Knowledge Presentation and Visualization

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Overview Knowledge Presentation and Visualization

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

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

[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

[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

[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

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

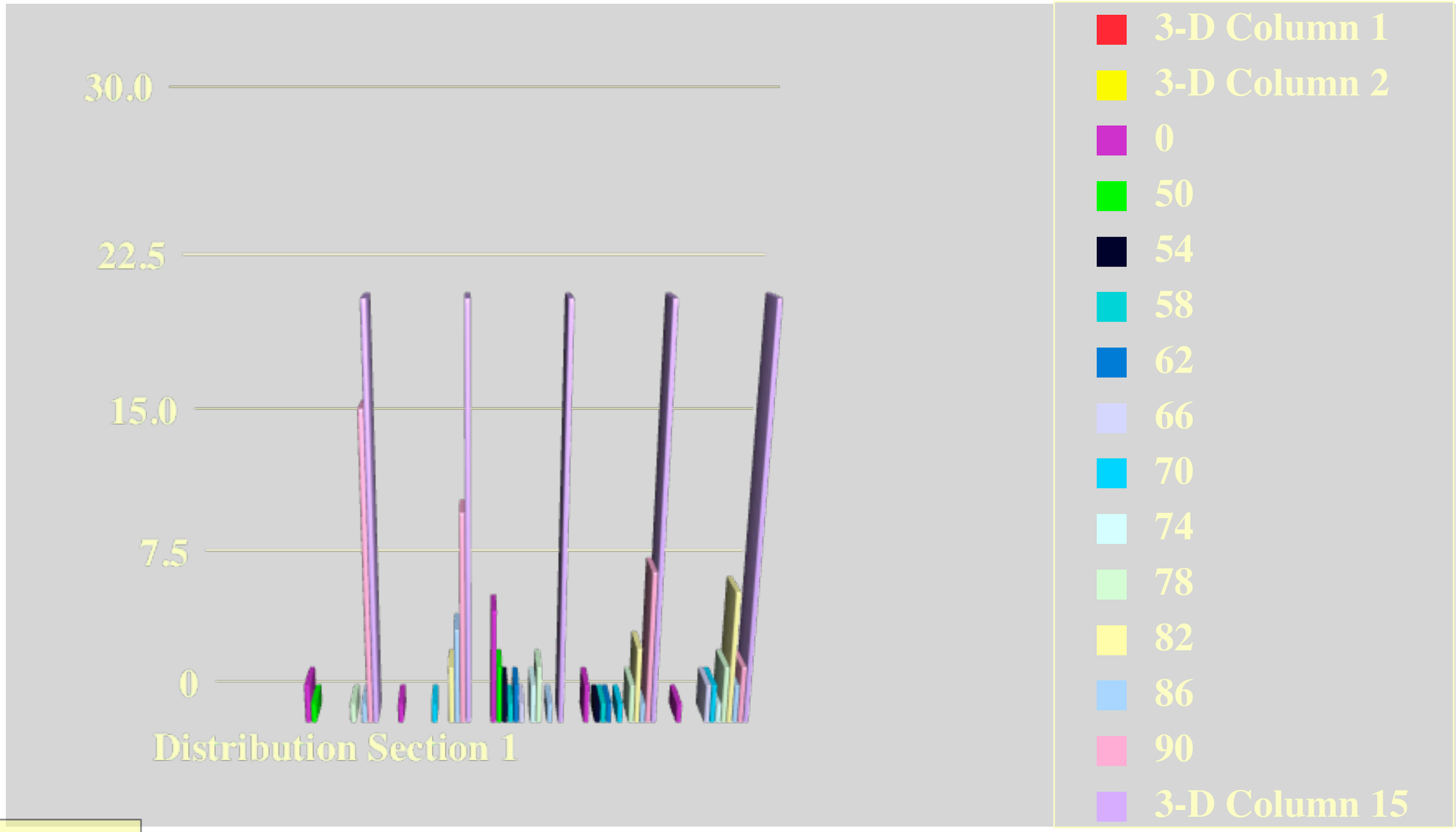
[Kowalski 1997]

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.

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

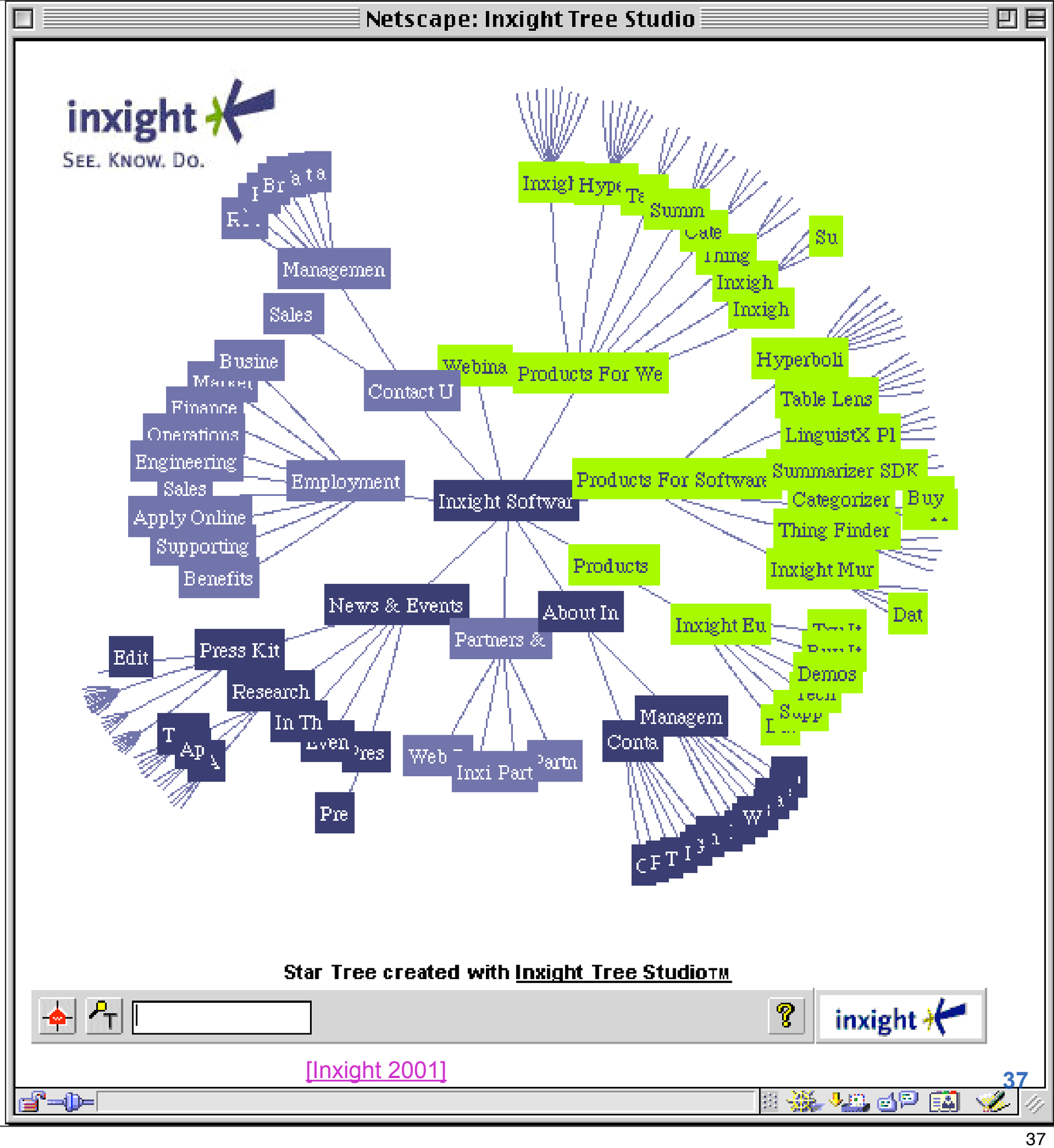
- hierarchical methods
  - trees
- graph-based methods
  - concept maps, mind maps, conceptual diagrams
- similes
  - the appearance of the proxy reflects the original
    - maps
- models
  - important functional properties are reproduced
- metaphors

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

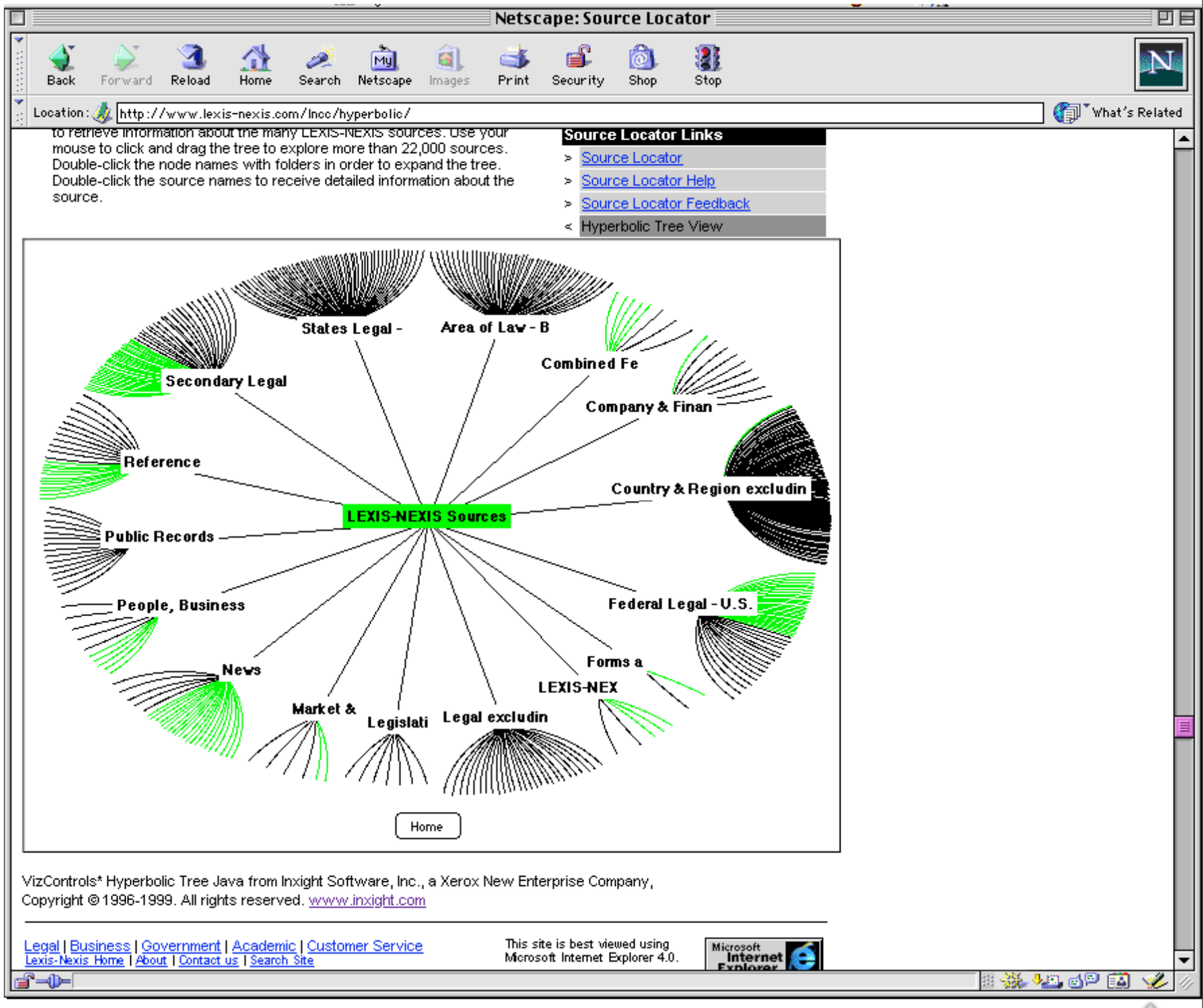
- tree displays the hierarchical structure of a Web site
- overview of available contents
- quick navigation
- no details



[Inxight 2001]

