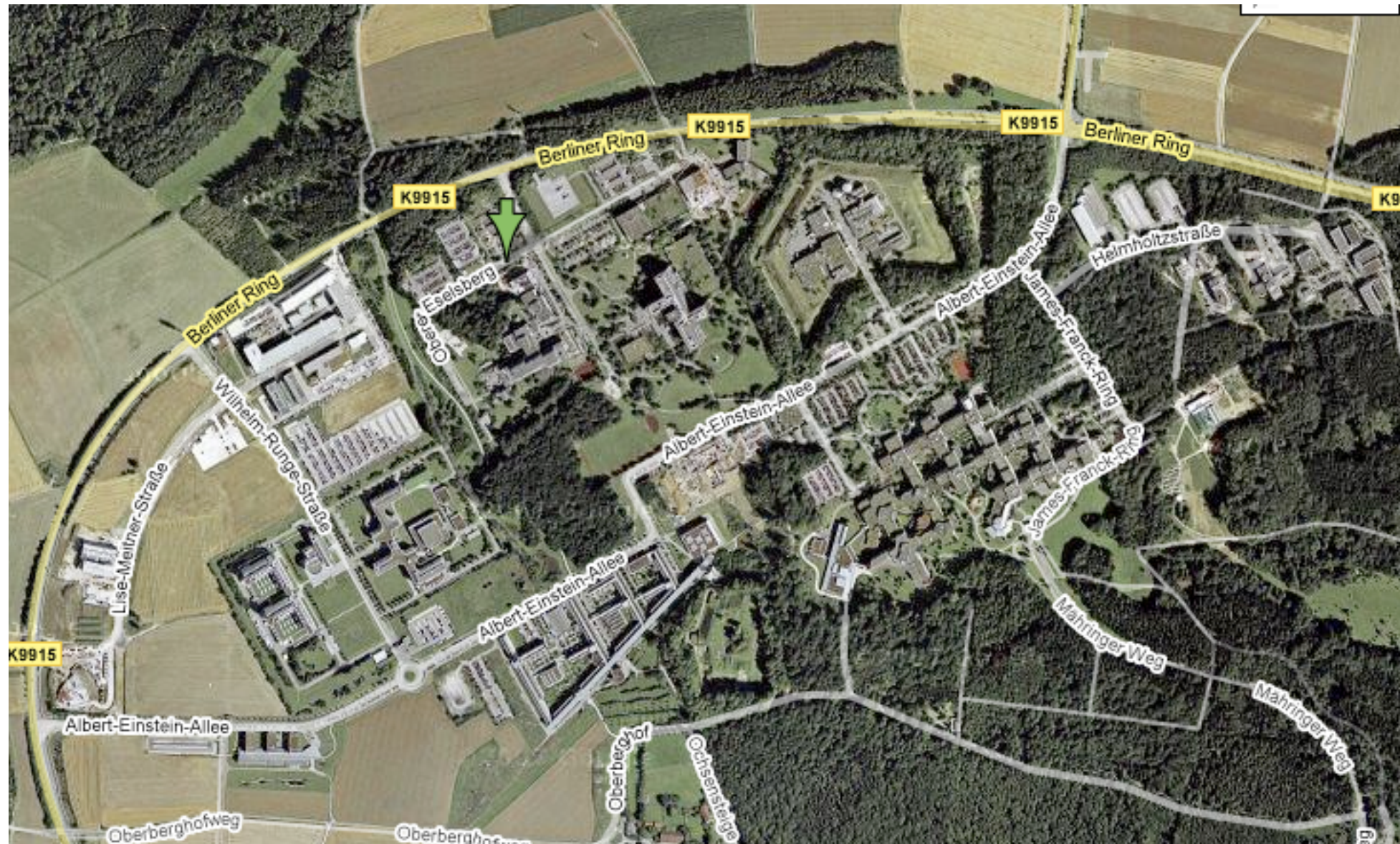
Example Concept Map



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?

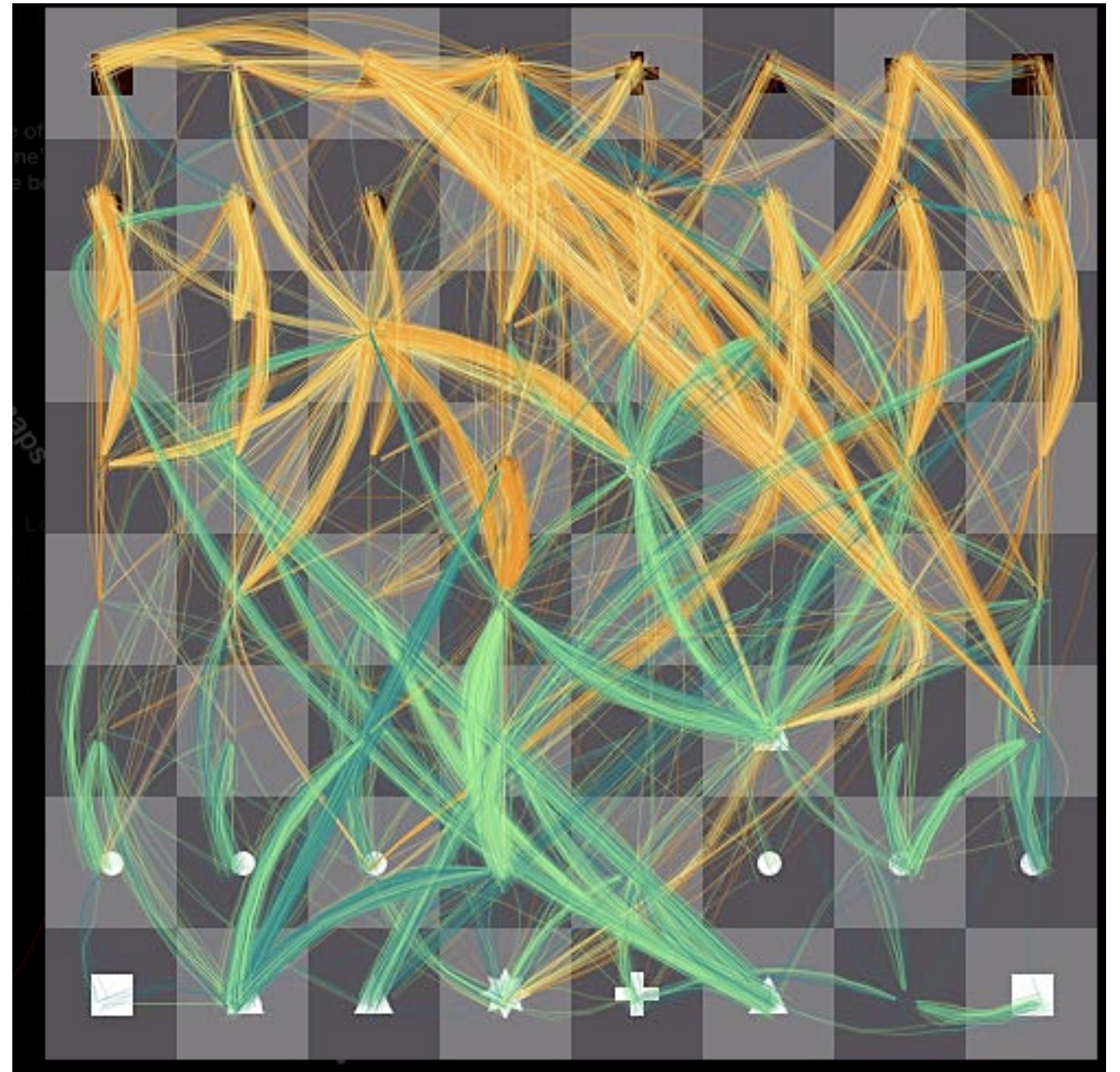


Models

- ❖ 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

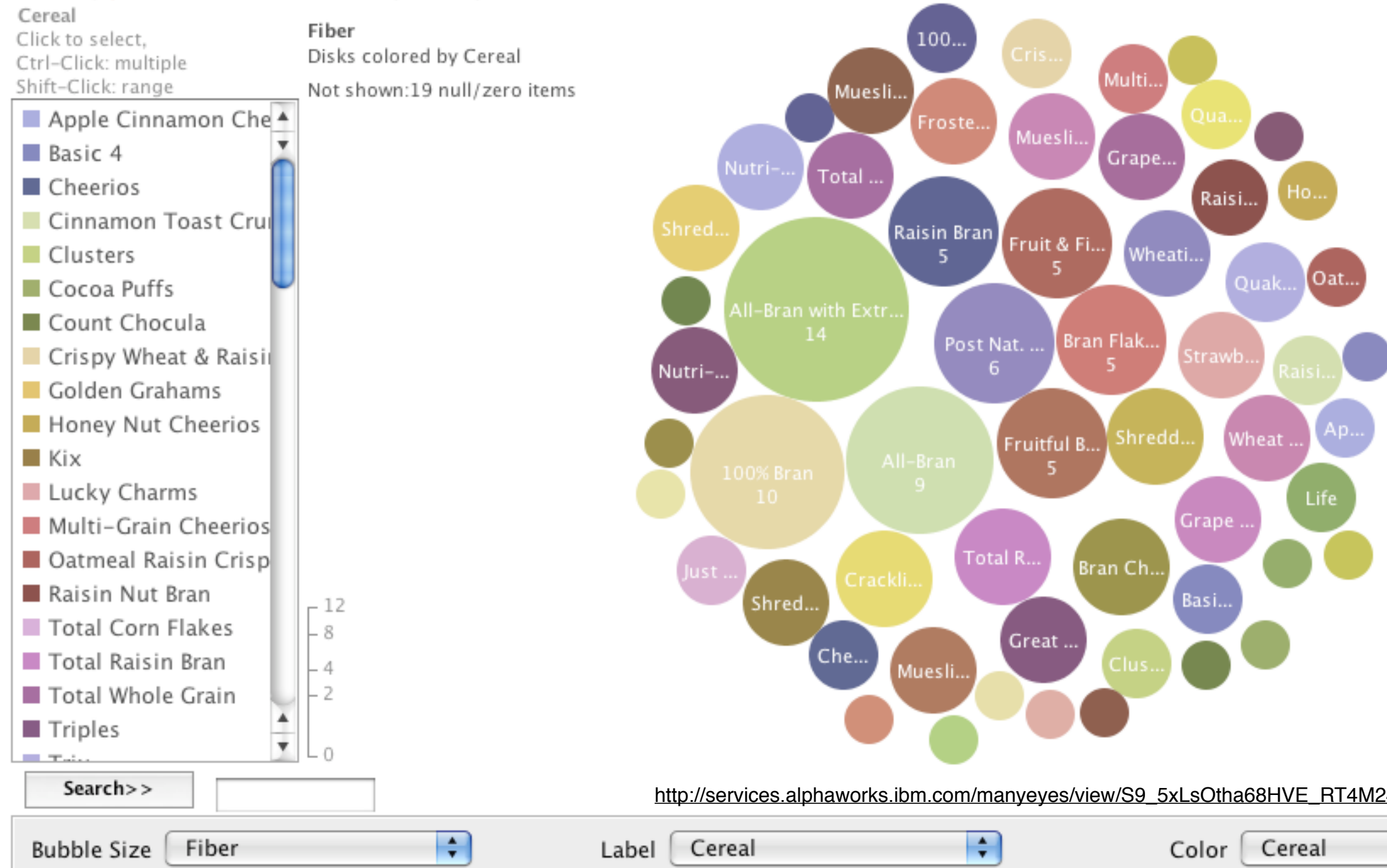
- ❖ Web site as service for the general public to visualize data sets
 - ❖ <http://www.many-eyes.com/>
 - ❖ <http://services.alphaworks.ibm.com/manyeyes/>
 - ❖ not only for academics
- ❖ various types of frequently used visualizations
 - ❖ arranged by purpose
 - ❖ explanations with examples and guidelines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

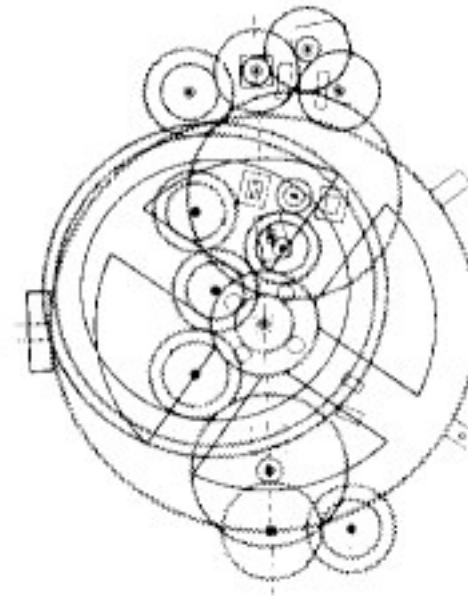
- ❖ creation of artifacts that represent important aspects of knowledge
- ❖ replication of physical systems
- ❖ demonstration of processes
- ❖ simulation for experiments

