



# Knowledge Presentation and Visualization

*Franz J. Kurfess*

*Computer Science Department  
California Polytechnic State University  
San Luis Obispo, CA, U.S.A.*





# Acknowledgements

*This lecture series has been sponsored by  
the **European Community**  
under the **BPD program**  
with **Vilnius University**  
as host institution.*

*Material on the Internet2 section was  
provided by the Internet2 consortium.*



# Use and Distribution of these Slides

These slides are primarily intended for the students in classes I teach. In some cases, I only make PDF versions publicly available. If you would like to get a copy of the originals (Apple KeyNote or Microsoft PowerPoint), please contact me via email at [fkurfess@calpoly.edu](mailto:fkurfess@calpoly.edu). I hereby grant permission to use them in educational settings. If you do so, it would be nice to send me an email about it. If you're considering using them in a commercial environment, please contact me first.

# 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

# 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

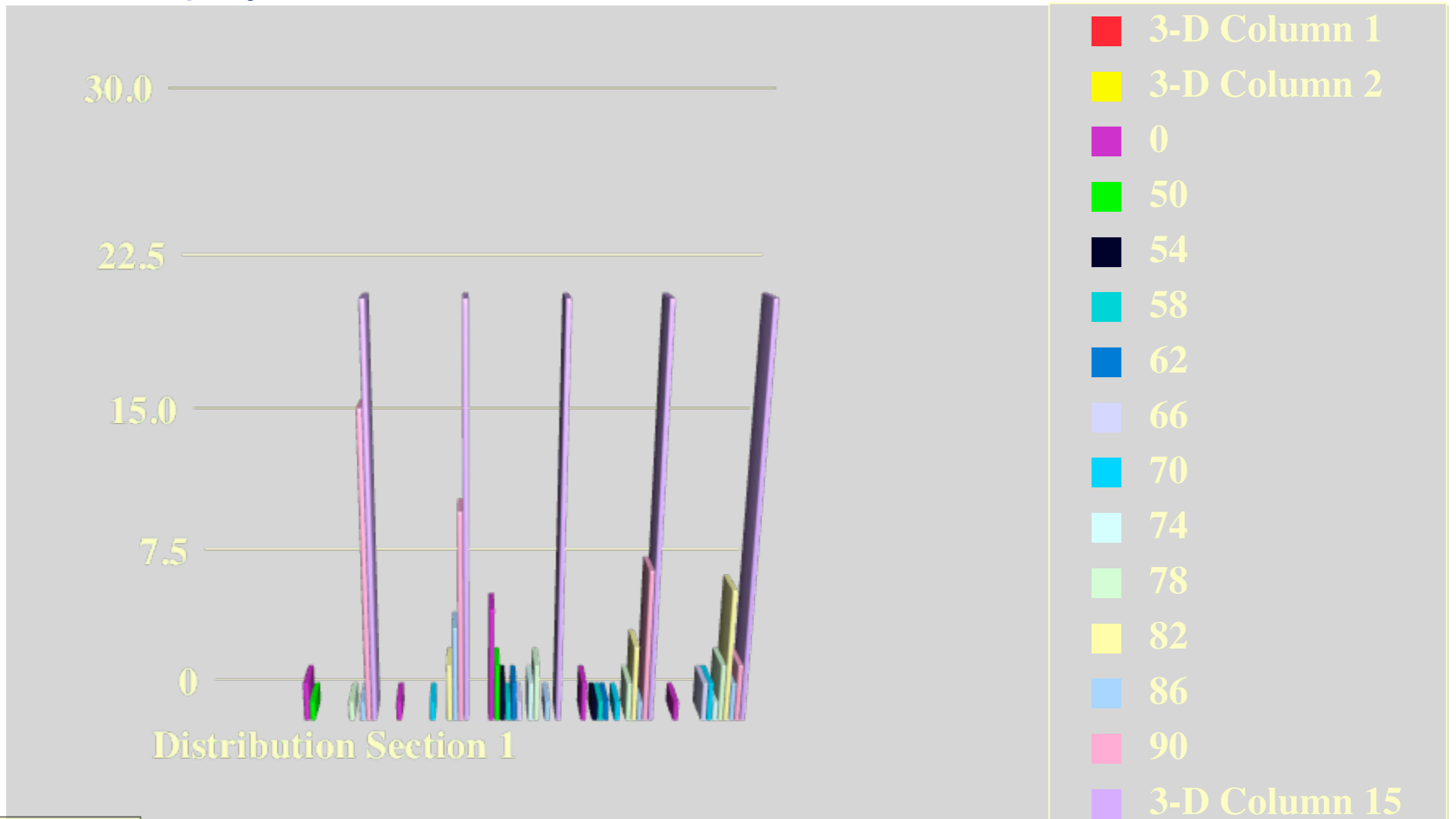


# Auditory Presentation Techniques

- ❖ 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