Lexis-Nexis Tree

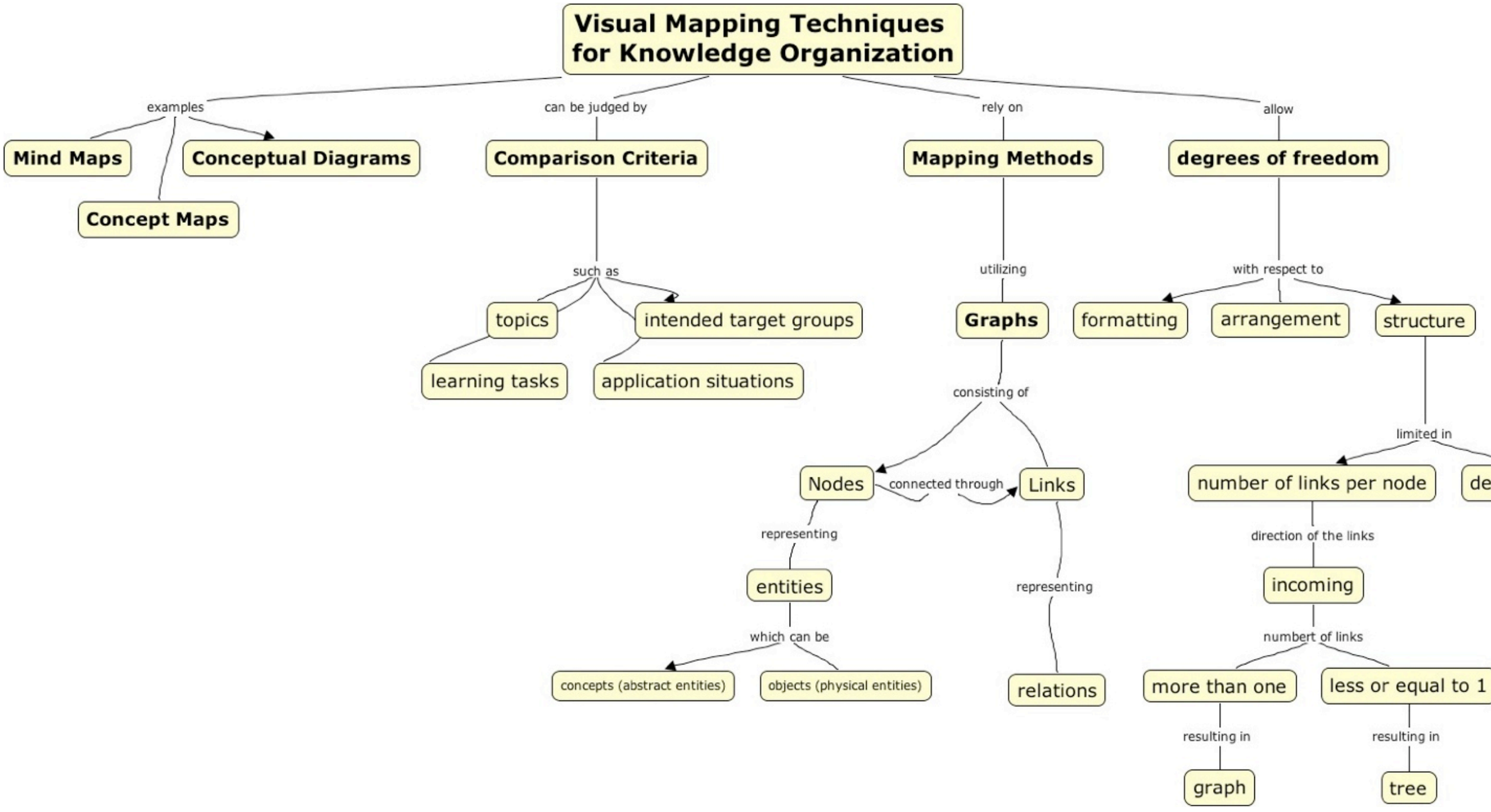
- built with Inxight Tree Studio



Graph-Based Presentations

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

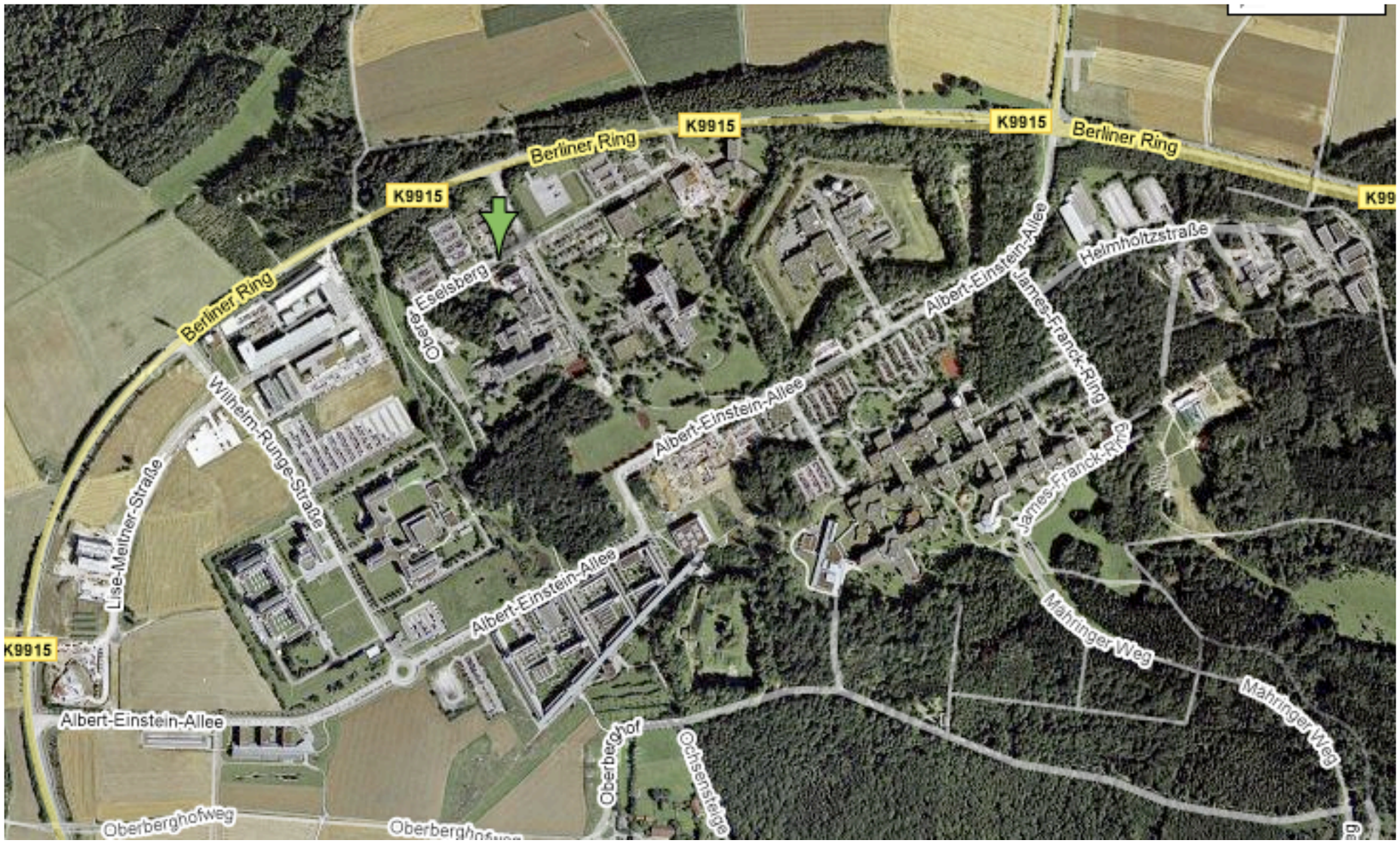
Example Concept Map



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

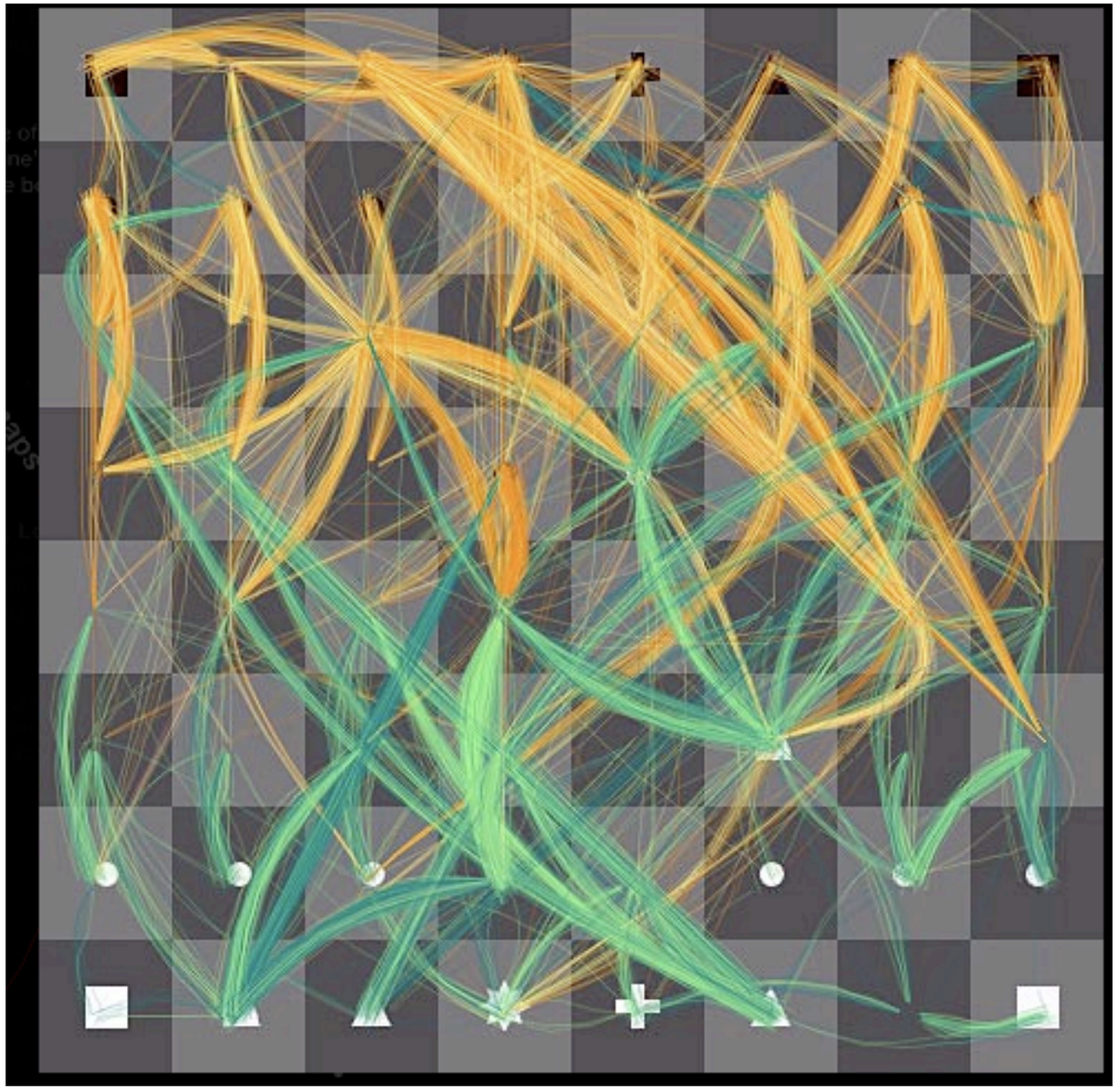
Simile or Graph?

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

Cereal
Click to select,
Ctrl-Click: multiple
Shift-Click: range

- Apple Cinnamon Che
- Basic 4
- Cheerios
- Cinnamon Toast Cru
- Clusters
- Cocoa Puffs
- Count Chocula
- Crispy Wheat & Raisi
- Golden Grahams
- Honey Nut Cheerios
- Kix
- Lucky Charms
- Multi-Grain Cheerios
- Oatmeal Raisin Crisp
- Raisin Nut Bran
- Total Corn Flakes
- Total Raisin Bran
- Total Whole Grain
- Triples