Knowledge Embodiment Examples

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

❖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: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



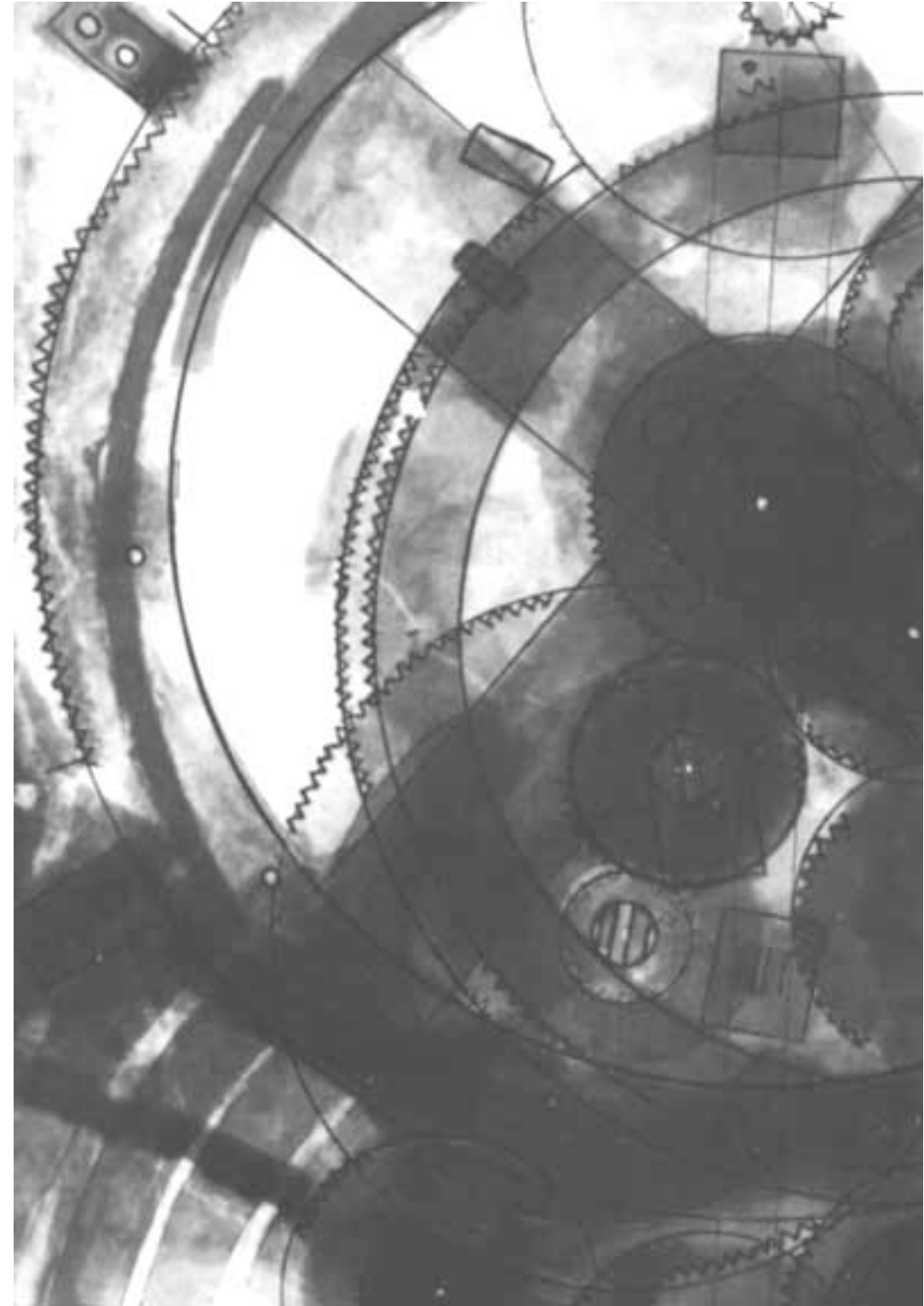
<http://www.crystalinks.com/antikythera.jpg>



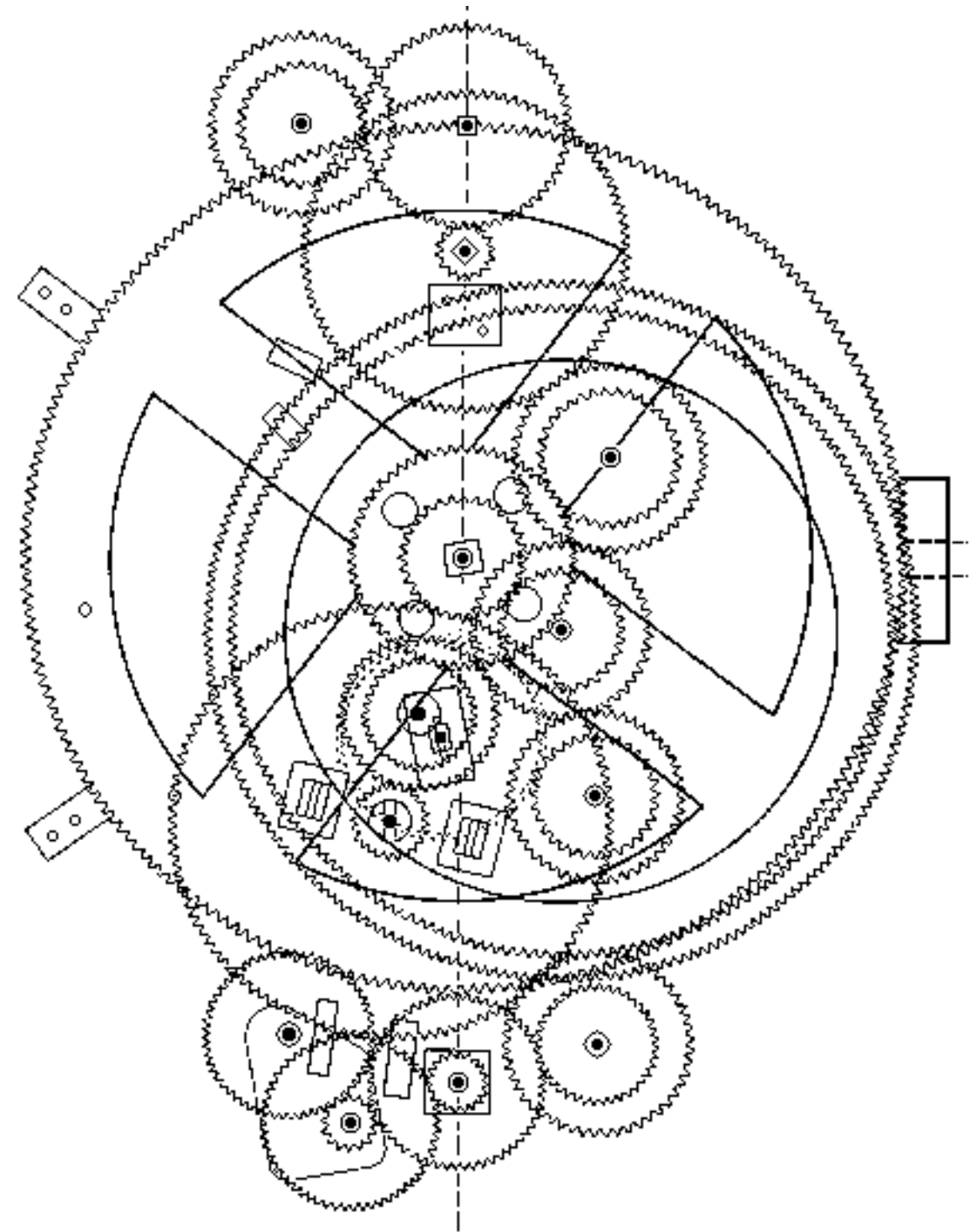
http://news.bbc.co.uk/nol/shared/spl/hi/pop_ups/06/technology_enl_1164817474/img/1.jpg