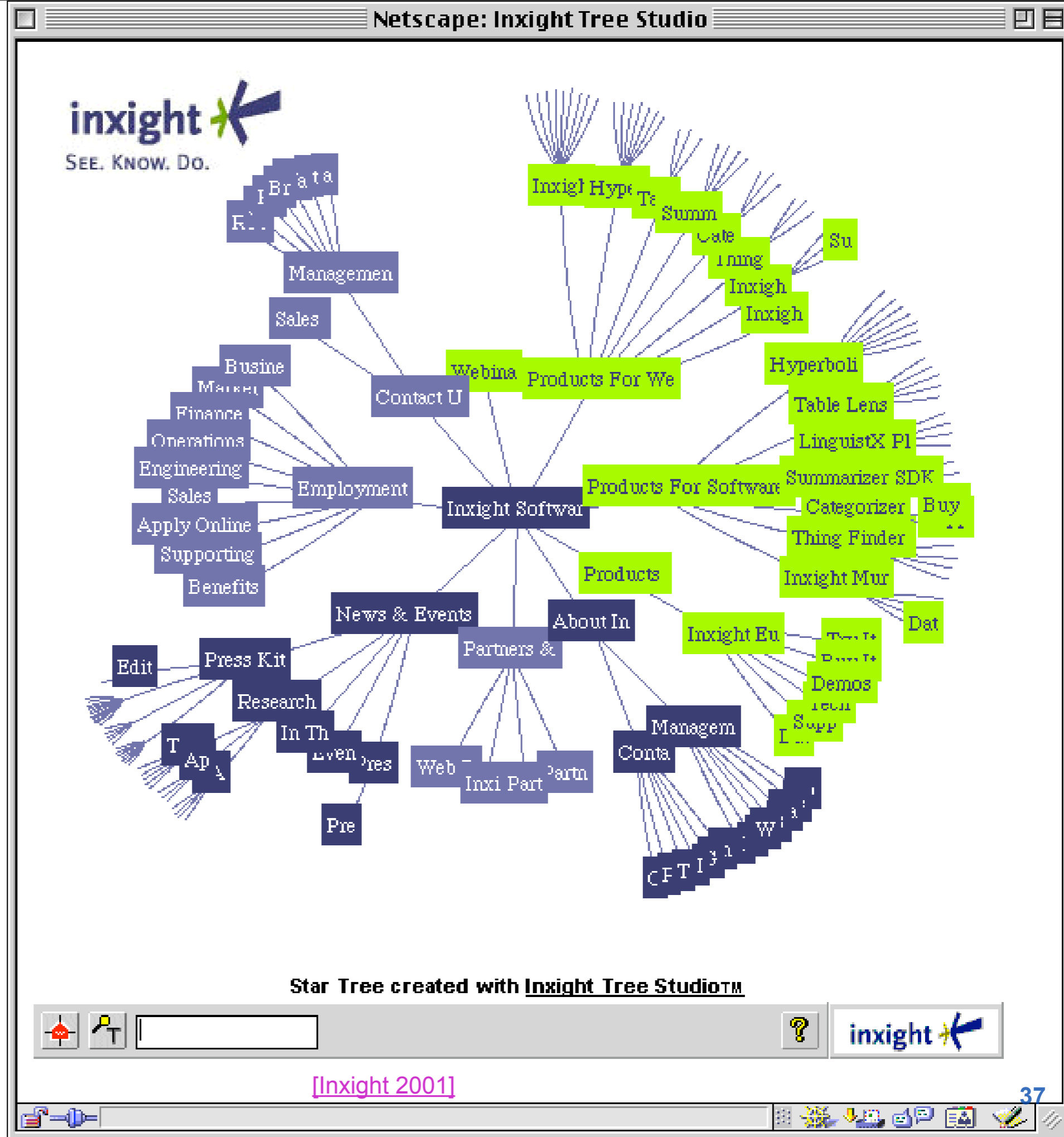
- ❖ hierarchical methods
  - ❖ trees
- ❖ graph-based methods
  - ❖ concept maps, mind maps, conceptual diagrams
- ❖ similes
  - ❖ the appearance of the proxy reflects the original
    - ❖ maps
- ❖ models
  - ❖ important functional properties are reproduced
- ❖ metaphors

# 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

to retrieve information about the many LEXIS-NEXIS sources. Use your mouse to click and drag the tree to explore more than 22,000 sources. Double-click the node names with folders in order to expand the tree. Double-click the source names to receive detailed information about the source.

**Source Locator Links**

- > [Source Locator](#)
- > [Source Locator Help](#)
- > [Source Locator Feedback](#)
- < [Hyperbolic Tree View](#)

States Legal - Area of Law - B  
Secondary Legal Combined Fe  
Reference Company & Finan  
Public Records LEXIS-NEXIS Sources Country & Region excludin  
People, Business Federal Legal - U.S.  
News Market & Legislative Legal excludin Forms a LEXIS-NEX  
Home

VizControls\* Hyperbolic Tree Java from Inxight Software, Inc., a Xerox New Enterprise Company, Copyright © 1996-1999. All rights reserved. [www.inxight.com](http://www.inxight.com)