12 8 4 2 0

Search>>

Fiber
Disks colored by Cereal

Not shown:19 null/zero items

http://services.alphaworks.ibm.com/manyeyes/view/S9_5xLsOtha68HVE_RT4M2~

To highlight click

Bubble Size: Fiber Label: Cereal Color: Cereal

Hybrid Presentations

- combinations of several techniques are used

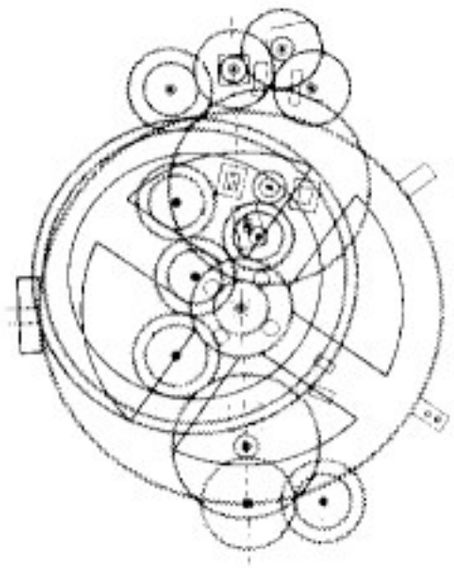
Embodiment of Knowledge

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

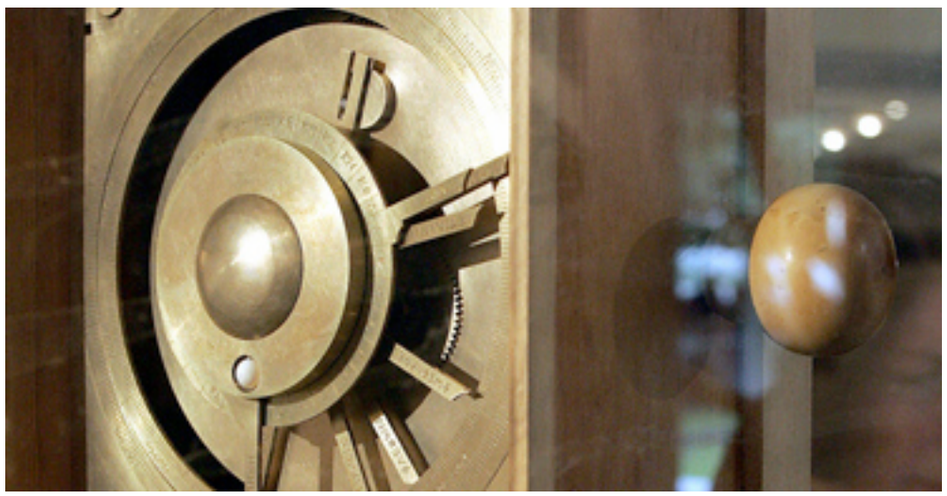
Knowledge Embodiment Examples

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

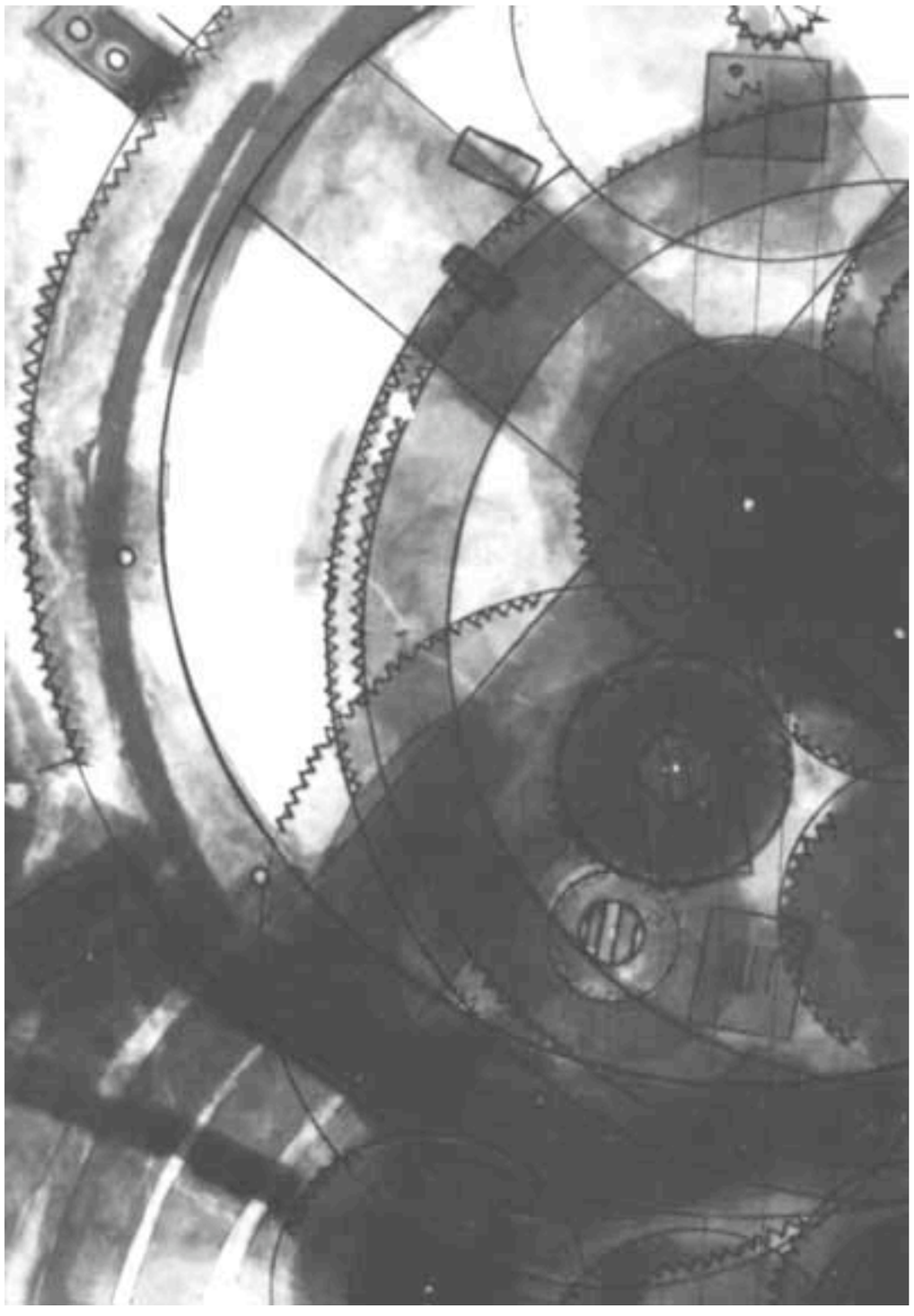
Antikythera Original

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

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

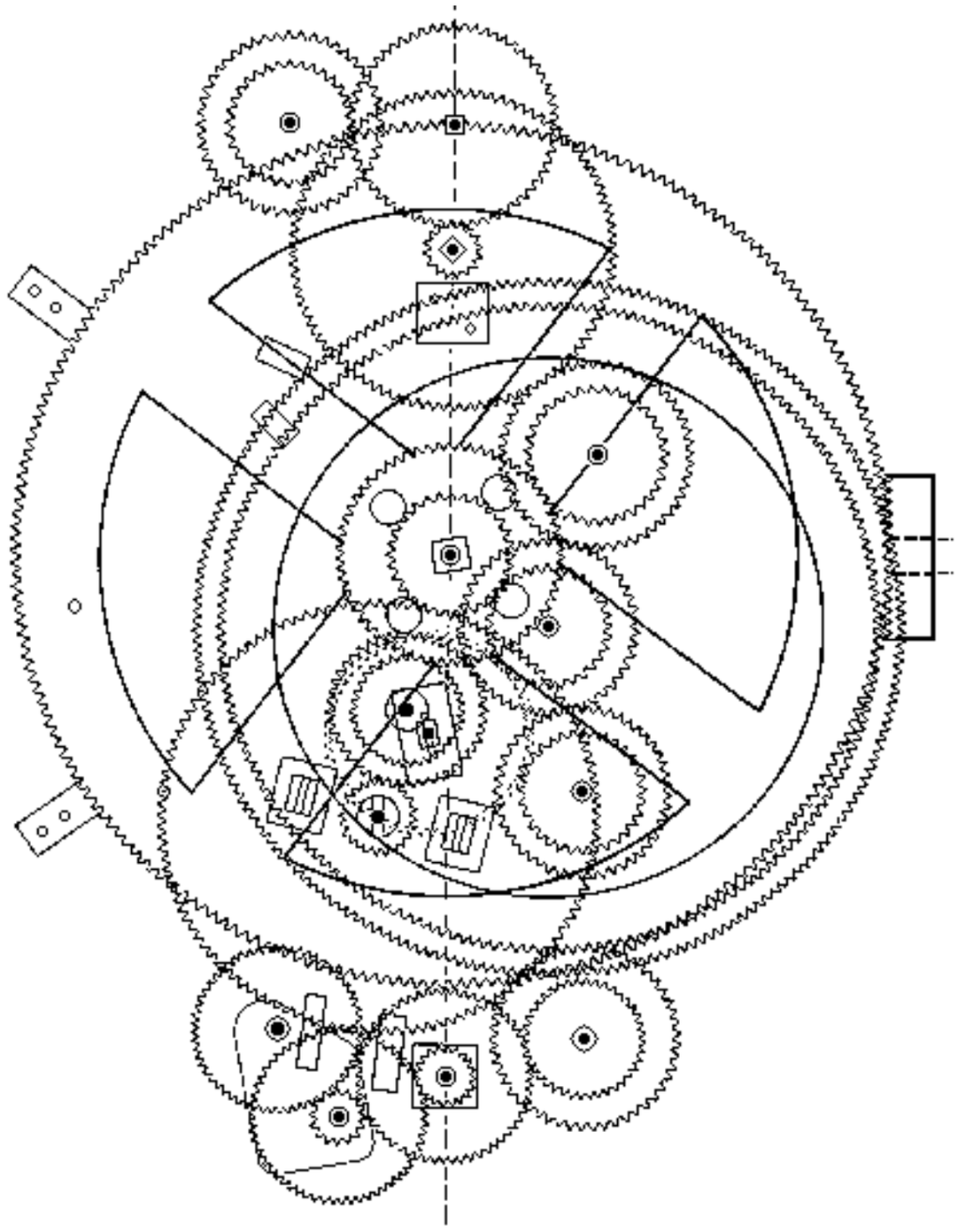
Antikythera Analysis

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



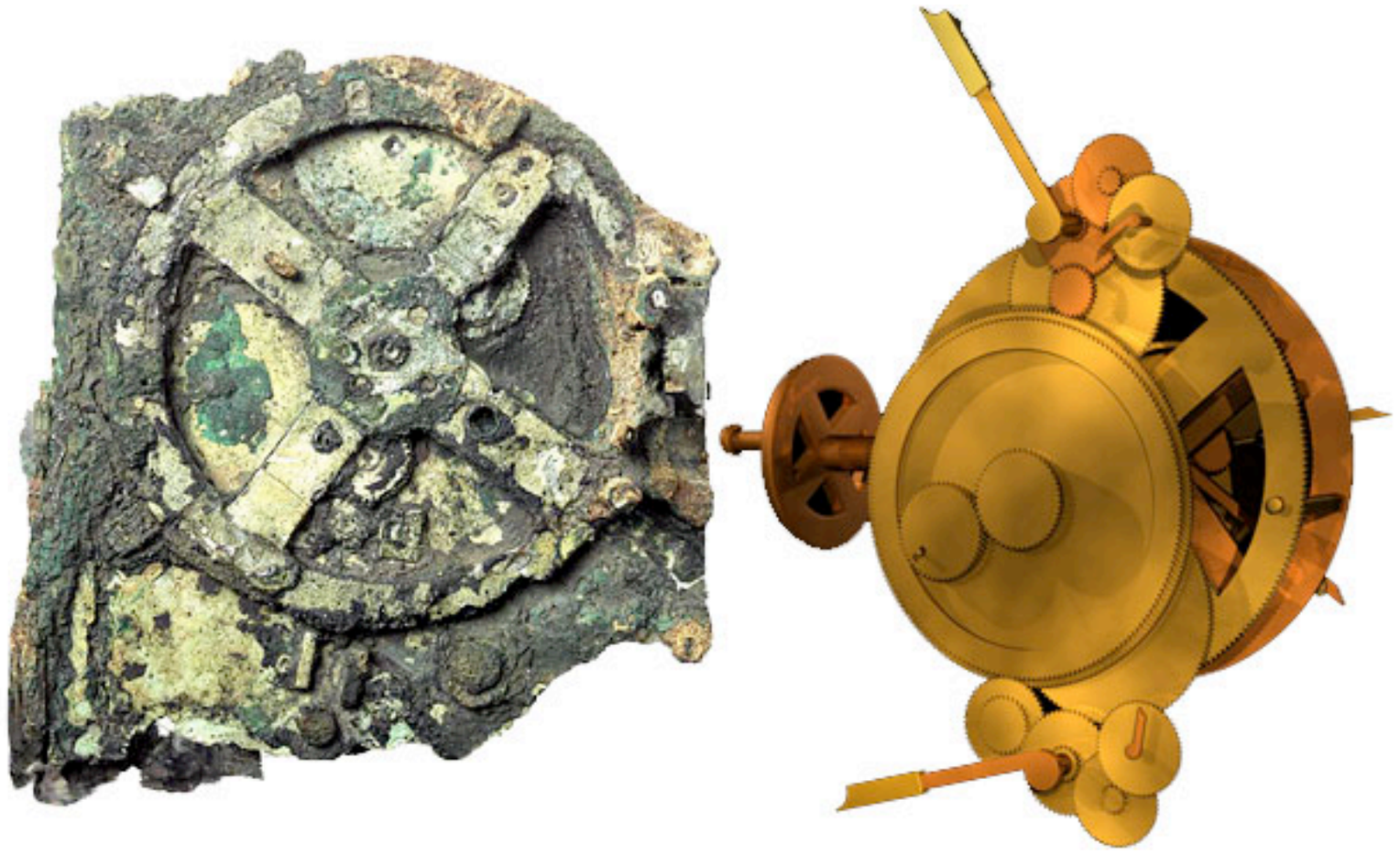
http://www.virtuescience.com/antikythera.jpg

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

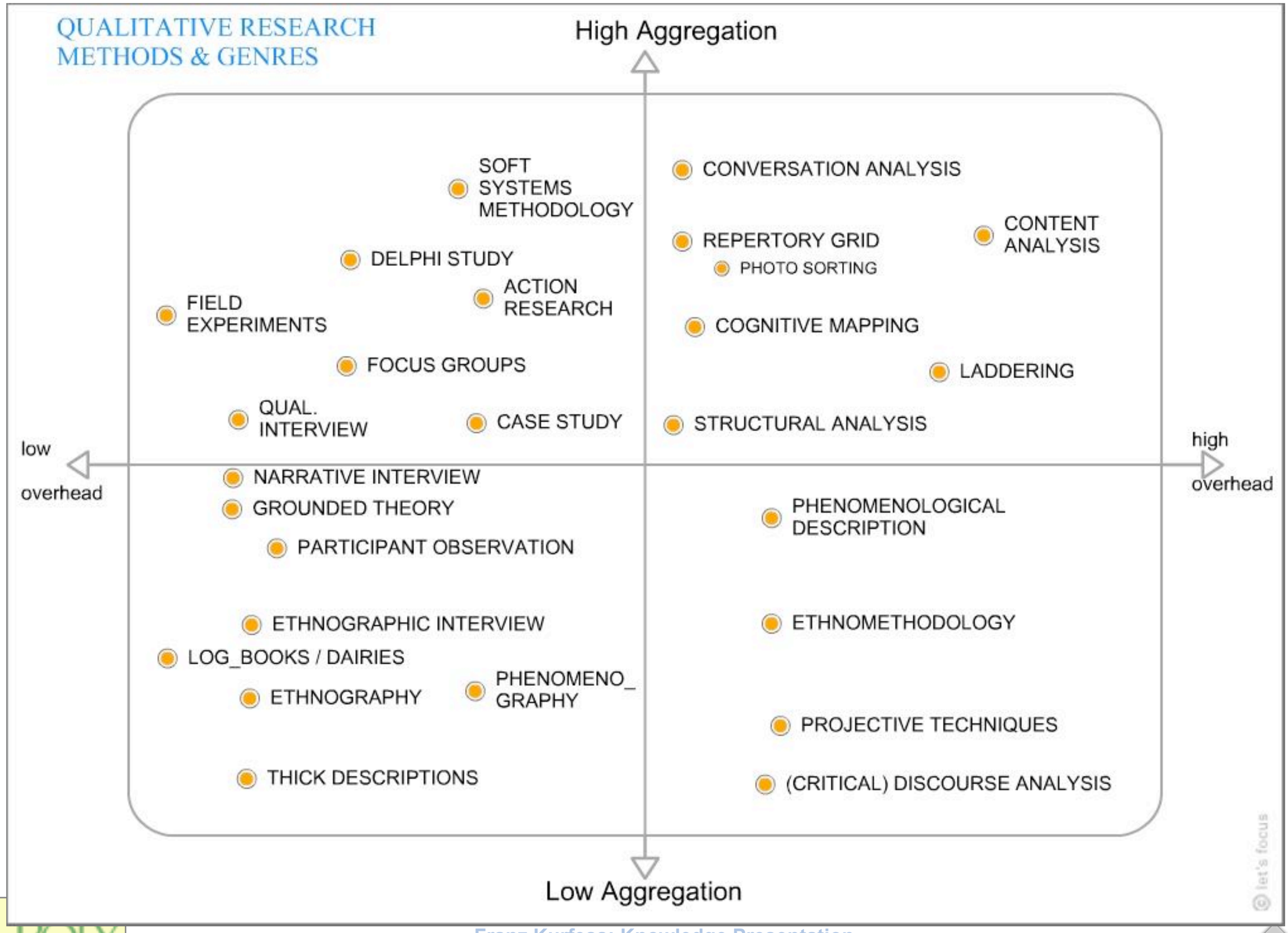
- later development
  - possibly influenced by the Antikythera mechanism