Antikythera Analysis

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

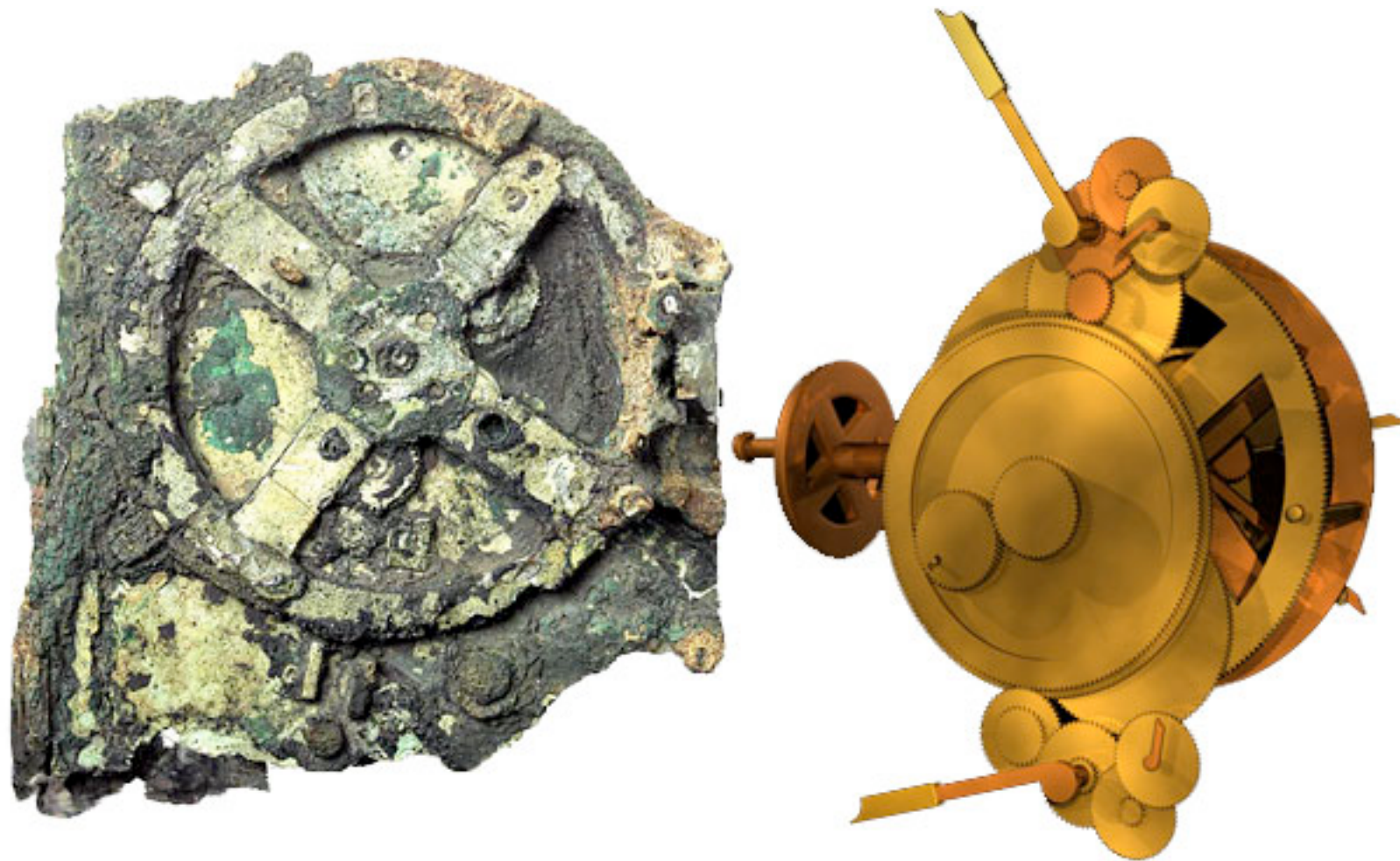


Antikythera Schematics



<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>

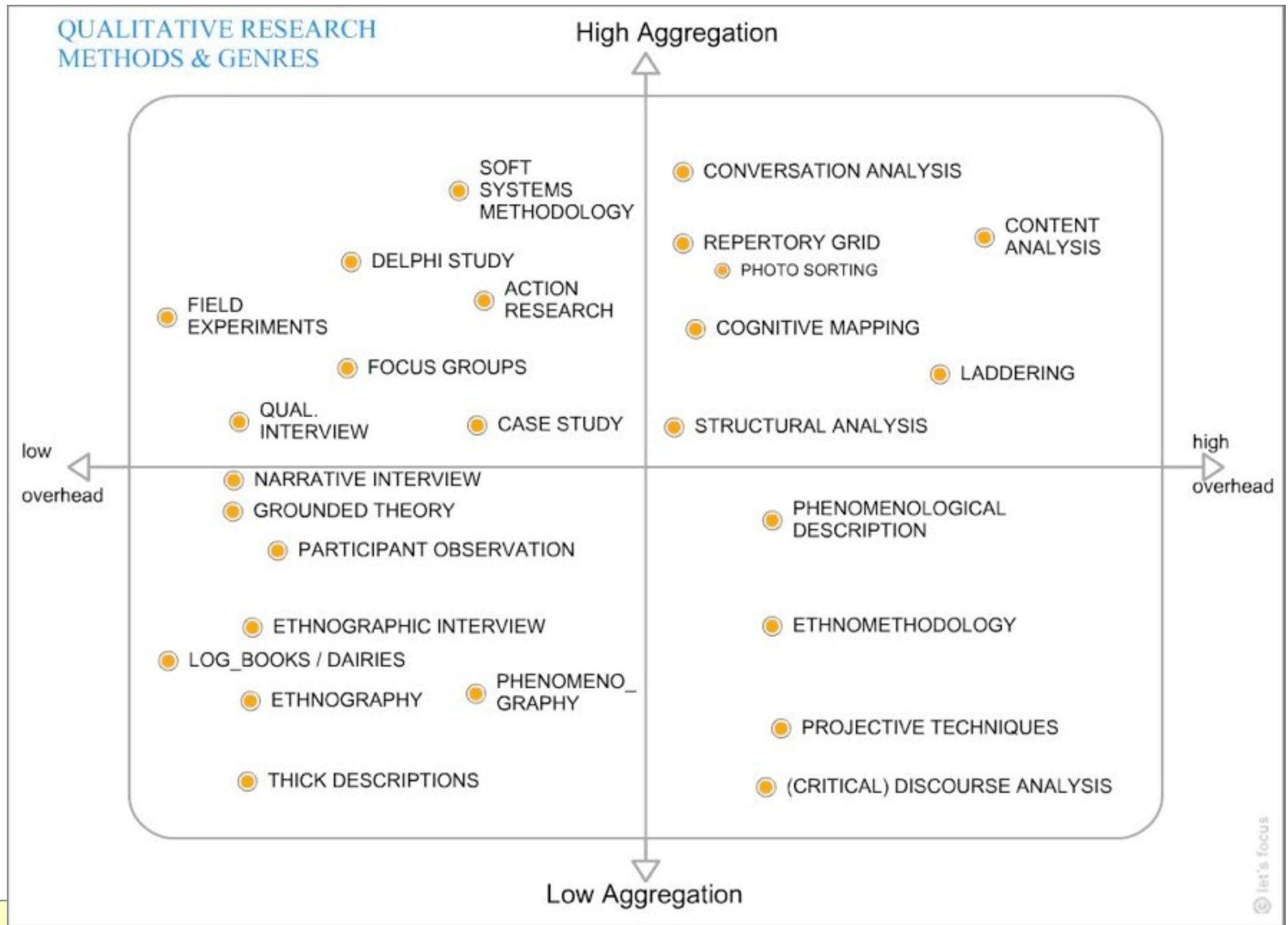
Astrolabe

- ❖ 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/>

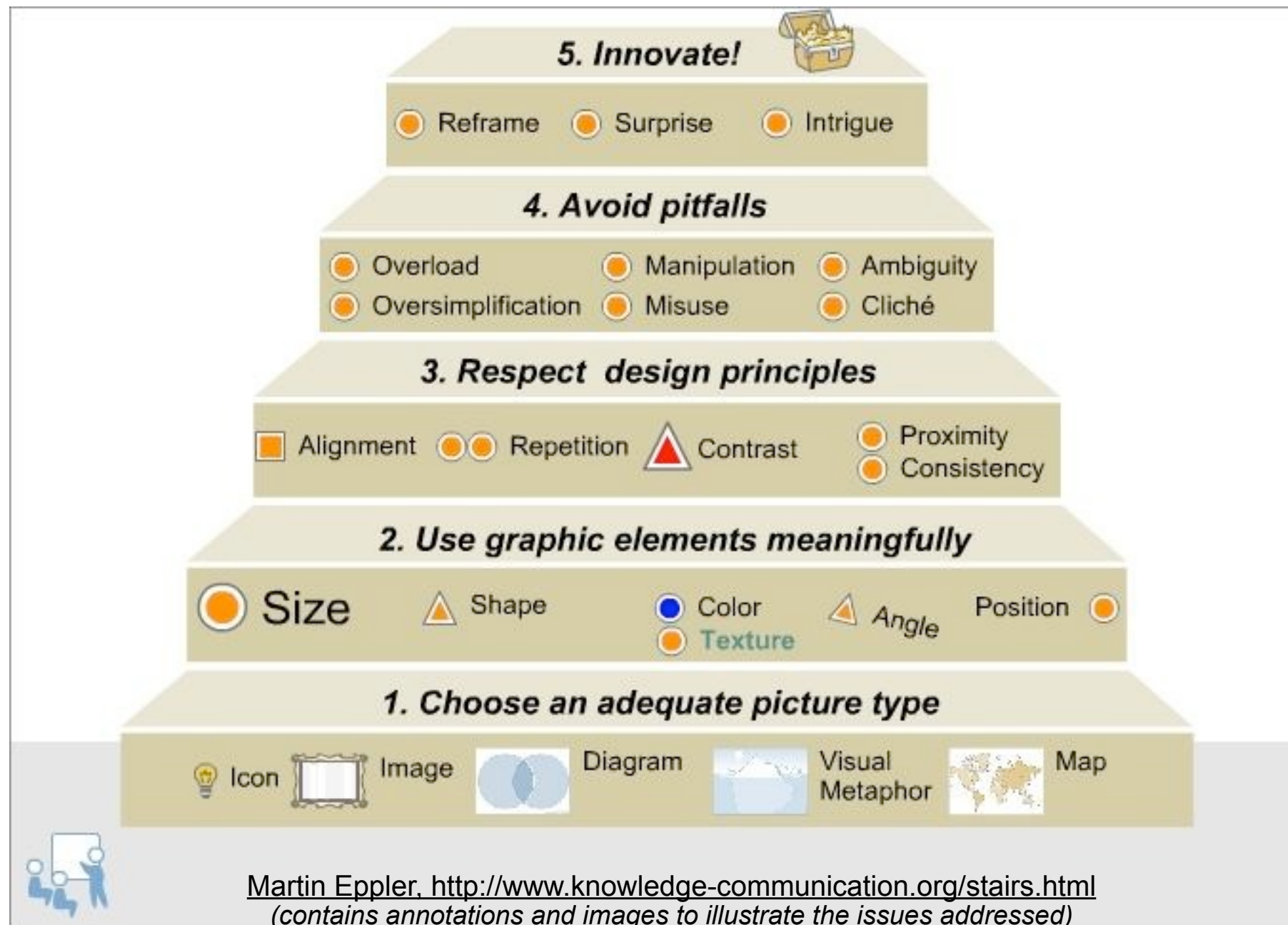
Qualitative Research Methods