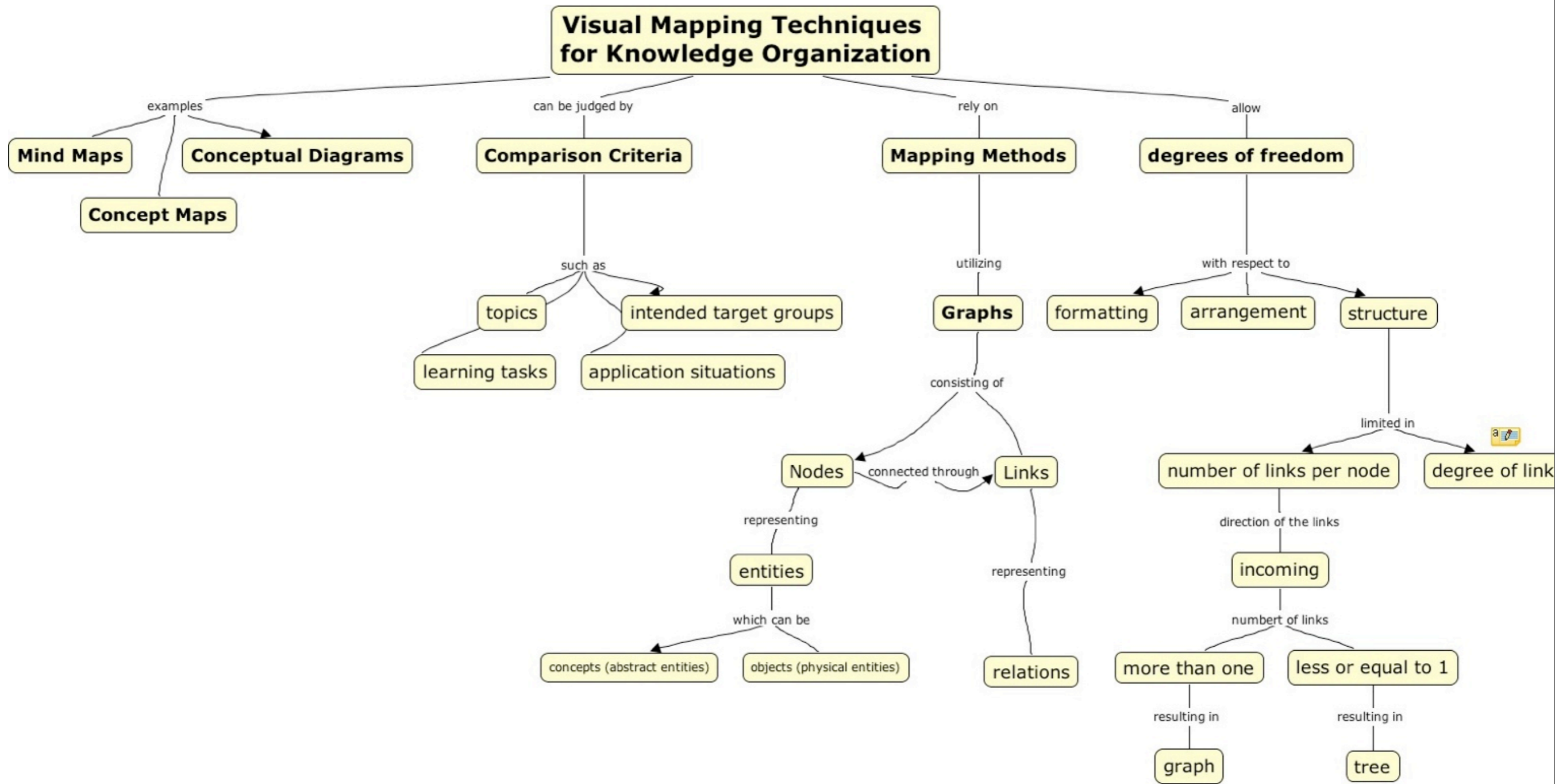
[Legal](#) | [Business](#) | [Government](#) | [Academic](#) | [Customer Service](#)  
[Lexis-Nexis Home](#) | [About](#) | [Contact us](#) | [Search Site](#)

This site is best viewed using Microsoft Internet Explorer 4.0.