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/

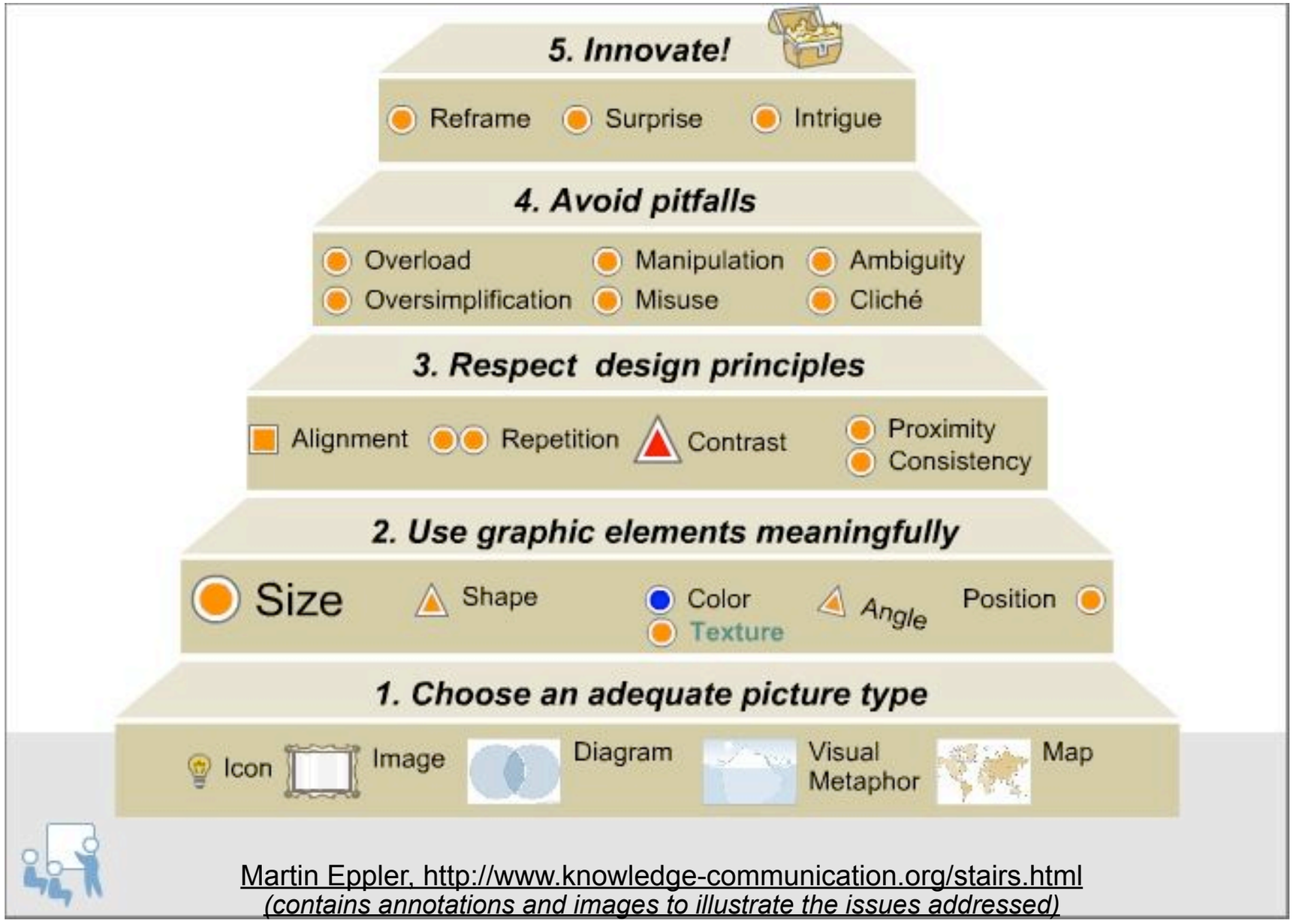
Qualitative Research Methods



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

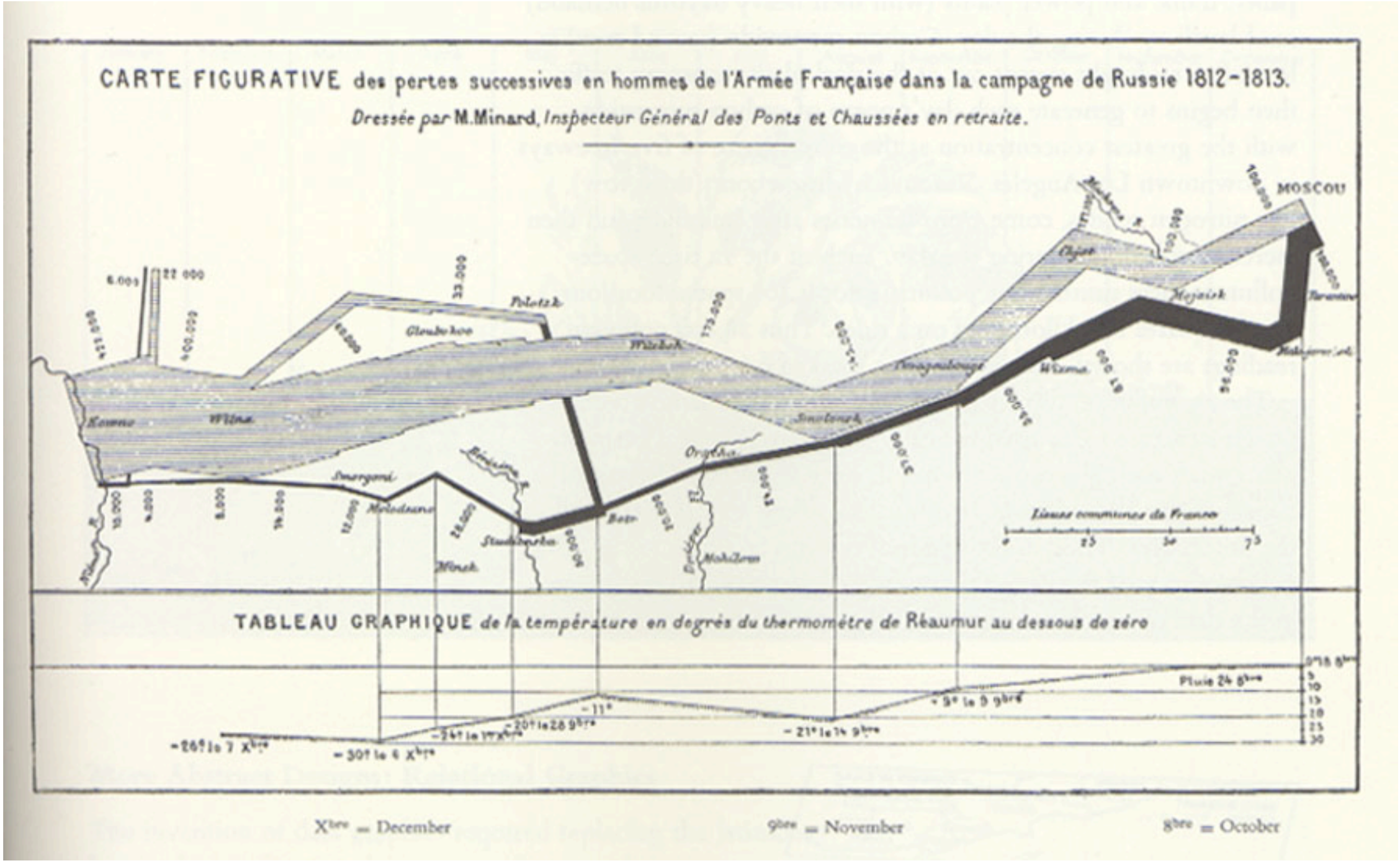
Knowledge Types

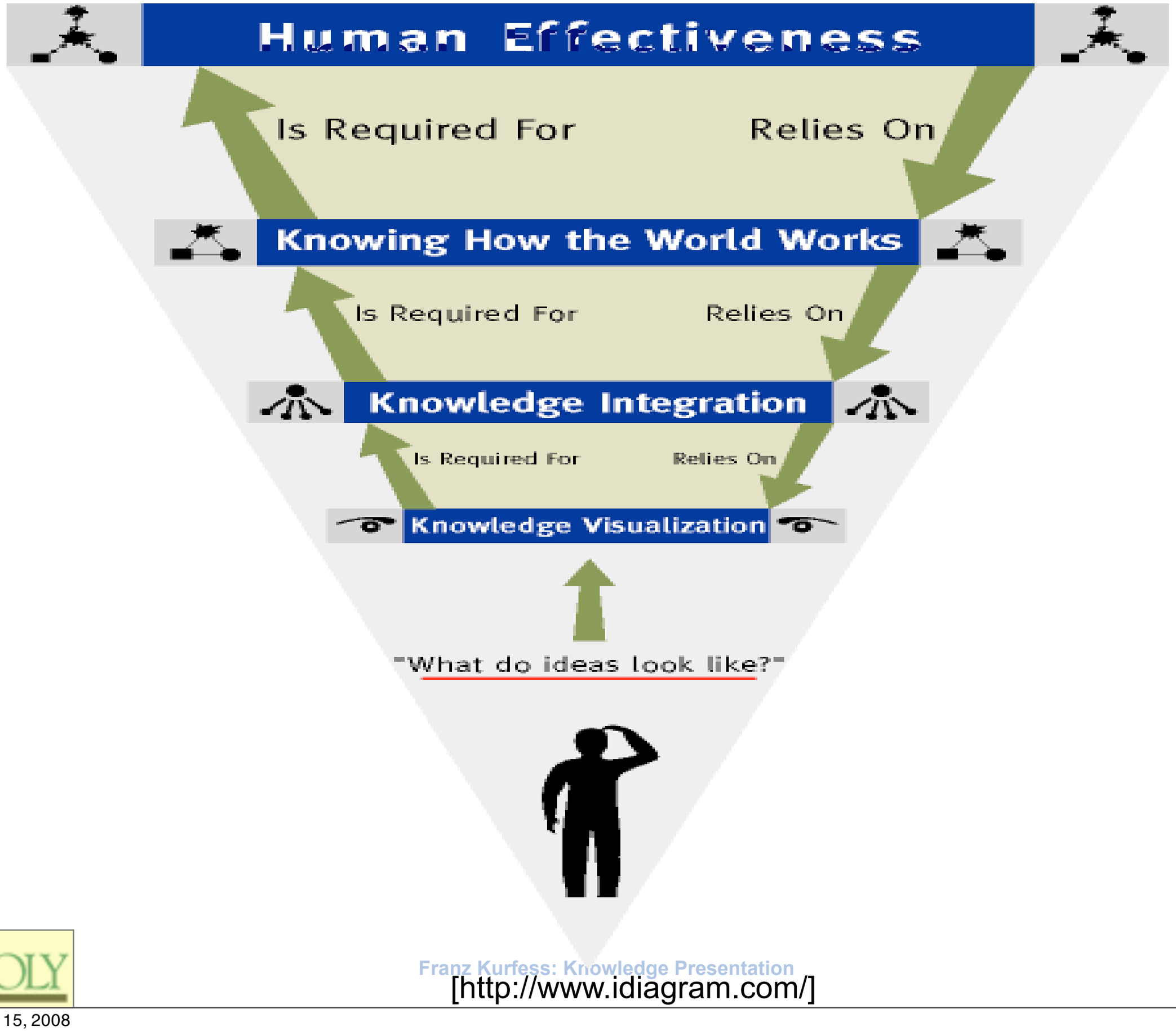
Stairs of Visualization