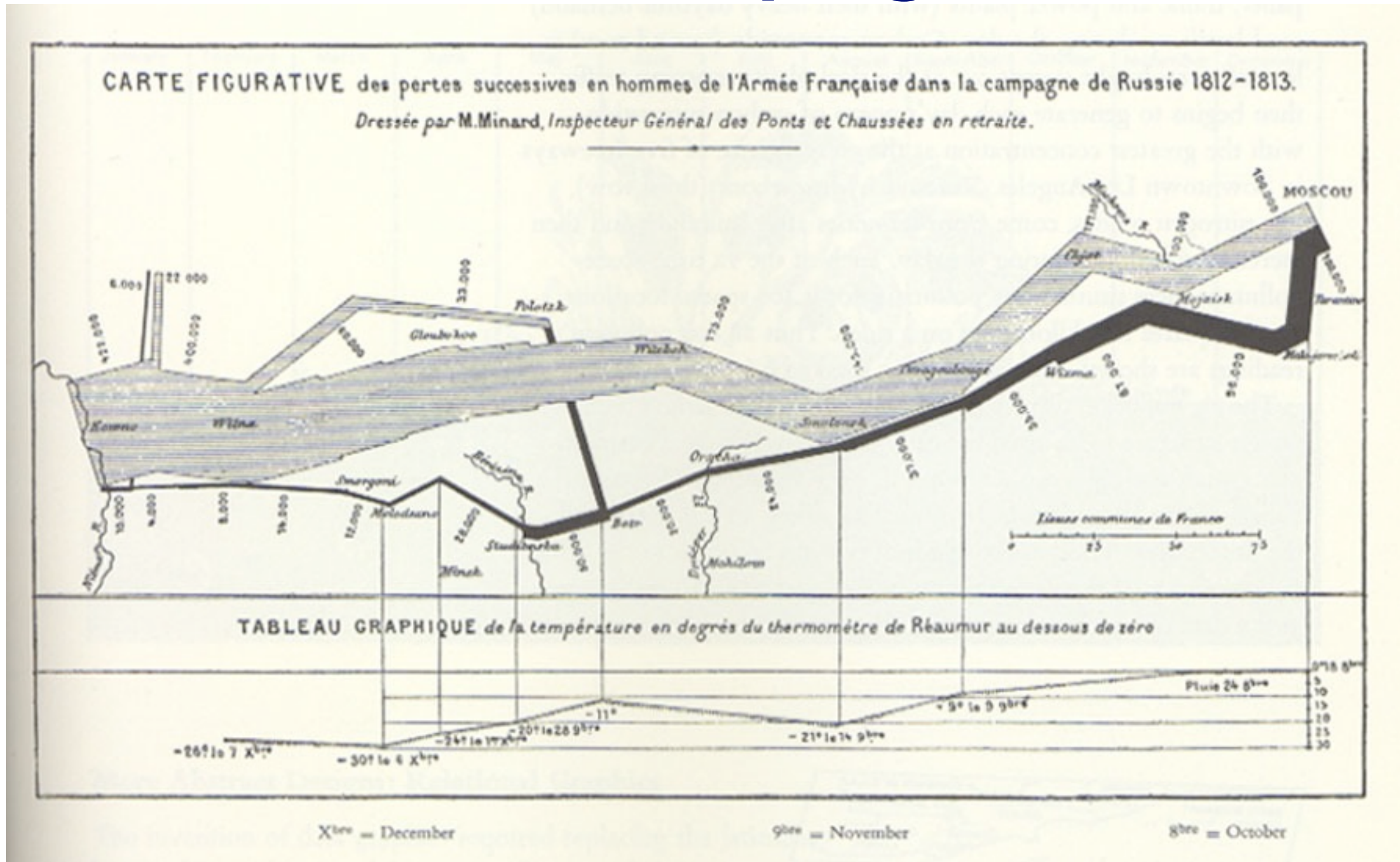
Knowledge Types

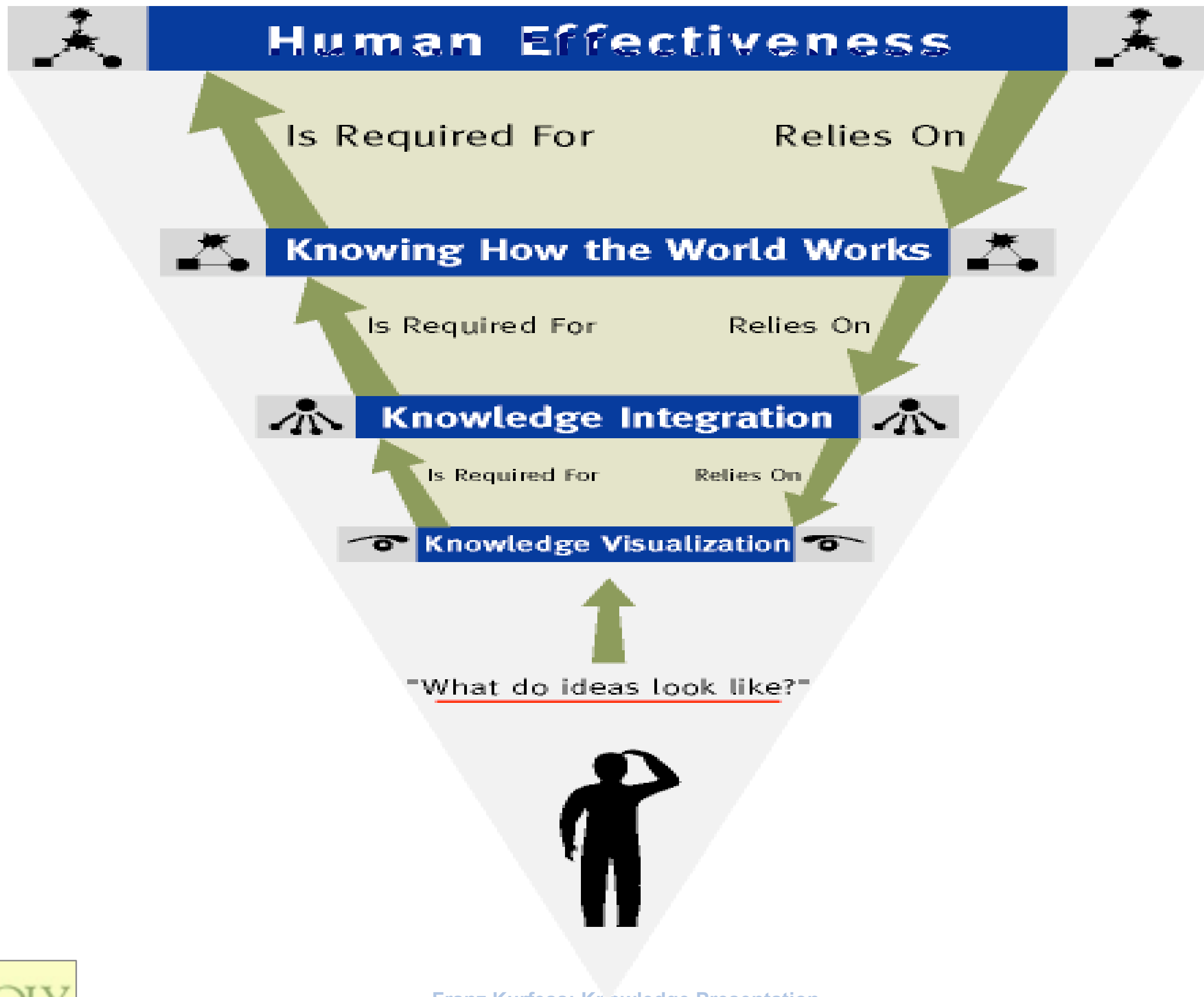


Stairs of Visualization



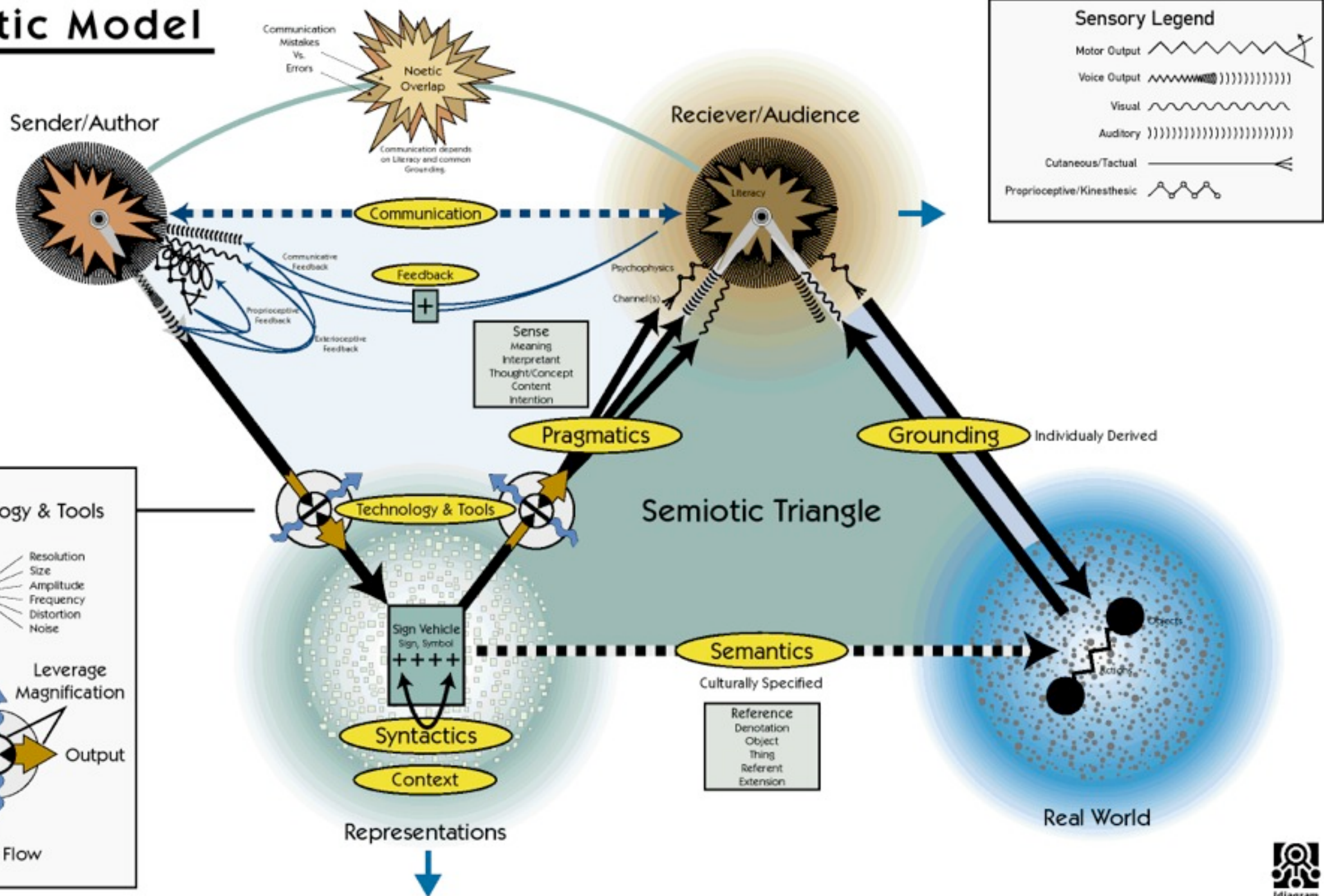
Minard: Napoleon's Russia Campaign





Semiotic Model

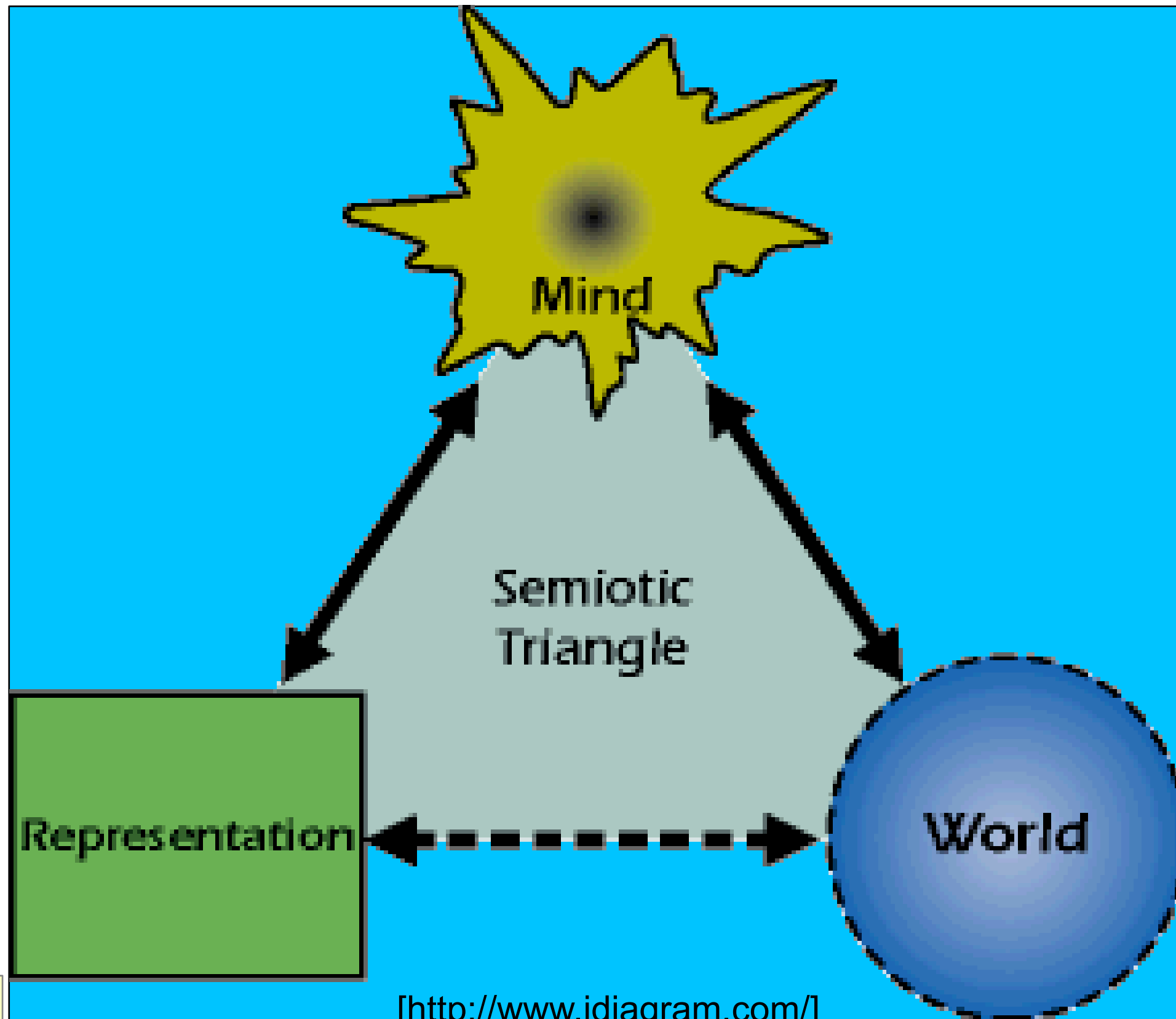
Semiotic Model



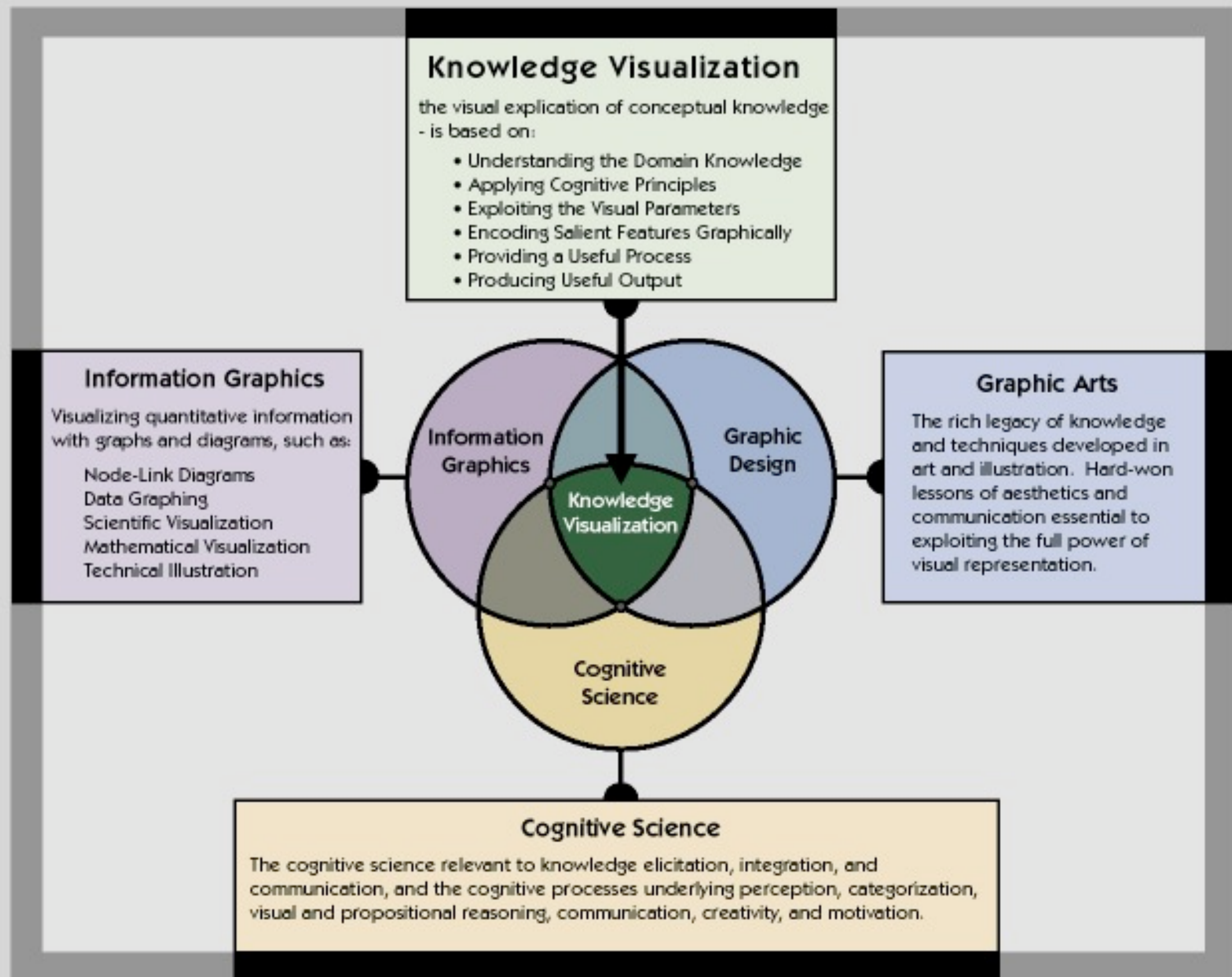
Idiagram Copyright © 1998 Marshall Clemens