# Graph-Based Presentations

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

# Example Concept Map

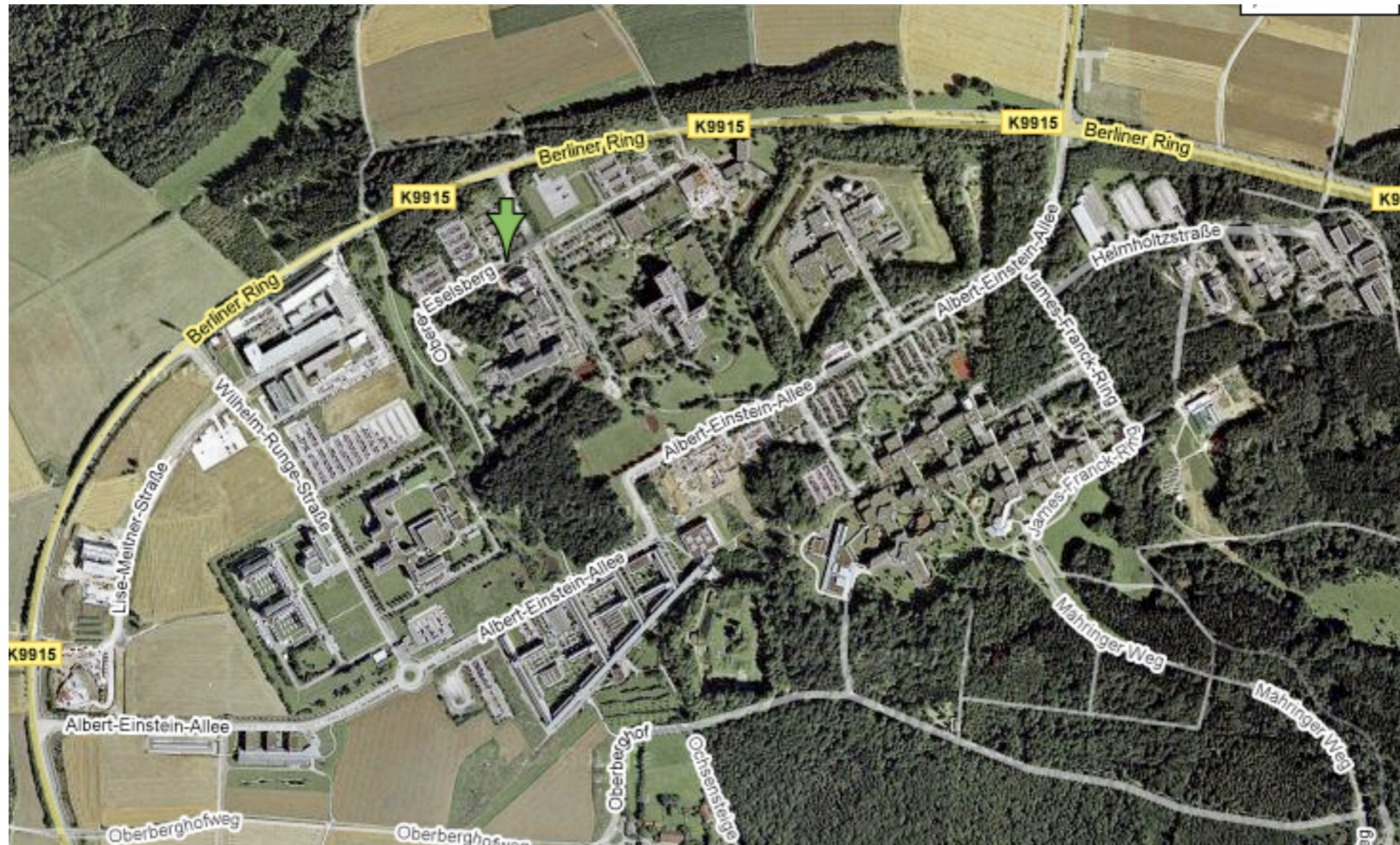




# Similes

- ❖ 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?