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

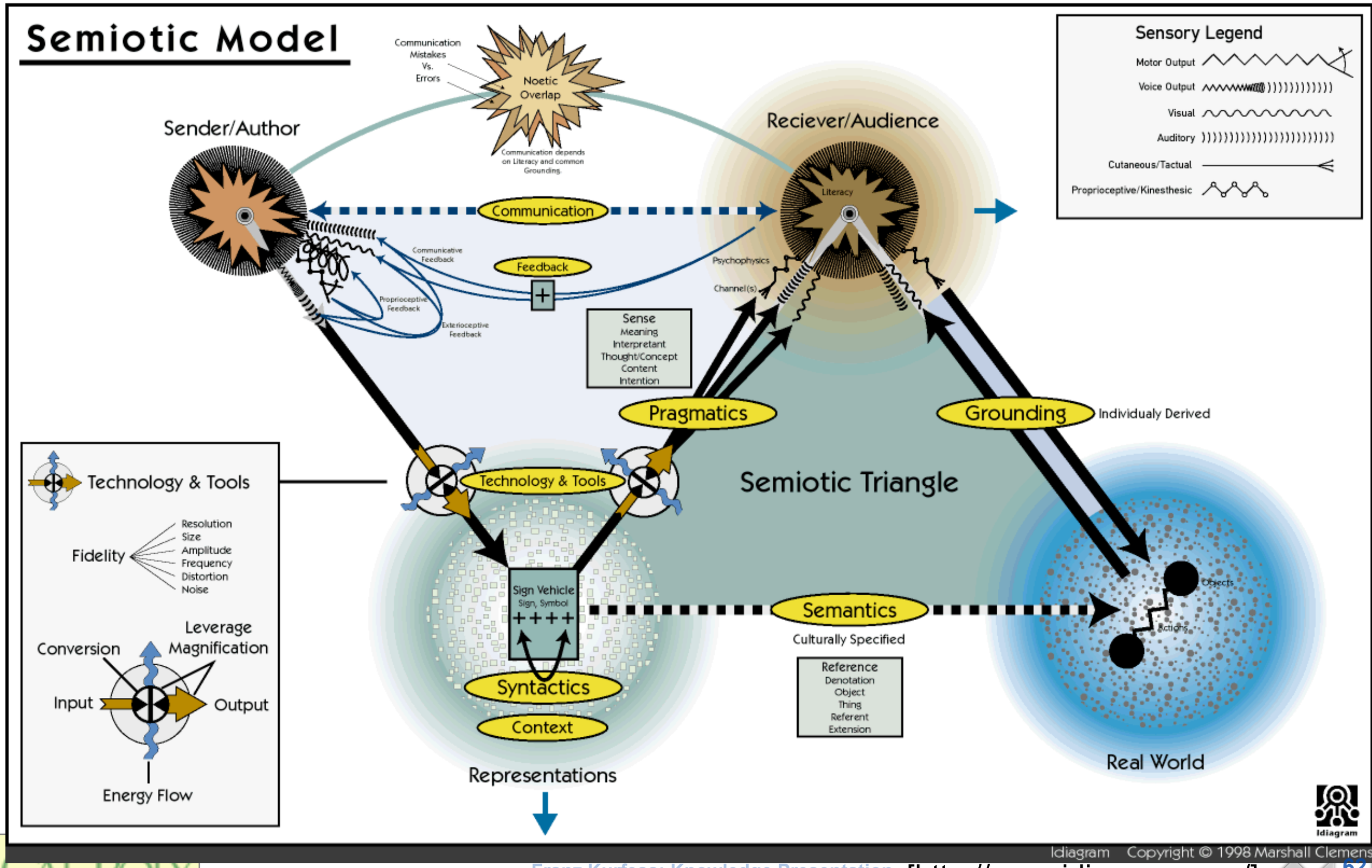
Minard: Napoleon's Russia Campaign



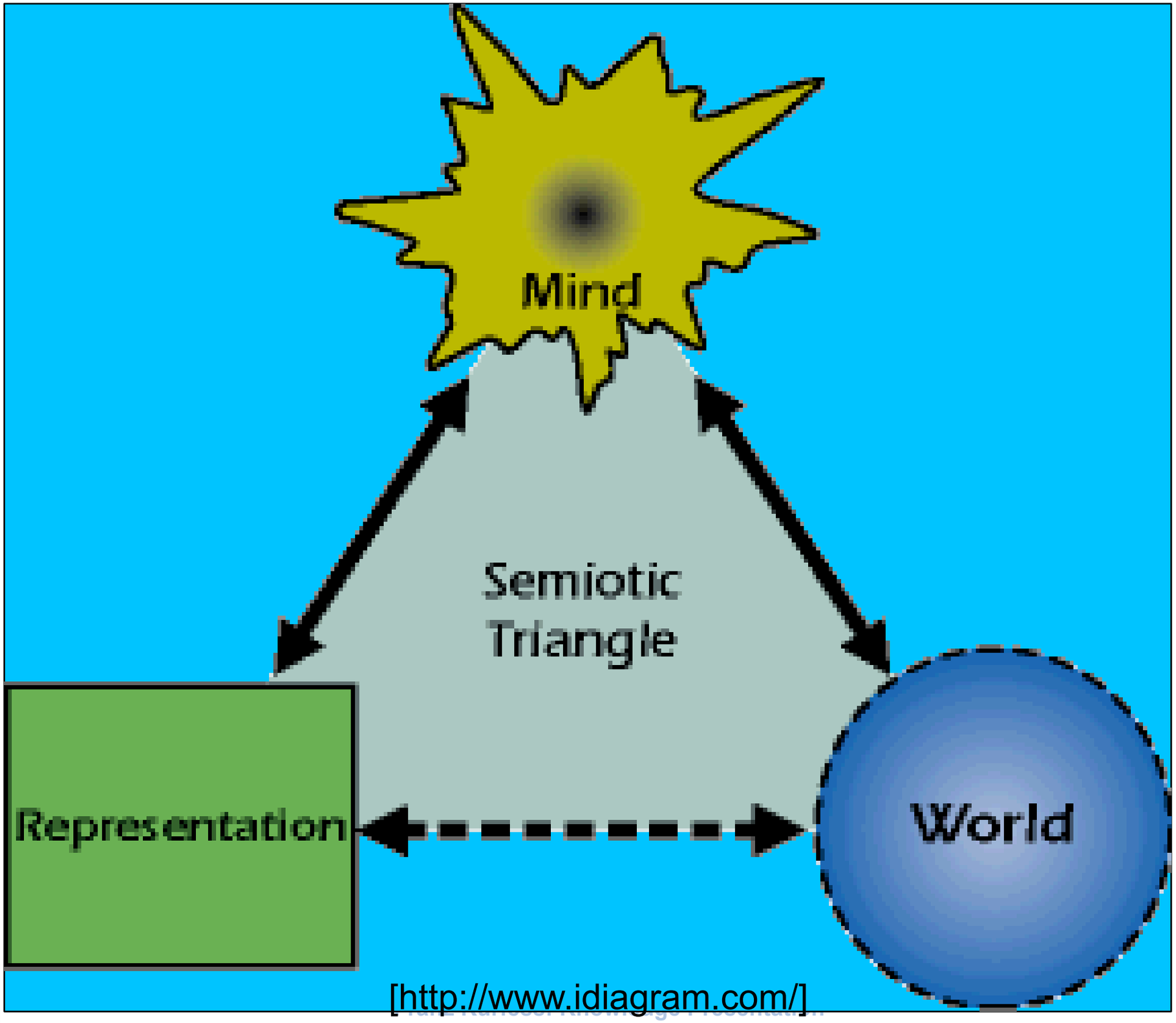


[http://www.idiagram.com/]

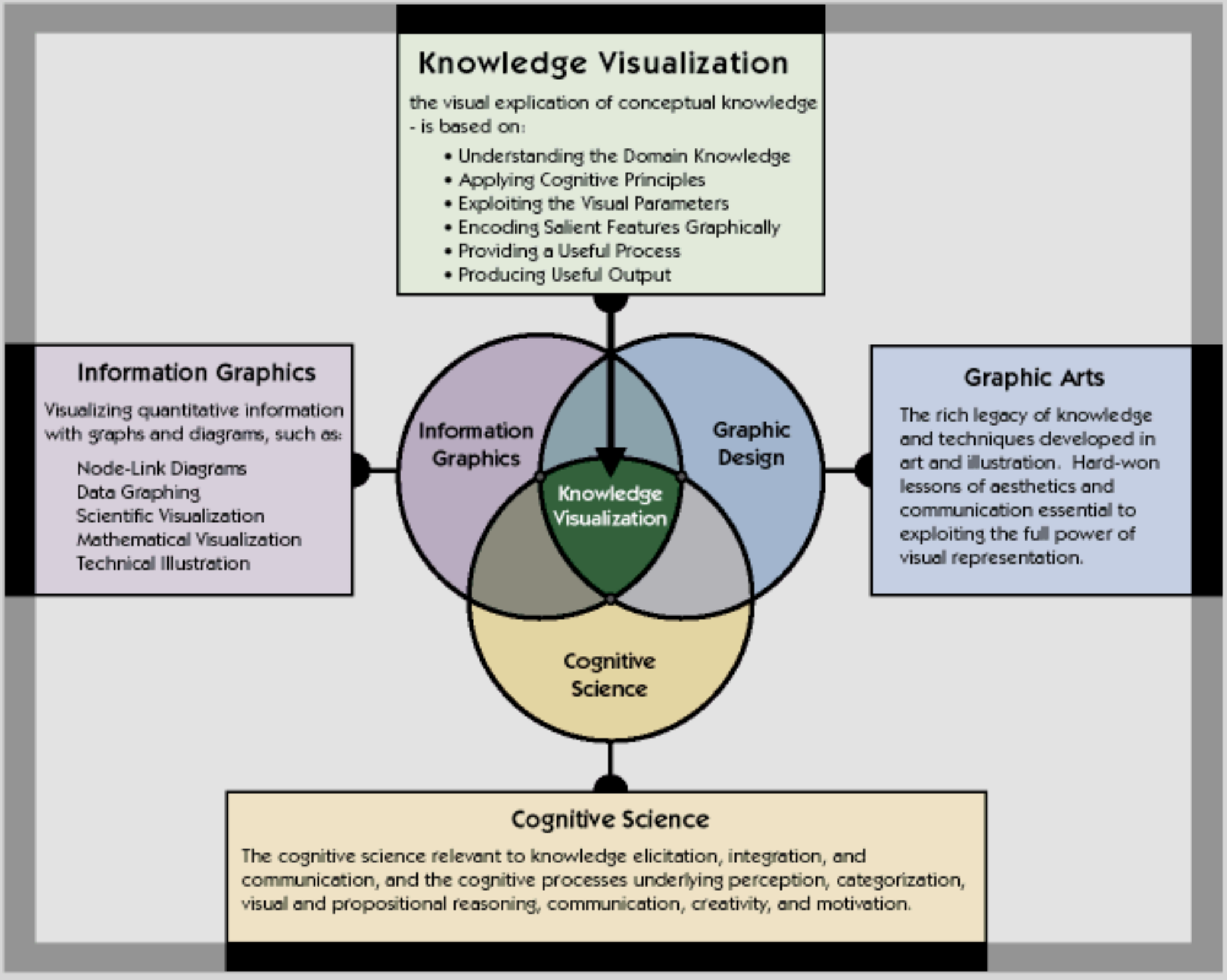
Semiotic Model



Semiotic Triangle

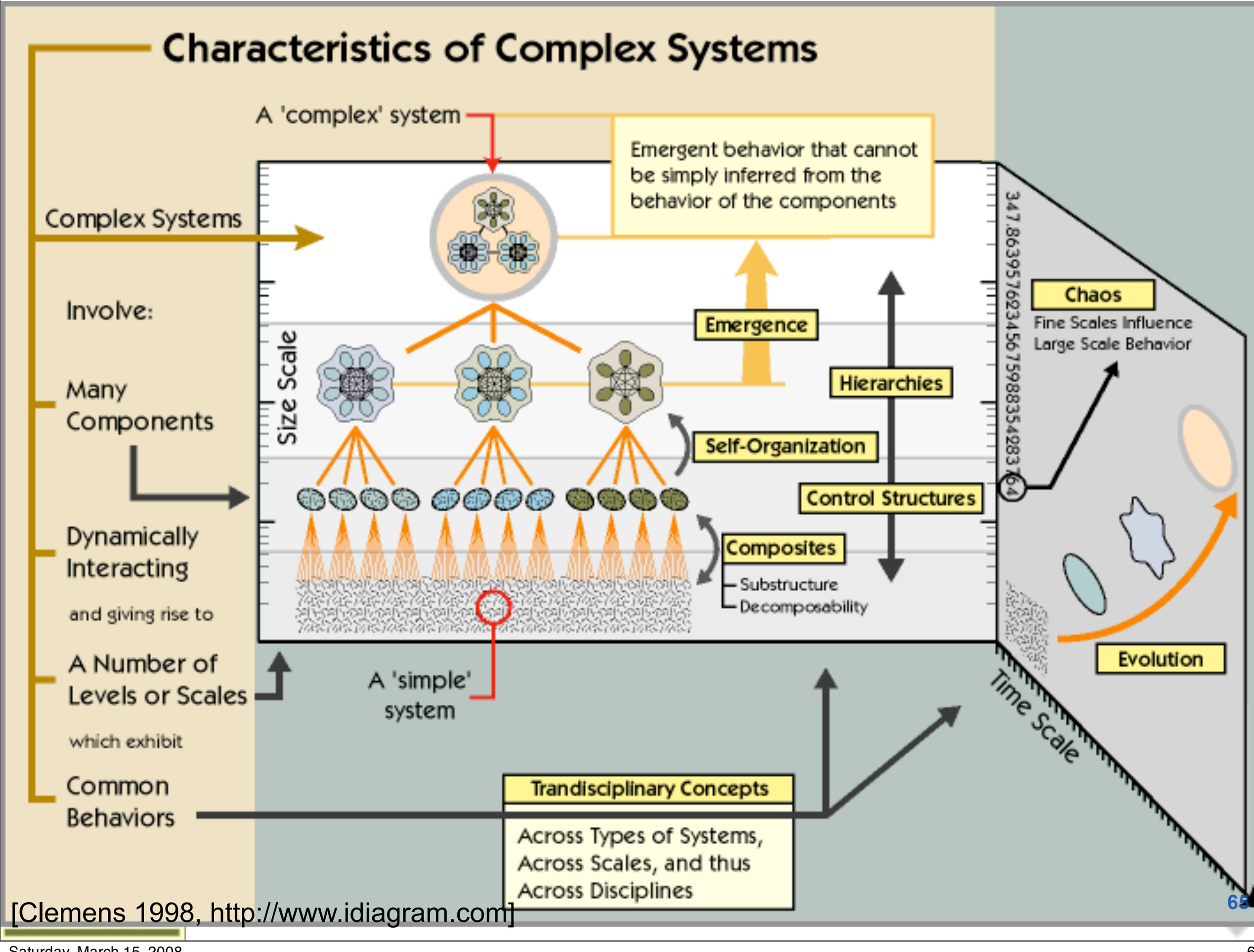


[http://www.idiagram.com/]