Franz Kurfess: Knowledge Presentation [http://www.idiagram.com/]

Semiotic Triangle

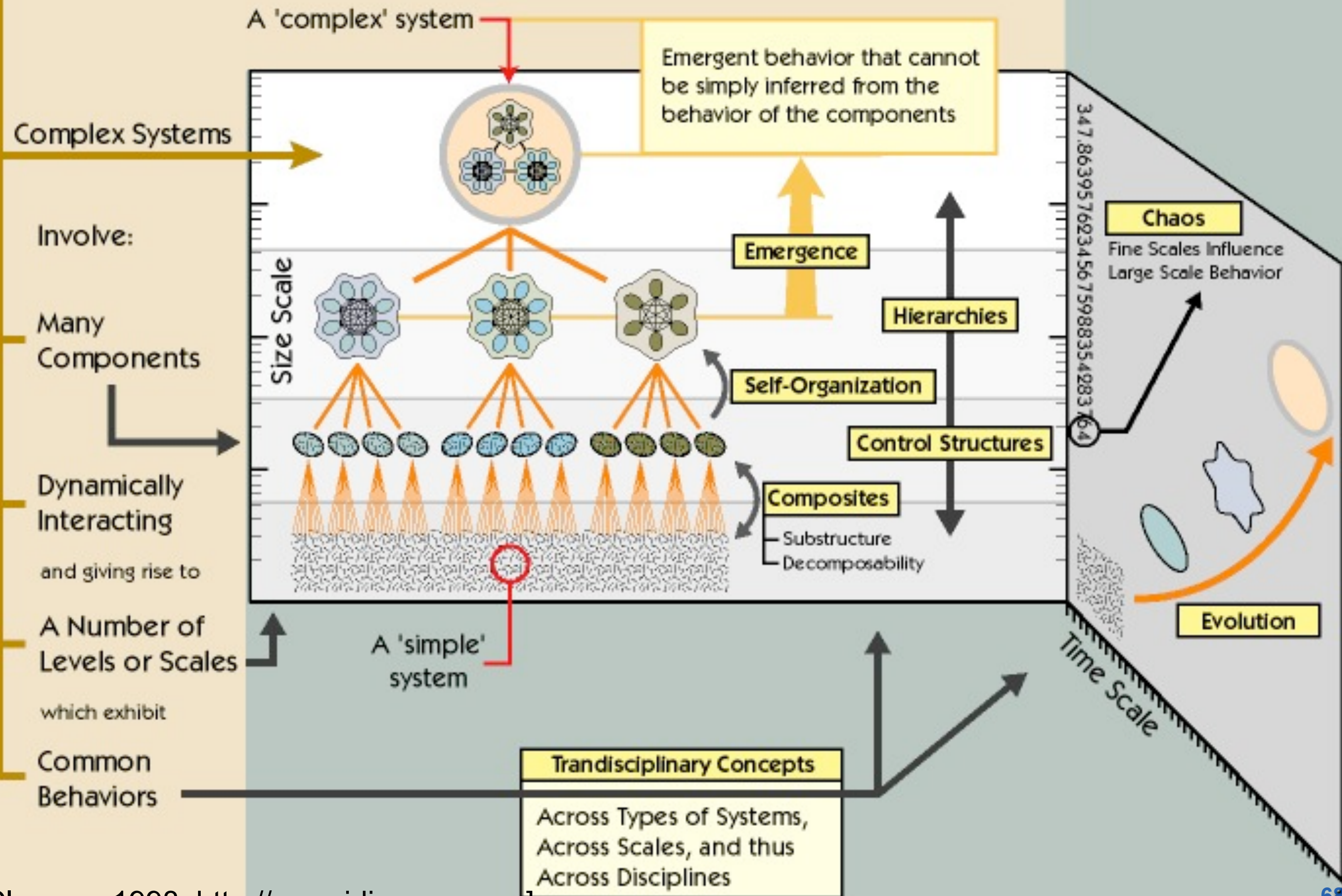


[<http://www.idiagram.com/>]

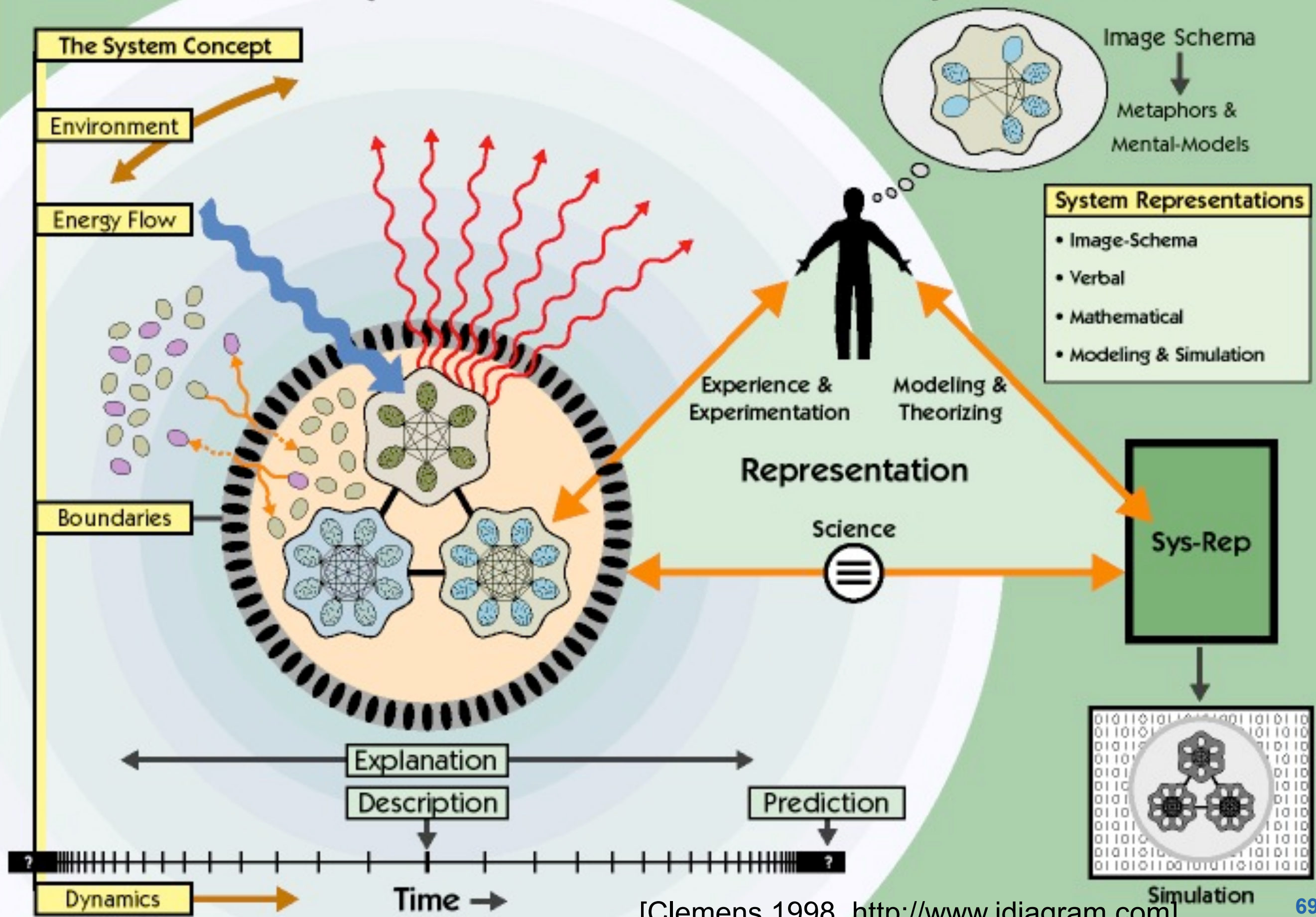


[Clemens 1998, http://www.idiagram.com/kv_venn.html]