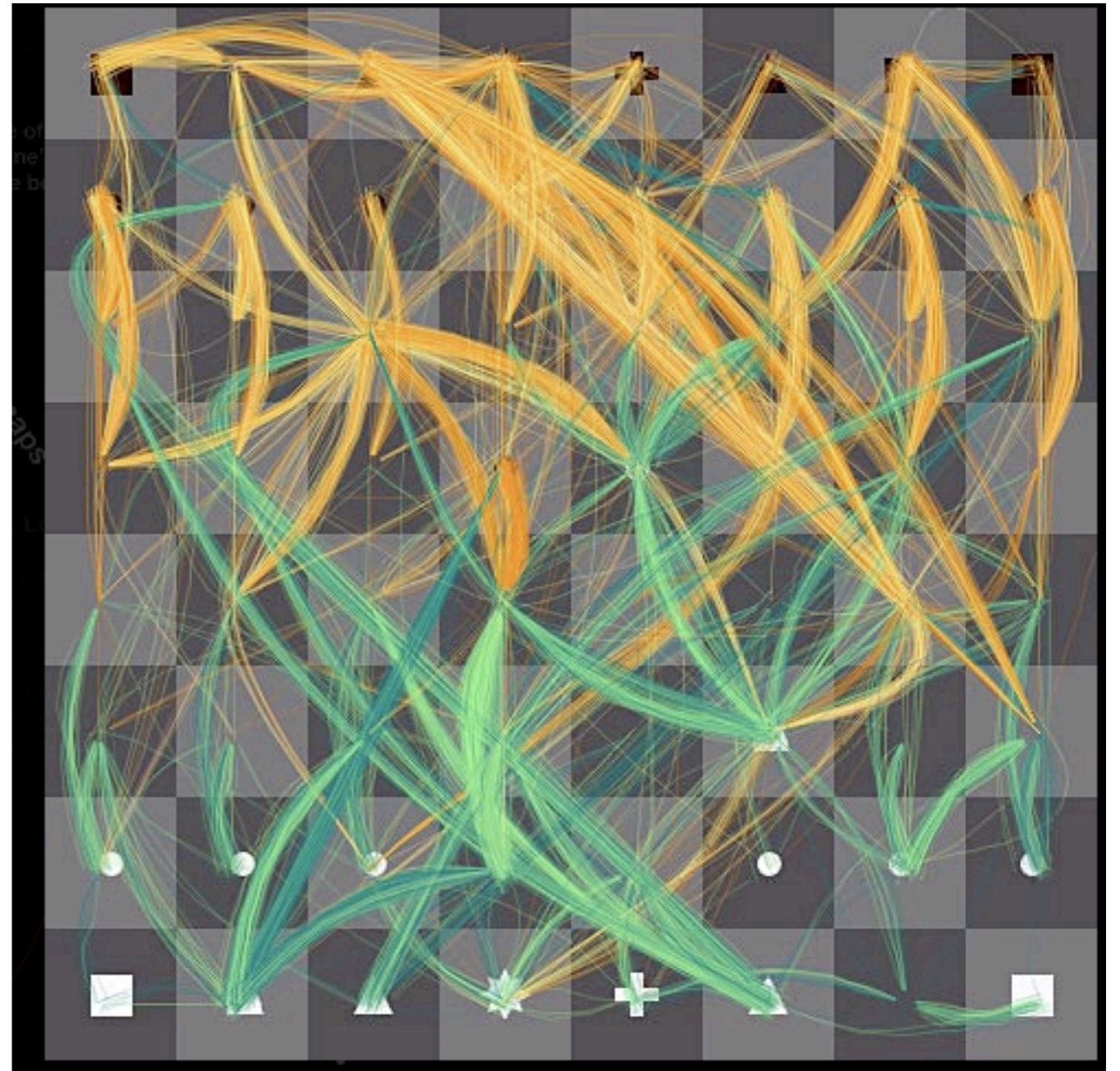


# Models

- ❖ 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

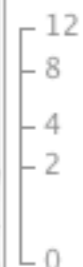
Can't see the visualization? Download the latest Java plugin [here](#). On Macs: best viewed in Safari.

Created by: [jenninat0r](#) Created on: Thursday February 14, 5:01 PM

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

**Fiber**  
Disks colored by Cereal  
Not shown: 19 null/zero items

- 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



[http://services.alphaworks.ibm.com/manyeyes/view/S9\\_5xLsOtha68HVE\\_RT4M2~](http://services.alphaworks.ibm.com/manyeyes/view/S9_5xLsOtha68HVE_RT4M2~)

To highlight  
click c

Search>>

Bubble Size  Label  Color

# 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

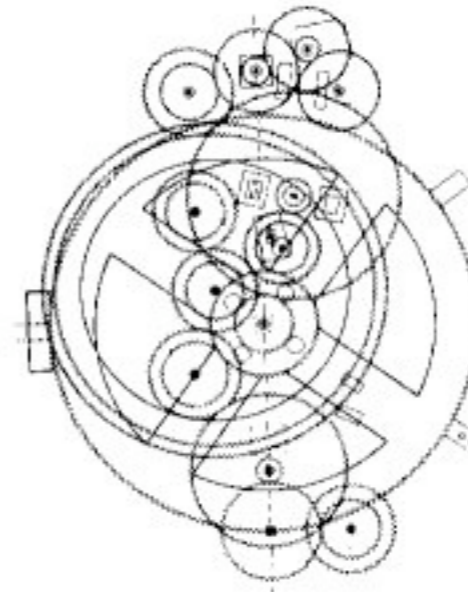
# Knowledge Embodiment Examples

[http://commons.wikimedia.org/wiki/Image:NAMA\\_Machine\\_d%27Anticyth%C3%A8re\\_1.jpg](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](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