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

Characteristics of Complex Systems



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

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

The System Concept

Environment

Energy Flow

Boundaries

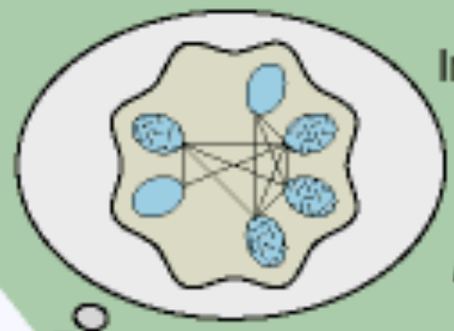


Image Schema

Metaphors &
Mental-Models

System Representations

- Image-Schema
- Verbal
- Mathematical
- Modeling & Simulation

Experience &
Experimentation

Modeling &
Theorizing

Representation

Science

Sys-Rep

Explanation

Description

Prediction

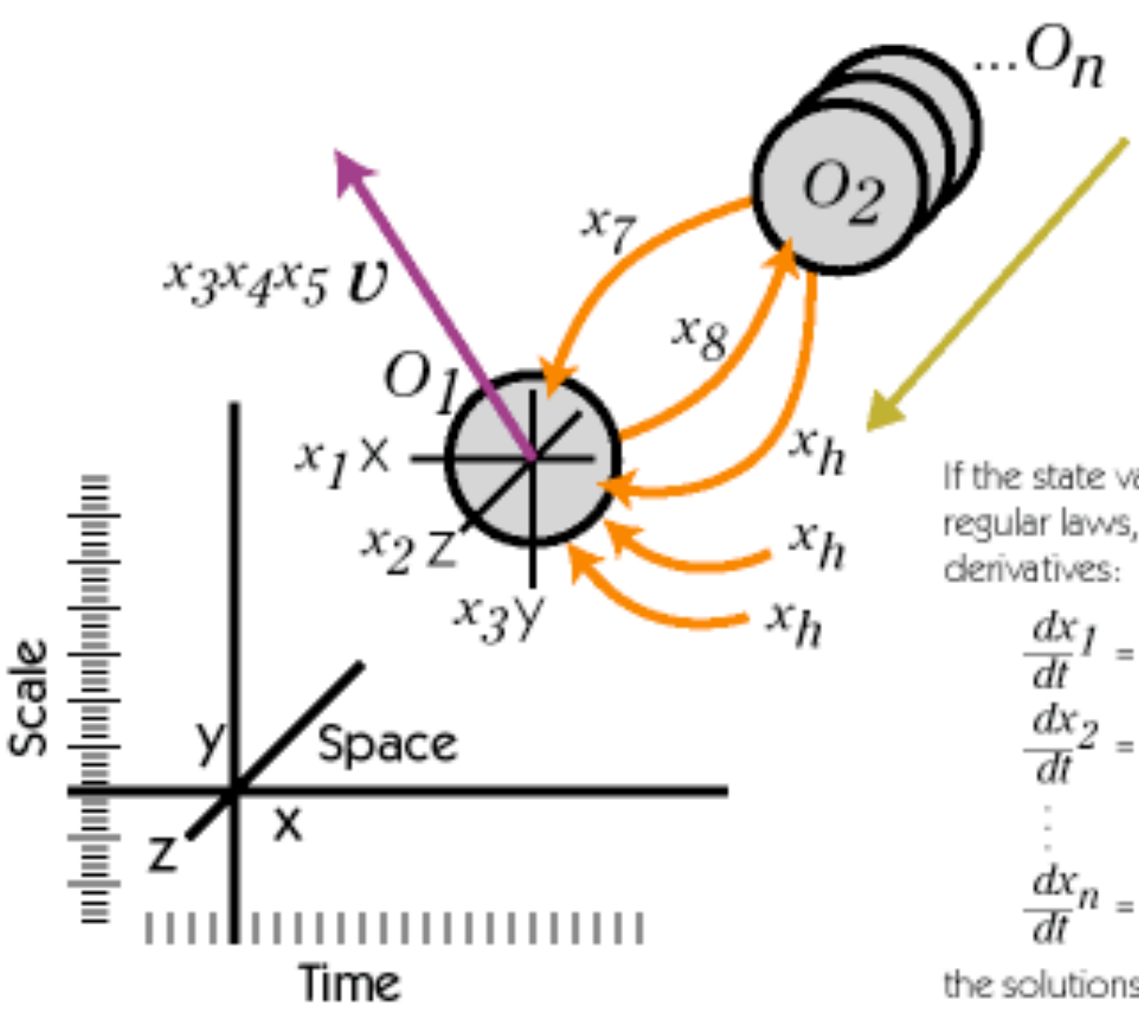
Dynamics

Time

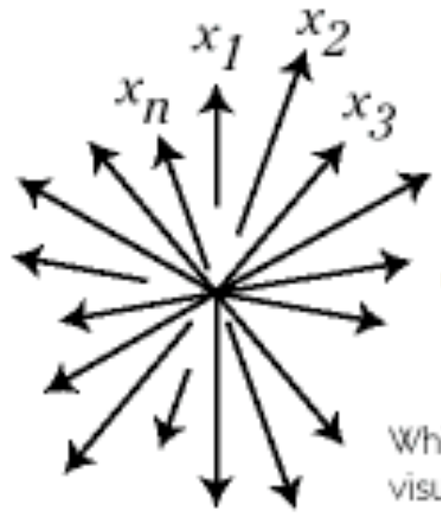
Simulation

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

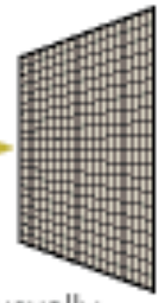
System Dynamics: State & Phase Space



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:

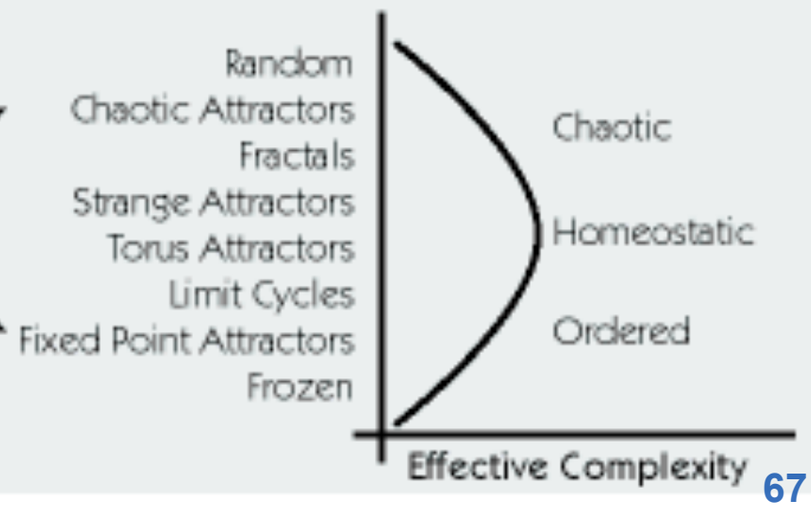
$$\frac{dx_1}{dt} = f_1(x_1, x_2, x_3 \ldots x_{Nn})$$
$$\frac{dx_2}{dt} = f_2(x_1, x_2, x_3 \ldots x_{Nn})$$
$$\vdots$$
$$\frac{dx_n}{dt} = f_n(x_1, x_2, x_3 \ldots x_{Nn})$$

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

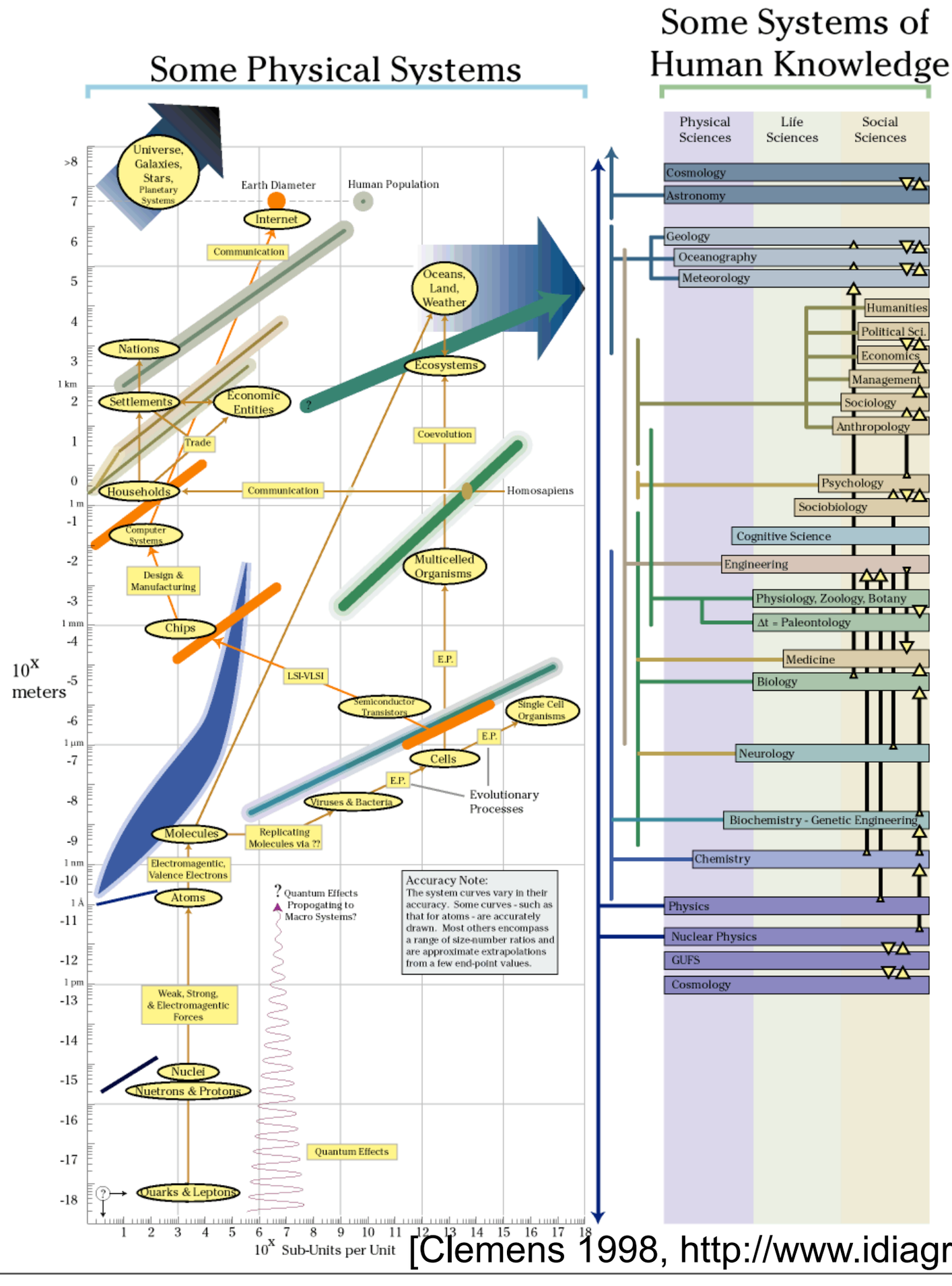
Statistical Approaches:
When there are too many units to keep track of individually, and the units all exhibit identical or similar behavior, the systems can be modeled using statistical methods.

Some Types of Trajectories

Disordered to Ordered

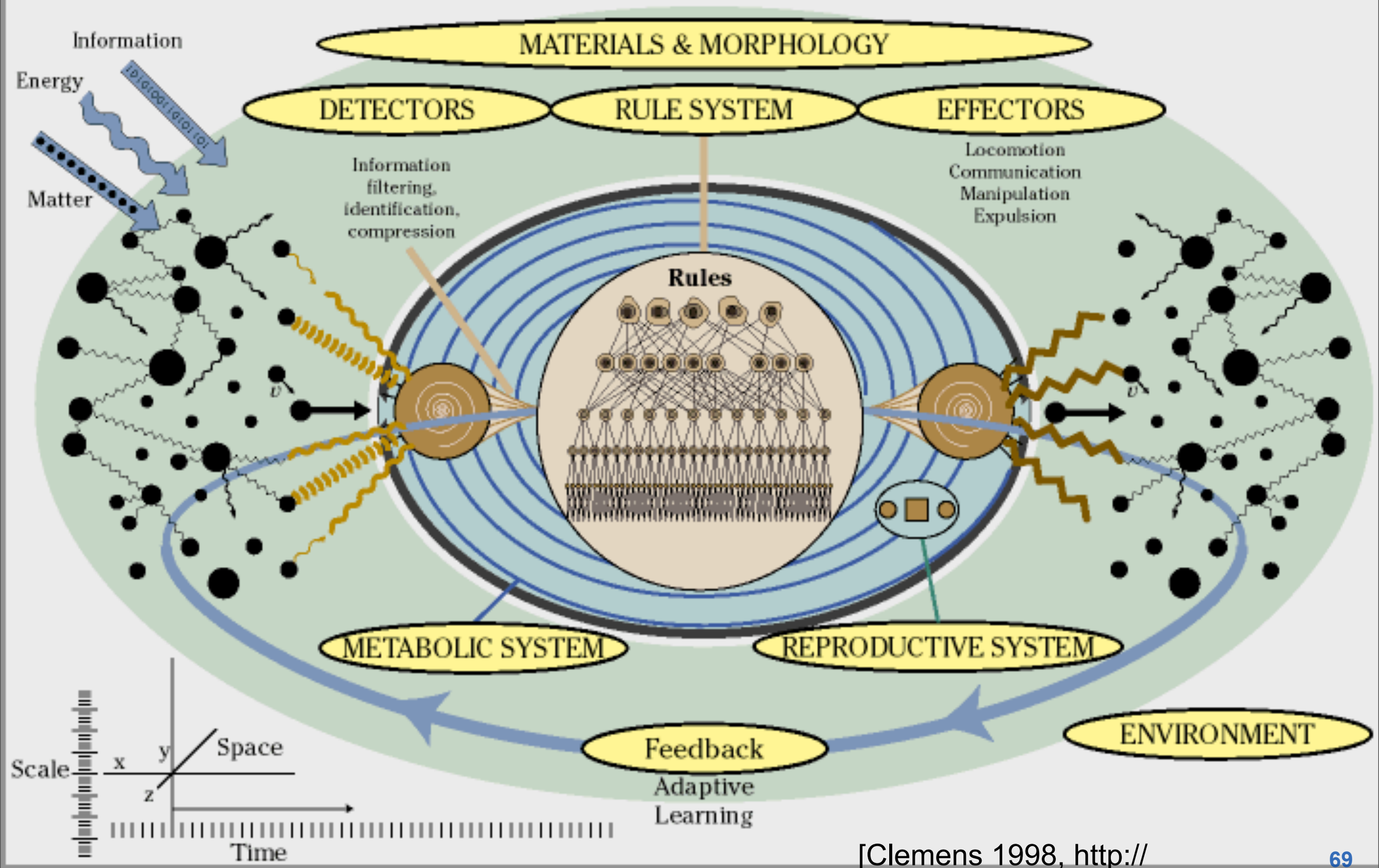


[Clemens 1998, http://www.idiagram.com]