Characteristics of Complex Systems

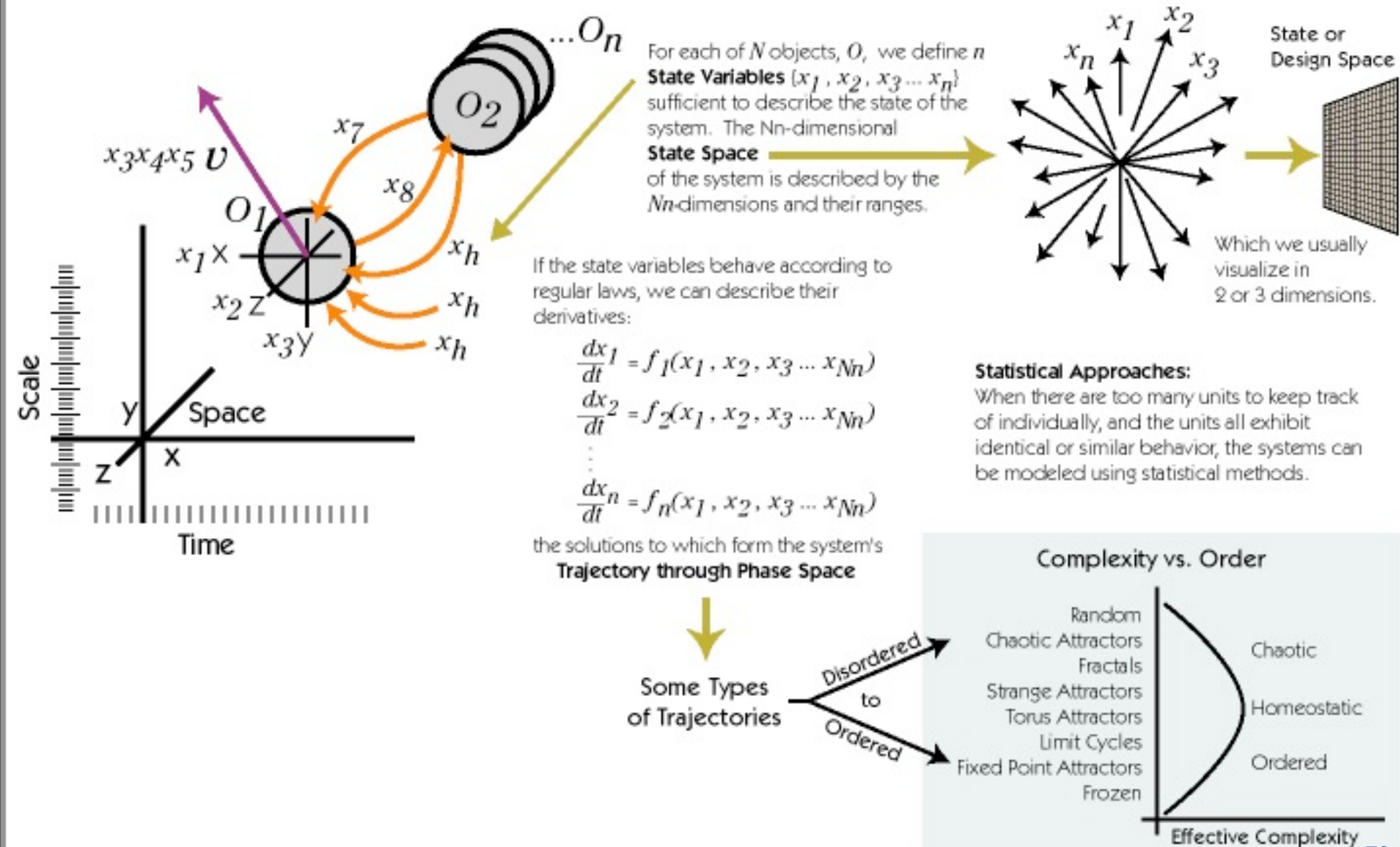


Systemsand their..... Representation



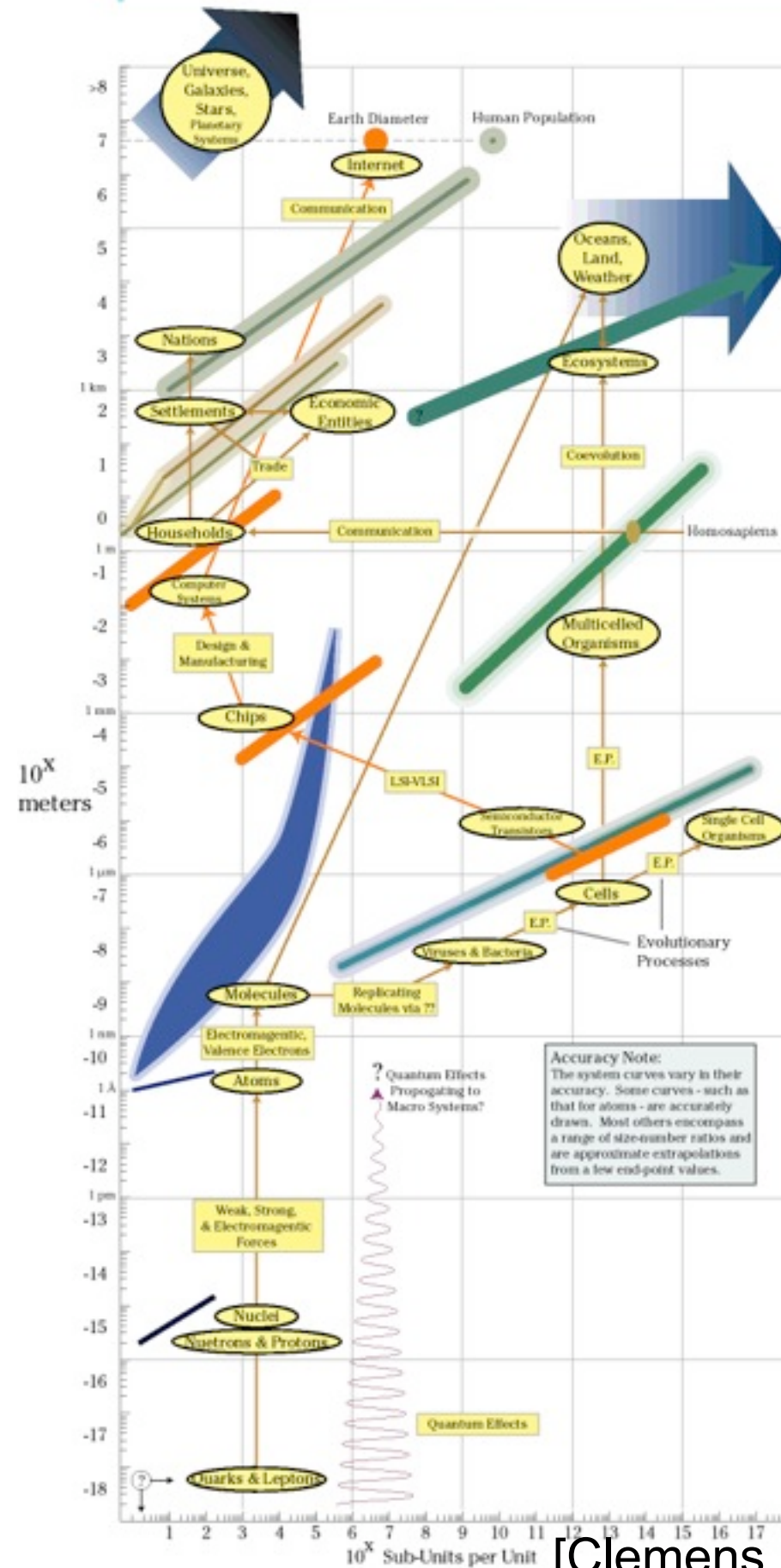
[Clemens 1998, <http://www.idiagram.com>]

System Dynamics: State & Phase Space

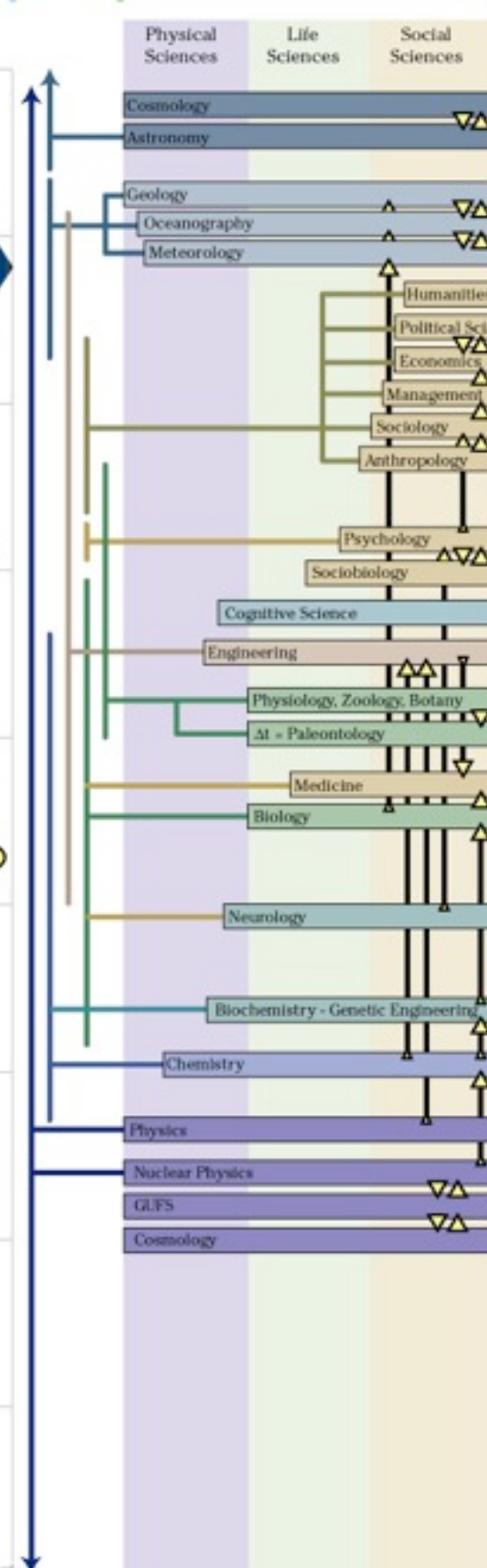


[Clemens 1998, <http://www.idiagram.com>]

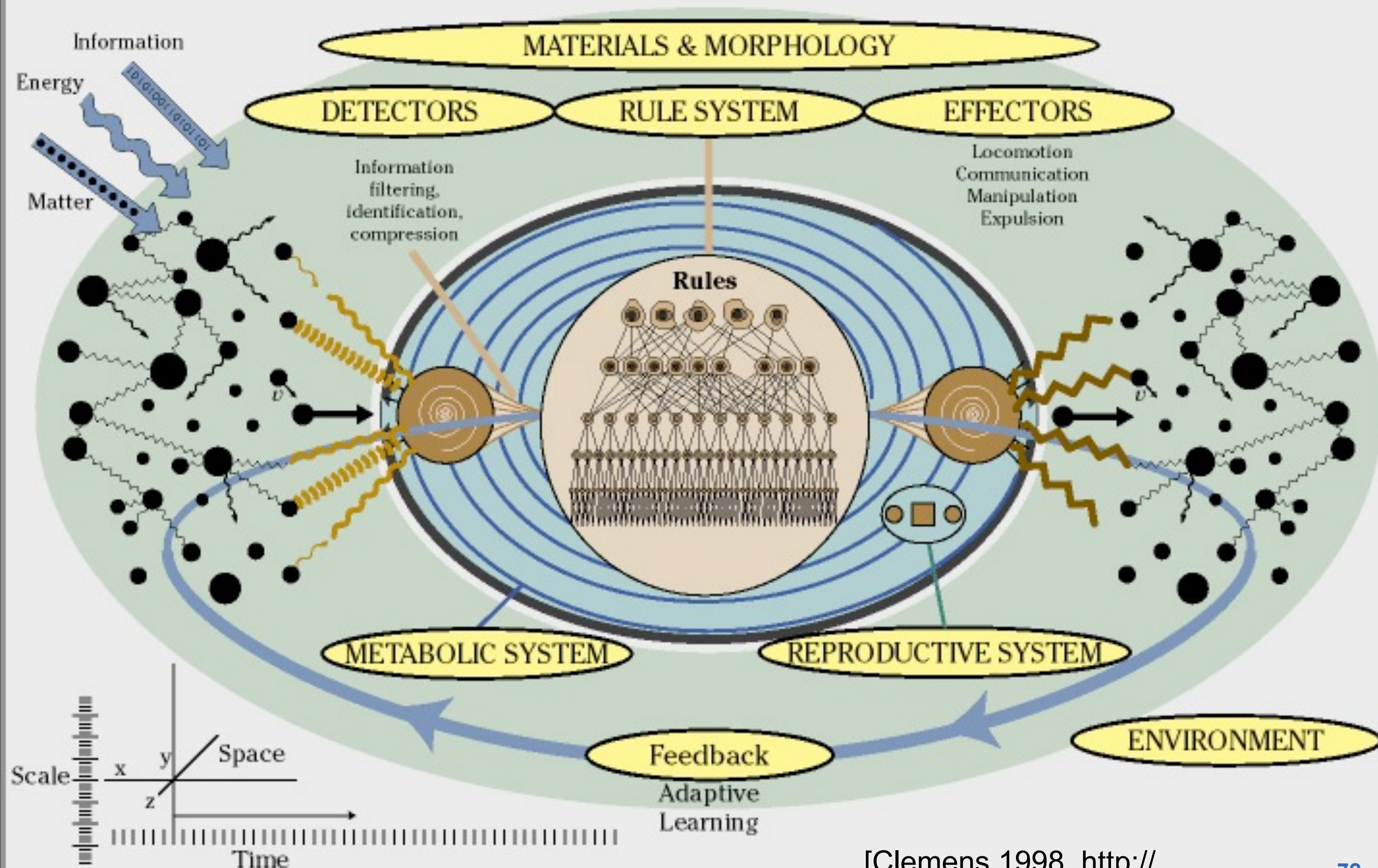
Some Physical Systems



Some Systems of Human Knowledge

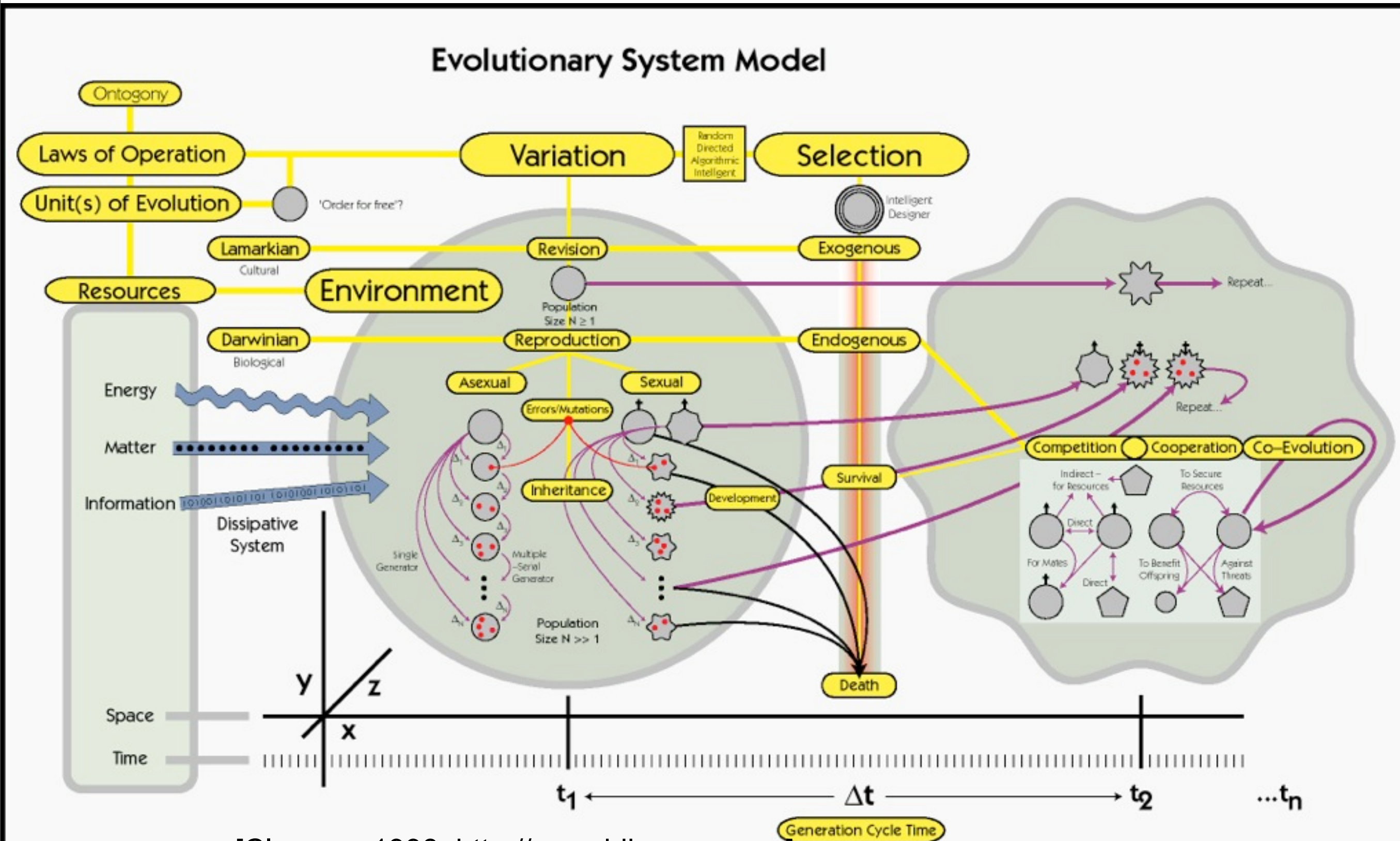


Complex Adaptive System Model



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

Evolutionary System Model



[Clemens 1998. <http://www.idiagram.com>]

Visualizing Complex Systems Science (CSS)

Why is Complexity Complicated?