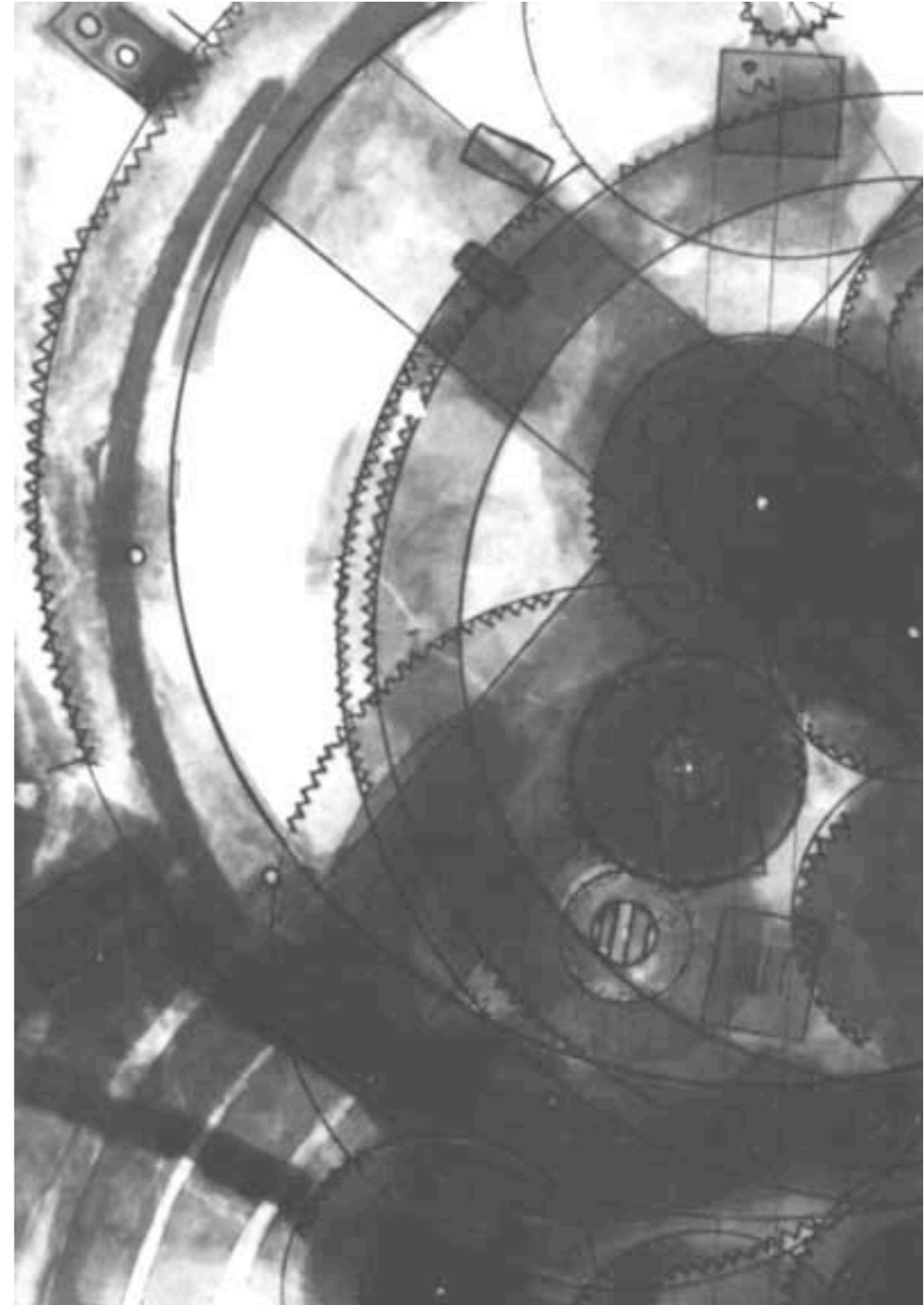
<http://www.crystalinks.com/antikythera.jpg>



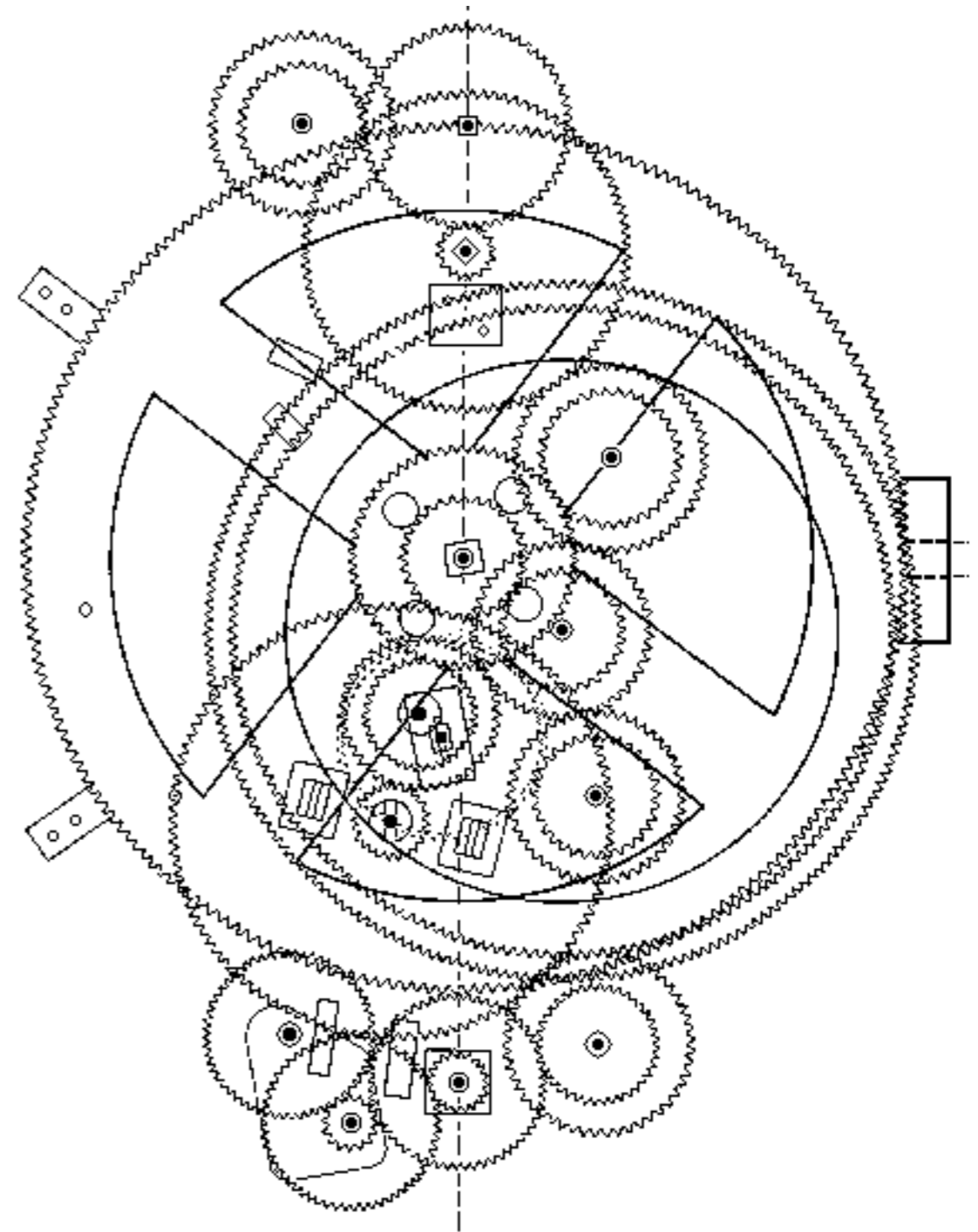
[http://news.bbc.co.uk/nol/shared/spl/hi/pop\\_ups/06/technology\\_enl\\_1164817474/img/1.jpg](http://news.bbc.co.uk/nol/shared/spl/hi/pop_ups/06/technology_enl_1164817474/img/1.jpg)