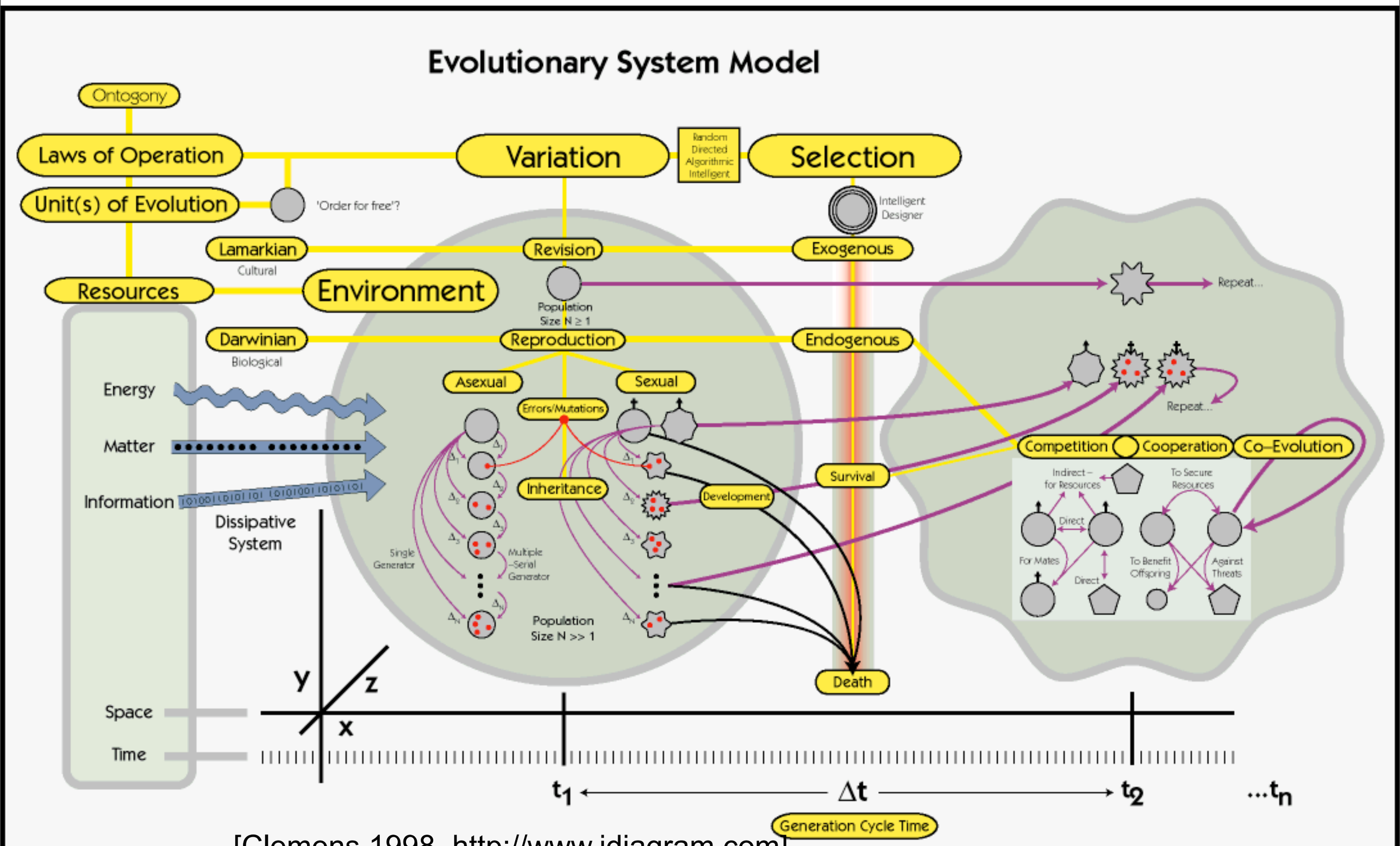
[Clemens 1998, http://www.idiagram.com]

Complex Adaptive System Model

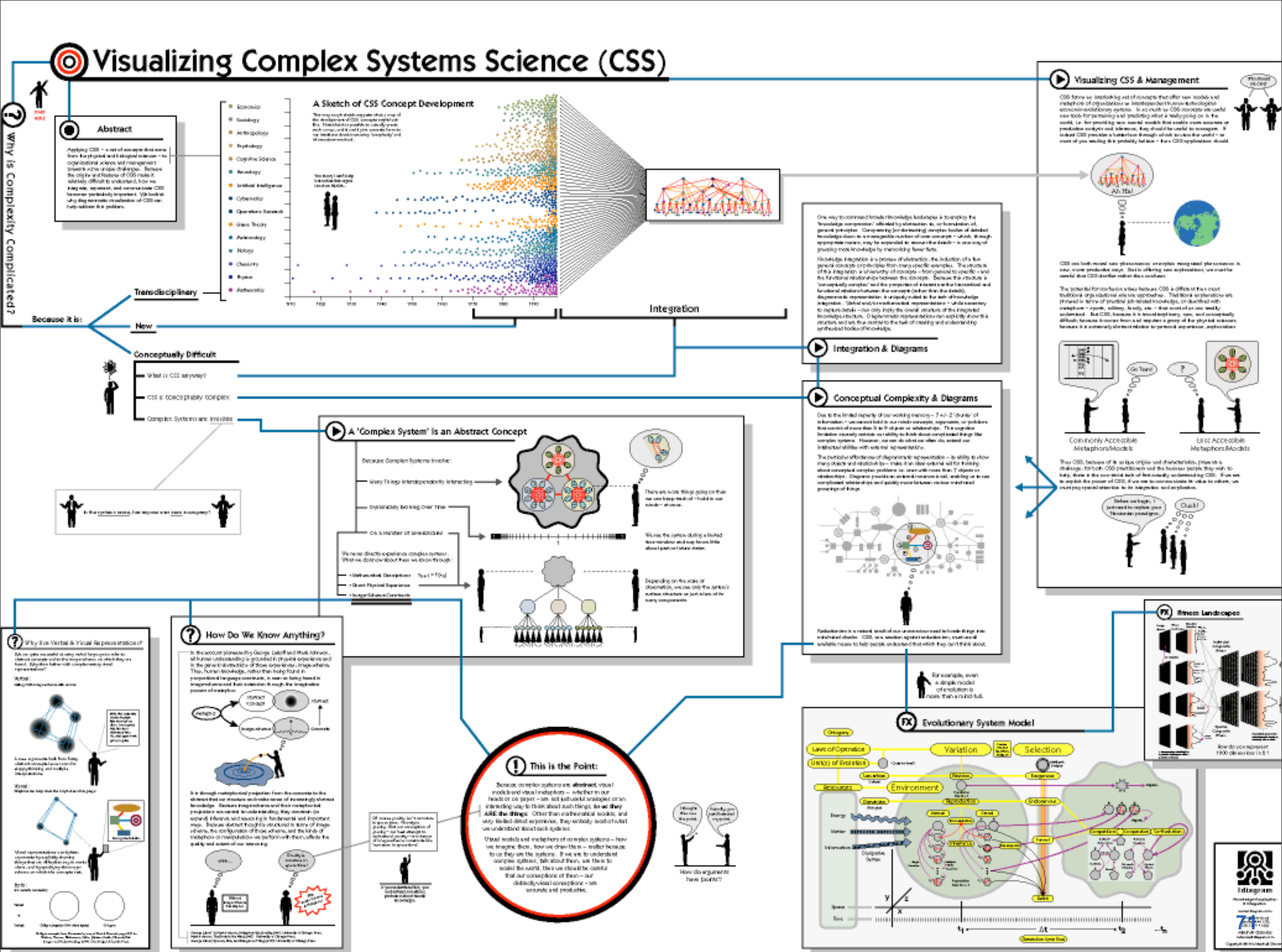


[Clemens 1998, http://www.idiagram.com]

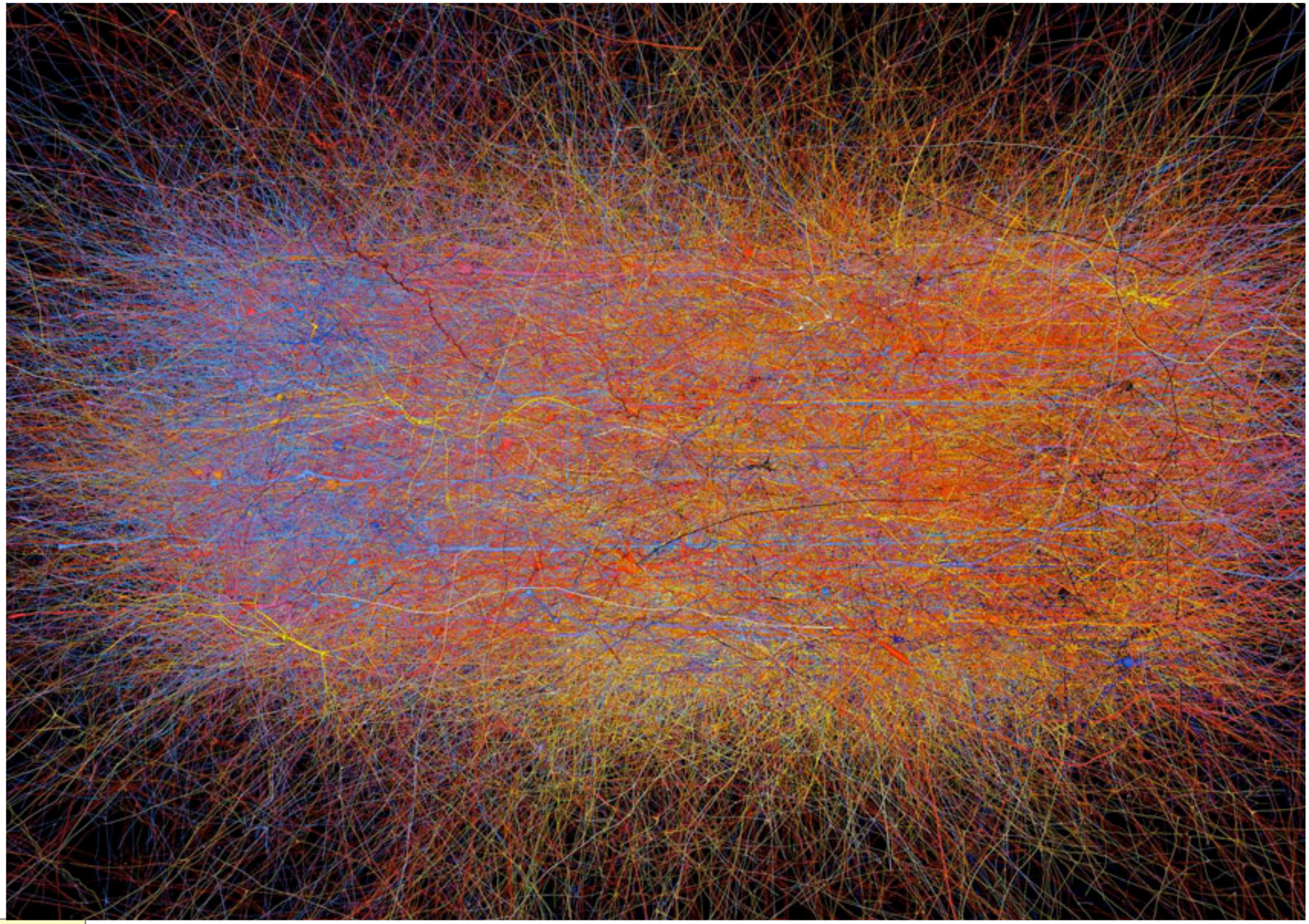
Evolutionary System Model



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

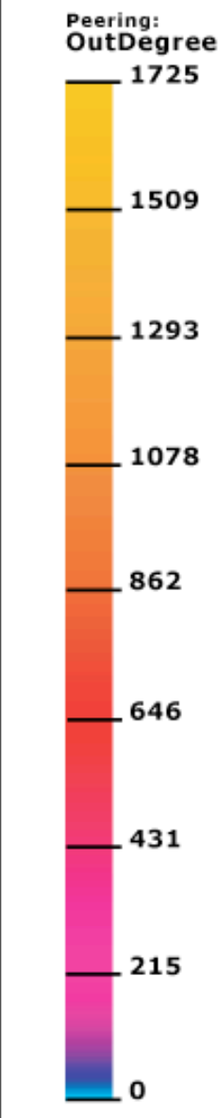

Visualizing Complex Systems Science (CSS)
Why is Complexity Complicated?
Abstract
A Sketch of CSS Concept Development
Transdisciplinary
Because it is:
New
Conceptually Difficult
Integration
Visualizing CSS & Management
Integration & Diagrams
Conceptual Complexity & Diagrams
A 'Complex System' Is an Abstract Concept
How Do We Know Anything?
This is the Point:
Evolutionary System Model
Fitness Landscapes
Commonly Accessible Metaphors/Models
Less Accessible Metaphors/Models
Ah Ha!
Variation
Selection
Environment