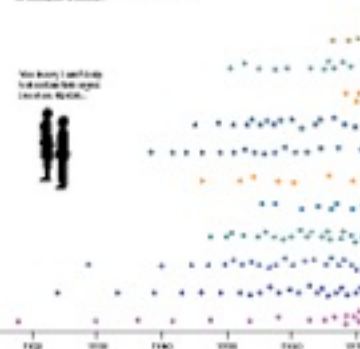
Abstract

Applying CSS – a set of concepts that come from the physical and biological sciences – to organizational science and management presents a unique challenge. Because the only two histories of CSS exist, it is difficult to understand how we bring new, relevant, and innovative CSS knowledge to bear on complex systems. This book is why doing so is a challenge and why CSS can help address the problem.

- Ecology
- Evolution
- Anthropology
- Psychology
- Cognitive Science
- Neurology
- Artificial Intelligence
- Cybernetics
- Operations Research
- Game Theory
- Antennology
- Polity
- Chemistry
- Physics
- Mathematics

A Sketch of CSS Concept Development

Many rough sketches of what a map of the development of CSS might look like. The sketch is a rough sketch of the development of CSS, showing the relationship between the various disciplines and the central concept of CSS.



Integration

One way to connect knowledge and concepts is to employ the 'knowledge compression' selected by the system, or, in other words, general principles. Connecting for the purpose of knowledge compression is a manageable number of concepts – which, if they are to be useful, may be selected to represent the system in a way that is not too complex by modeling fewer facts.

Knowledge integration is a process of abstraction, the selection of a few general concepts or principles from many specific examples. The result is of the integration a hierarchy of concepts – from general to specific – and the functional relationships between the concepts. Because the structure is 'hierarchy' and the concepts are 'general', the structure is a 'hierarchy' and the concepts are 'general'.

Integration & Diagrams

Conceptual Complexity & Diagrams

Due to the limited capacity of working memory – 7 +/- 2 'chunks' of information – we cannot hold in our minds concepts, systems, or problems that are more than 7 +/- 2 'chunks' of information. This cognitive limitation means we are unable to hold more than 7 +/- 2 'chunks' of information in our minds. However, we can do what we often do: we use our intellectual abilities with external representations.

The particular effectiveness of diagrams in representation – is ability to show many things and relationships in a single image. The diagram is a visual representation of a complex system. The diagram is a visual representation of a complex system.

Diagrams provide an external representation of a complex system. The diagram is a visual representation of a complex system. The diagram is a visual representation of a complex system.

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Visualizing CSS & Management

CSS offers us a new way of looking at the world. It is a new way of looking at the world. It is a new way of looking at the world. It is a new way of looking at the world. It is a new way of looking at the world.

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A 'Complex System' is an Abstract Concept

Because Complex Systems Involve: Many To many interdependencies interacting. Complexity too big to hold in our mind. Can't handle the complexity. We never directly experience complex systems. What we do know about them is through the integration of many parts.

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This is the Point:

Because complex systems are abstract, visual models and visual metaphors – whether in our heads or on paper – are an important tool for understanding complex systems. They are a way of looking at the world. They are a way of looking at the world. They are a way of looking at the world.

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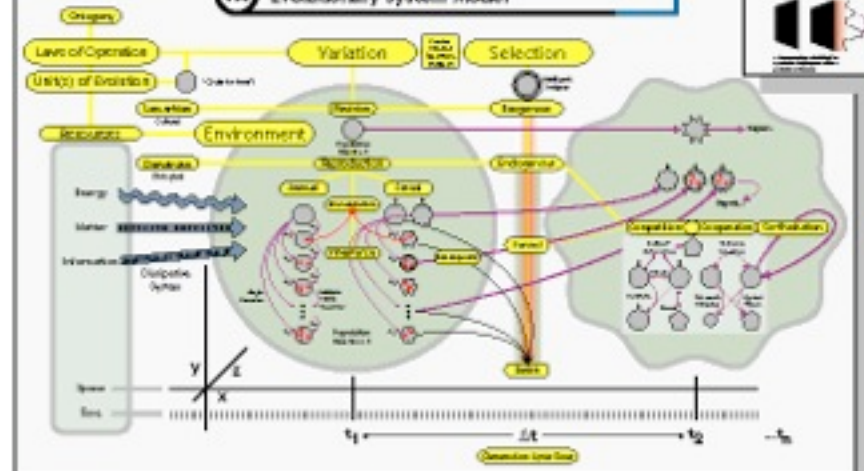
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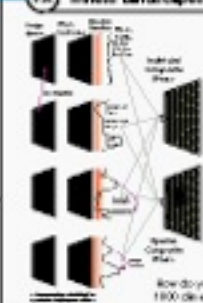
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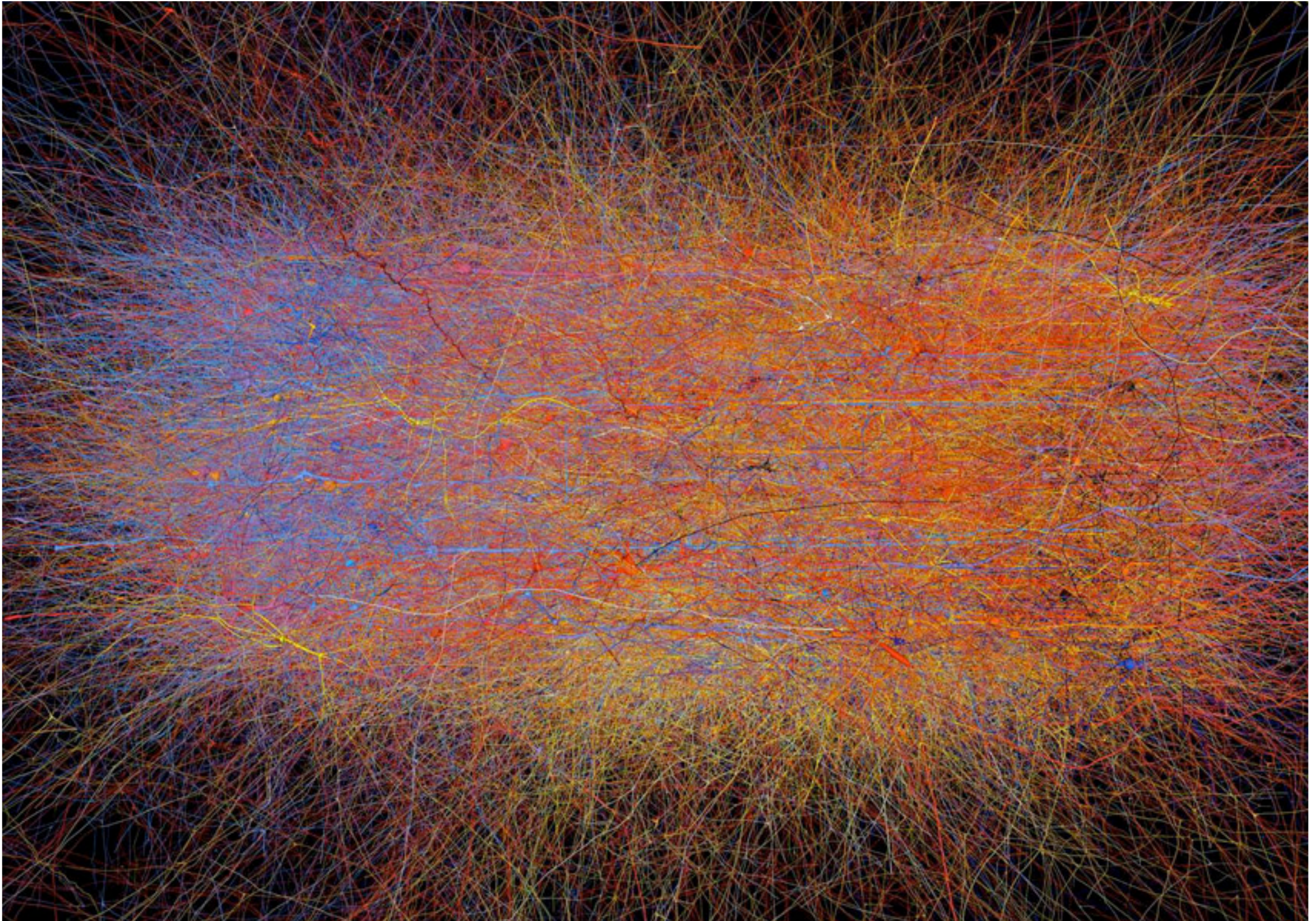
Evolutionary System Model



Business Landscapes



Mammalian Neocortical Column



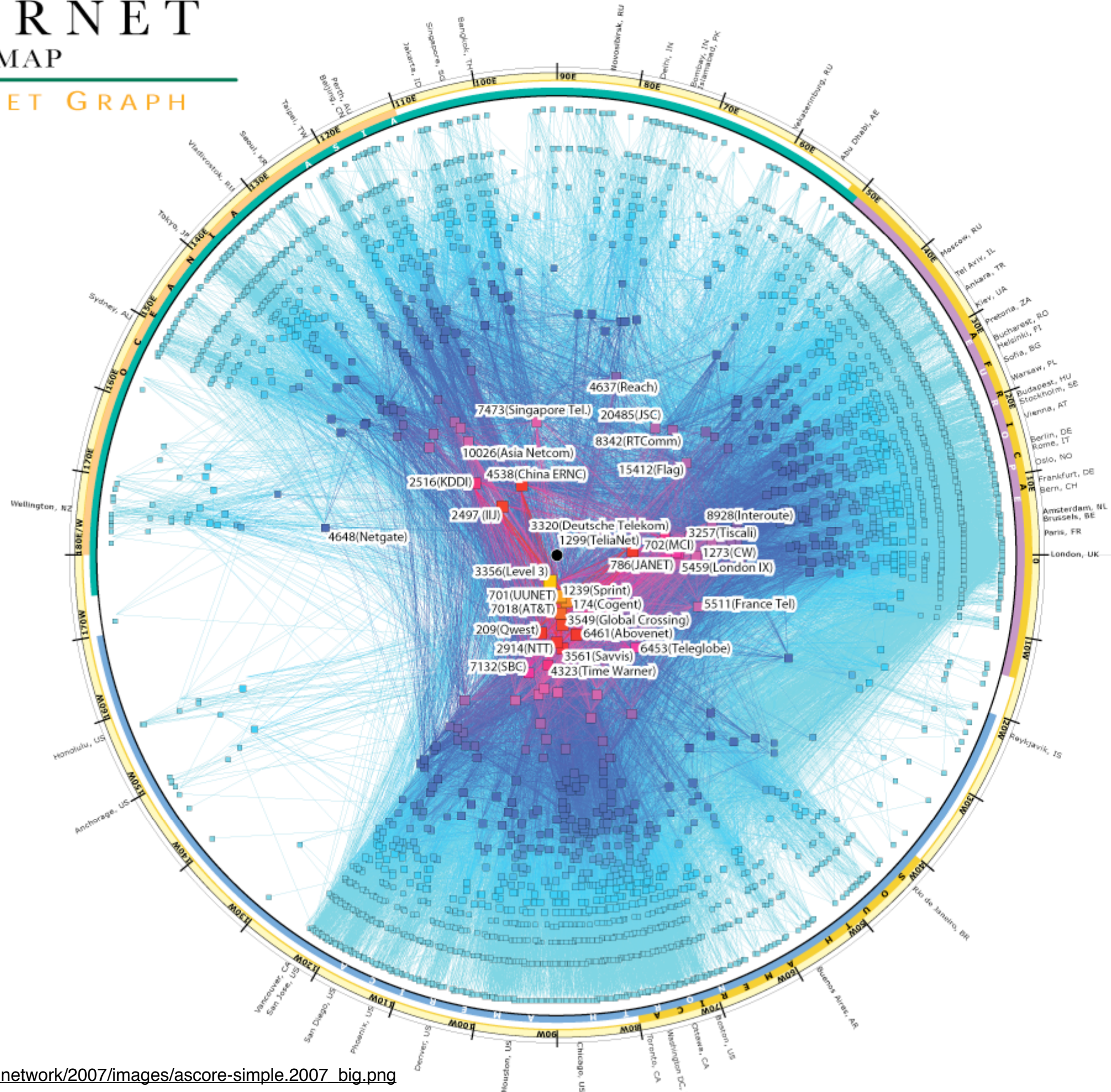
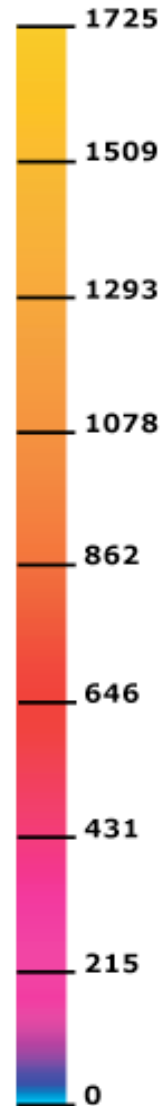
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IPv4 INTERNET TOPOLOGY MAP

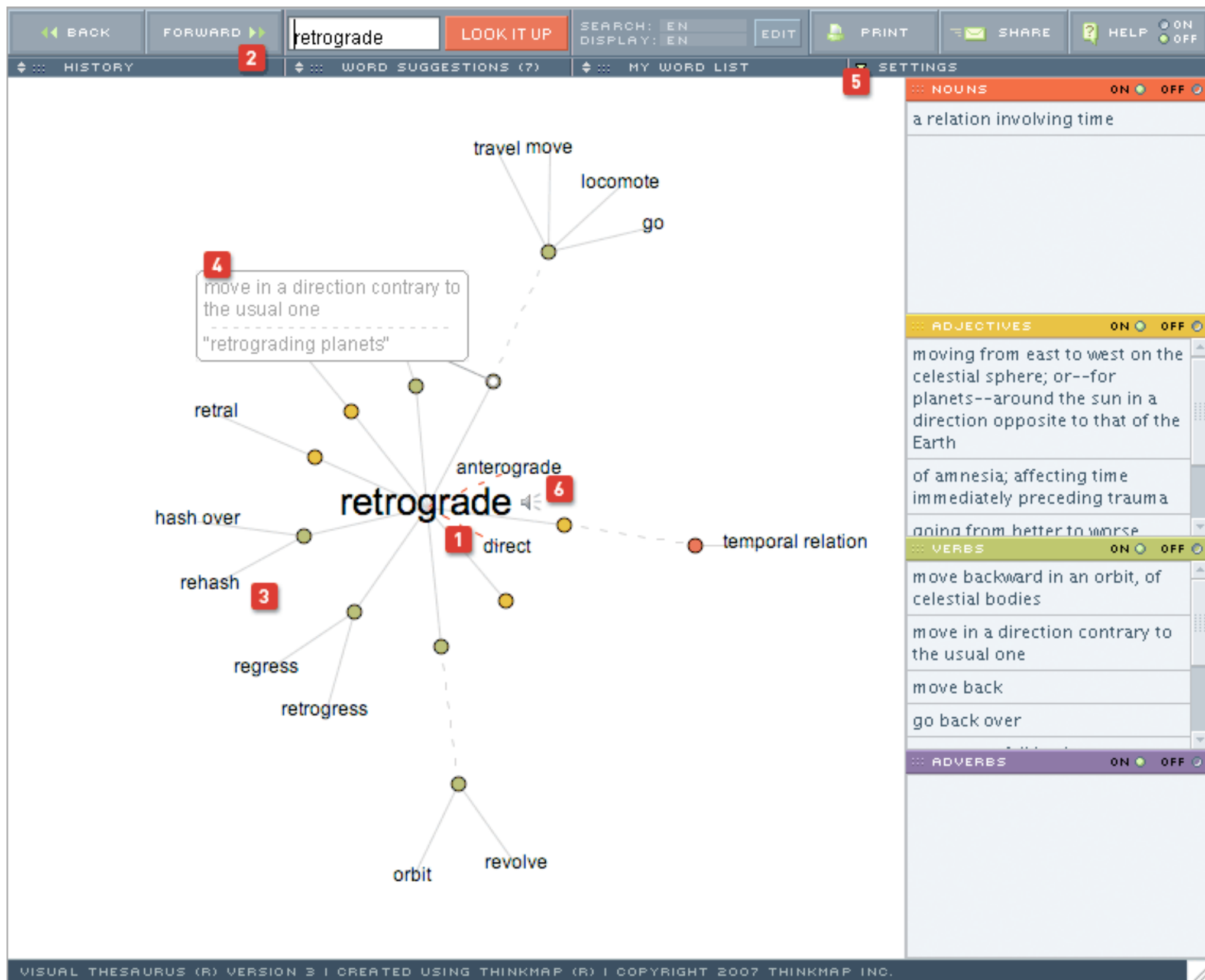
AS-level INTERNET GRAPH

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Peering:
OutDegree



Visual Thesaurus



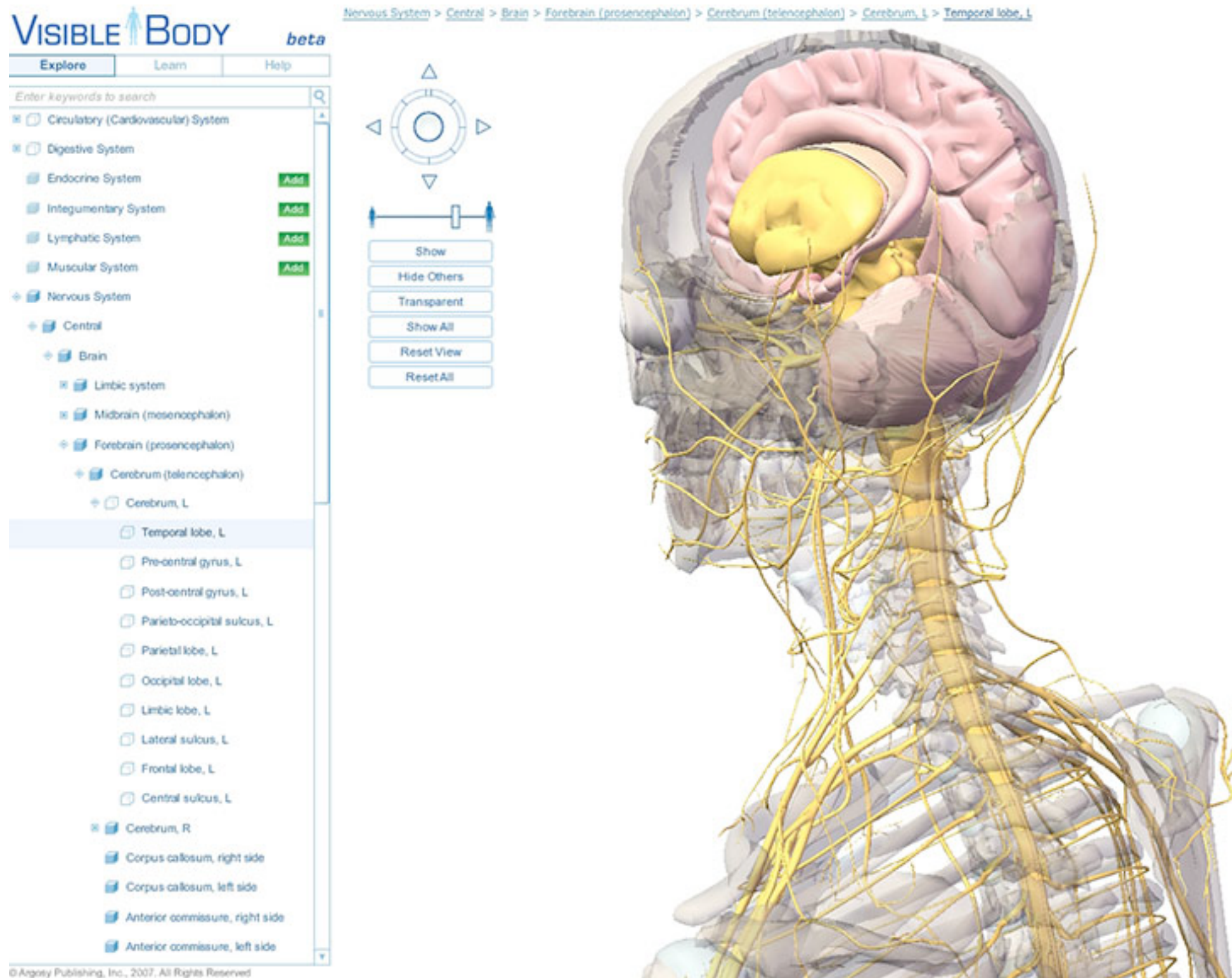
<http://www.visualthesaurus.com/howitworks/images/screen.gif>

Franz Kurfess: Knowledge Presentation

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

Visible Body Example: Brain



Enter keywords to search



☐ Circulatory (Cardiovascular) System

☐ Digestive System

☐ Endocrine System

☐ Integumentary System

☐ Lymphatic System

☐ Muscular System

☐ Nervous System

☐ Reproductive System

☐ Respiratory System

☒ Skeletal System

◆ Axial

☒ Skull

◆ Vertebral column

☐ C1 (Atlas)

☐ C2 (Axis)

☐ C3 Intervertebral disc

☐ C3 Vertebra

☐ C4 Intervertebral disc

☐ C4 Vertebra

☐ C5 Intervertebral disc

☐ C5 Vertebra

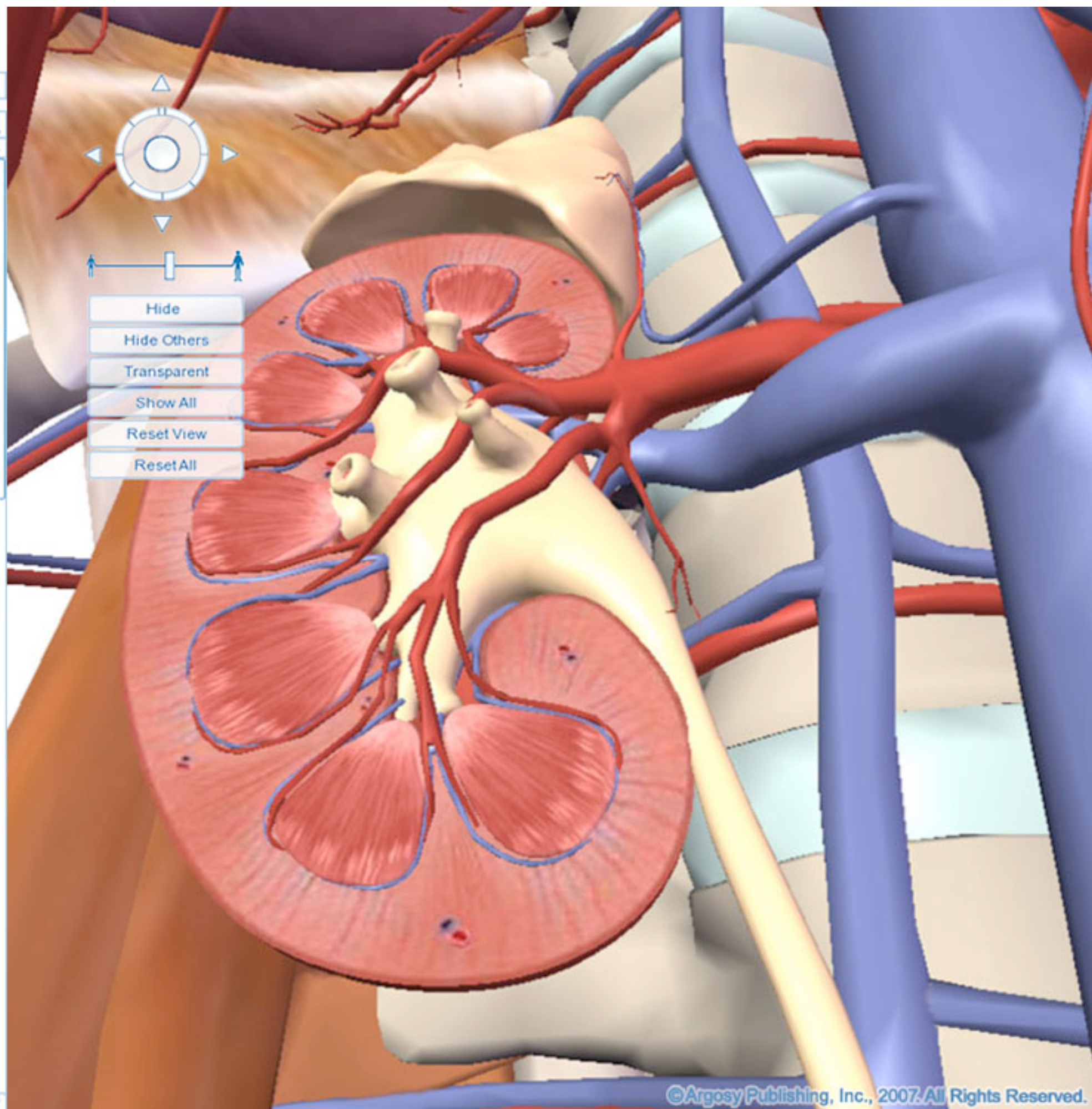
☐ C6 Intervertebral disc

☐ C6 Vertebra

☐ C7 Intervertebral disc

☐ C7 Vertebra

☐ C8 Intervertebral disc



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.