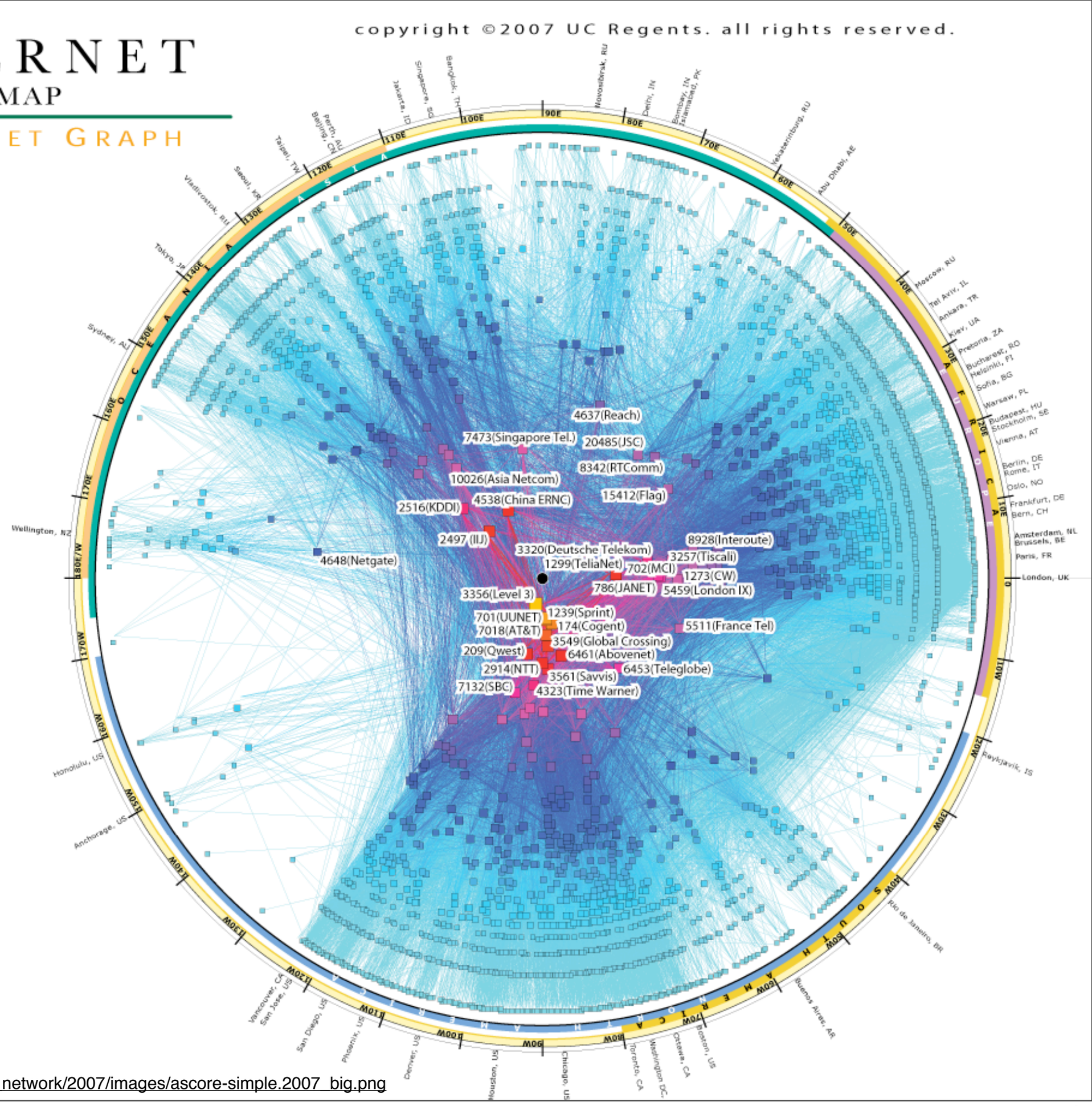
Mammalian Neocortical Column



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

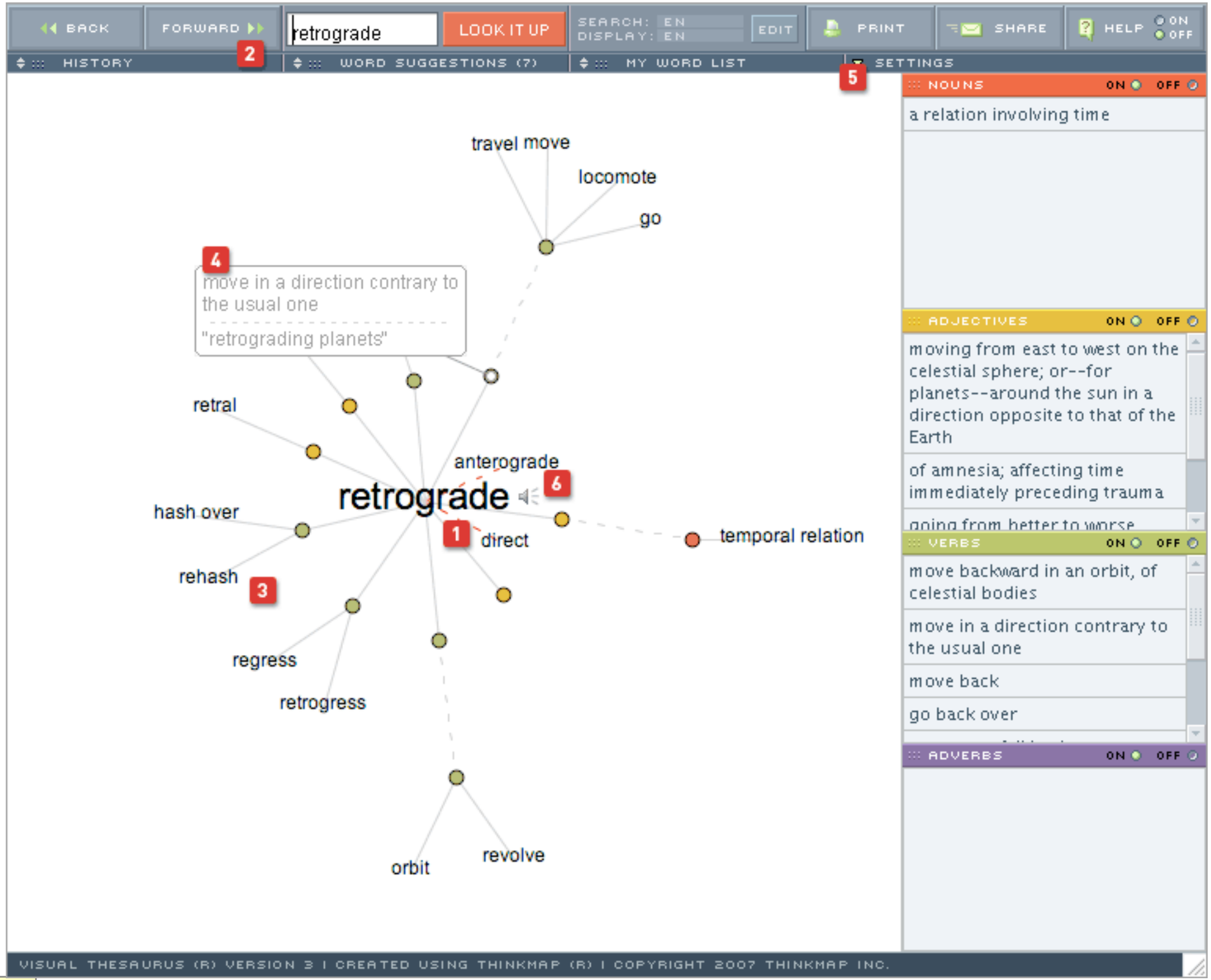
IPv4 INTERNET
TOPOLOGY MAP
AS-level INTERNET GRAPH





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

Visual Thesaurus

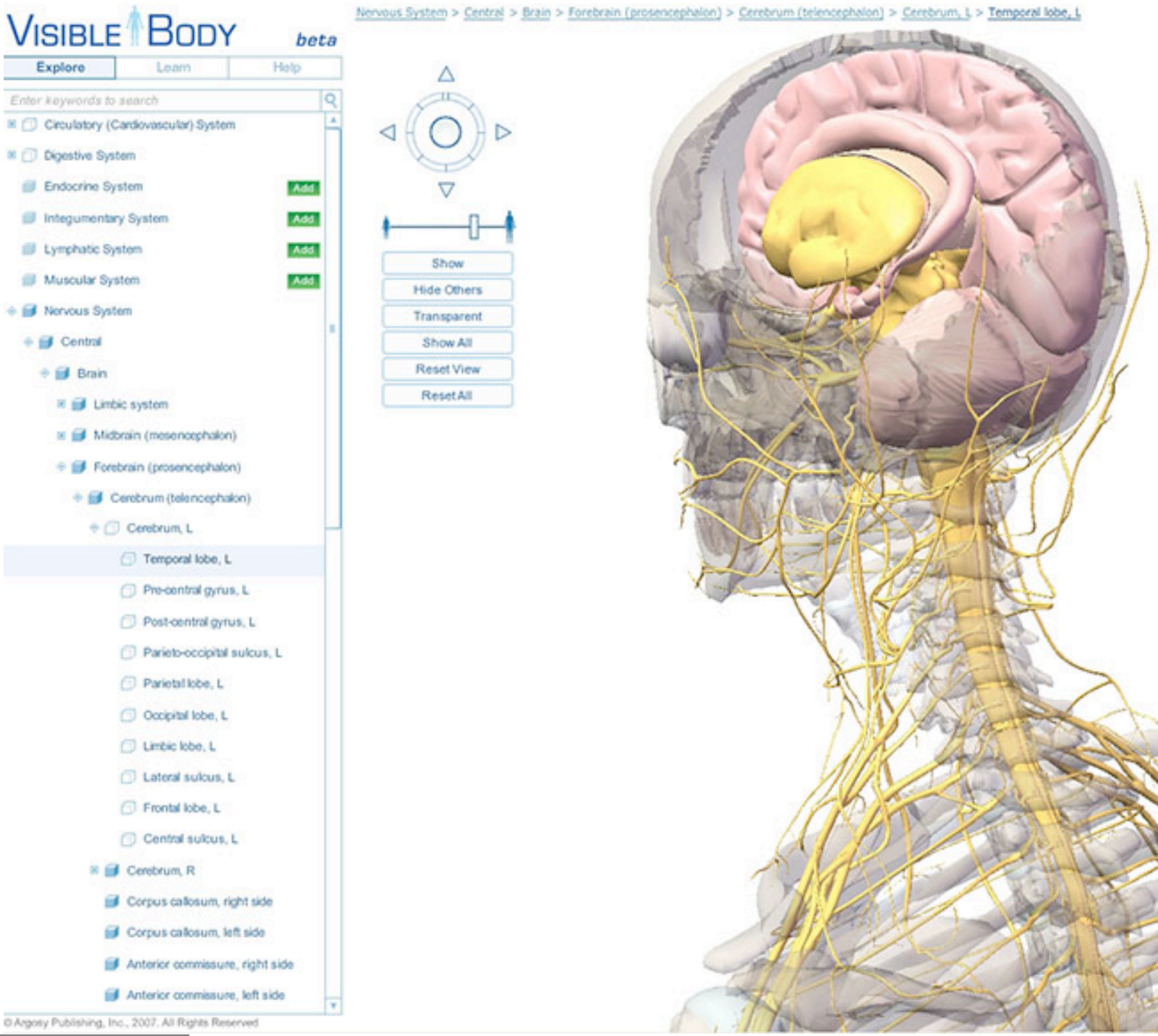


http://www.visualthesaurus.com/howitworks/images/screen.gif

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



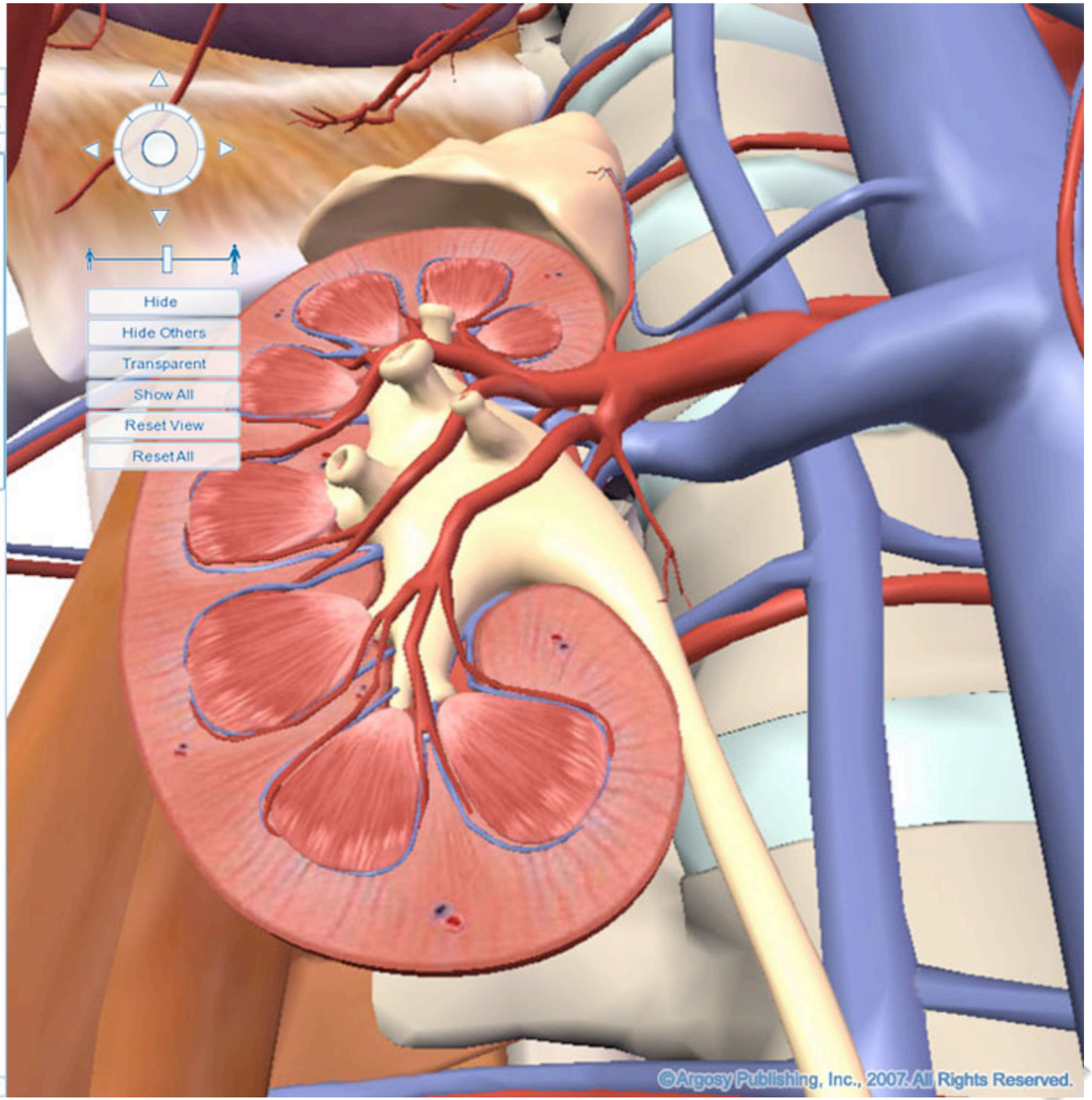
http://www.visiblebody.com/nervous_system2.html

VISIBLE BODY beta

Explore | Learn | Help

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
      - C6 Intervertebral disc



http://www.visiblebody.com/human_anatomy3.html

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.