# Antikythera Analysis

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

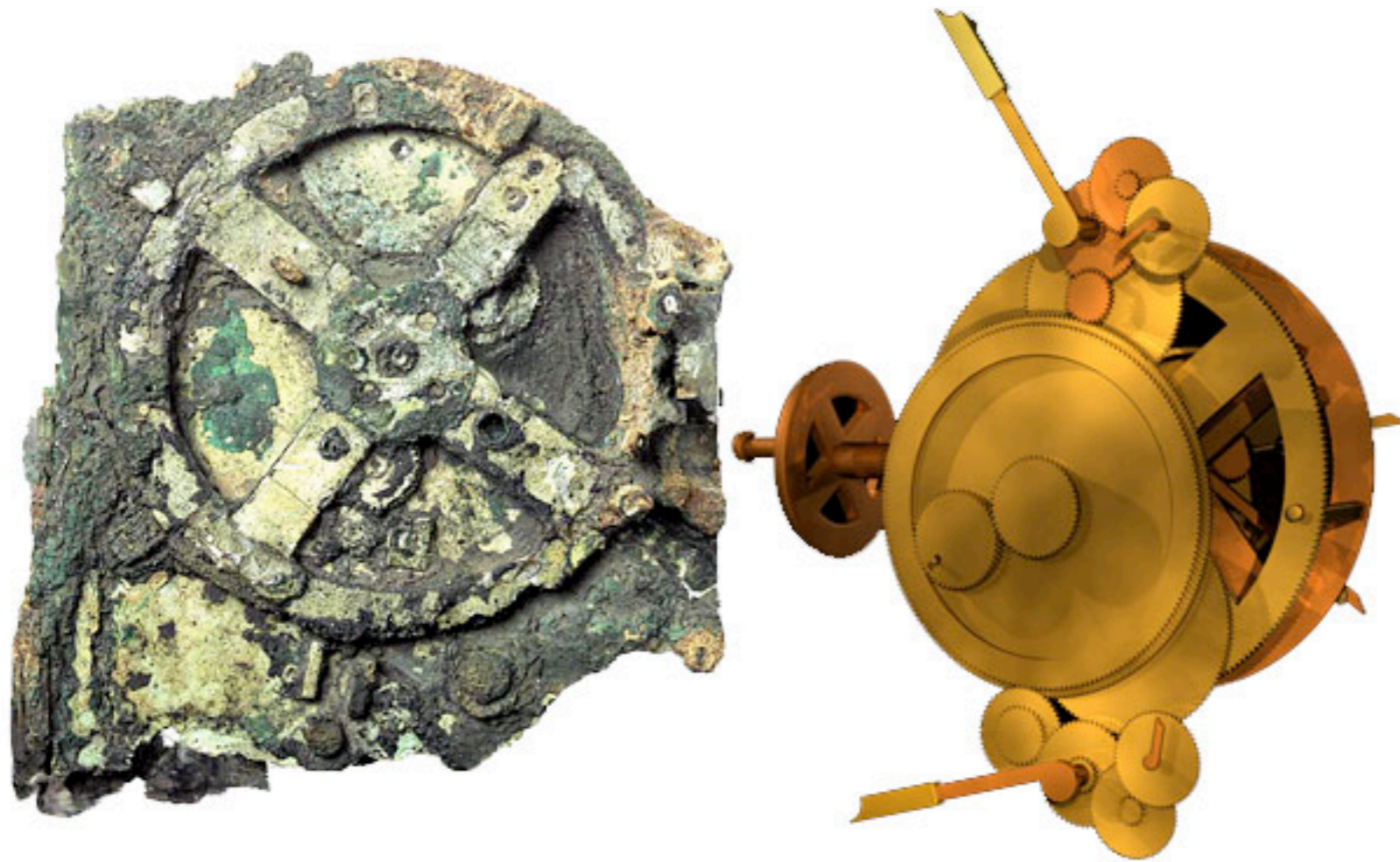


# Antikythera Schematics



<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

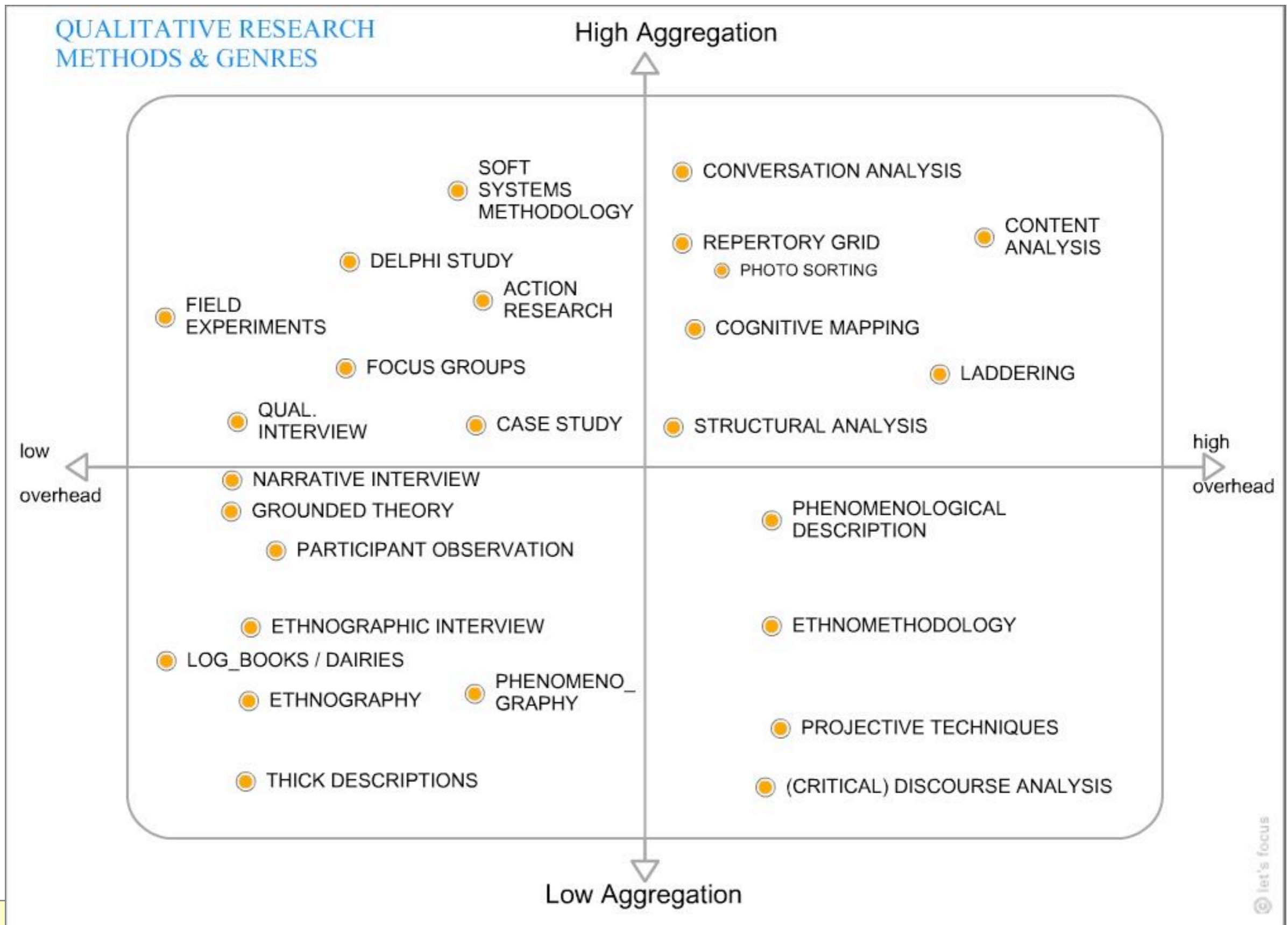
- ❖ later development
- ❖ possibly influenced by the Antikythera mechanism



New York Metropolitan Museum of Art, April 2003.  
[en.wikipedia.org/wiki/Astrolabe](http://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



© let's focus

# Knowledge Types

**Board**

**Other distinctions:**

- memorable vs. unmemorable
- secret vs. public
- innate vs. acquired
- current vs. outdated
- useful vs. useless
- doxa (opinion) vs. science (episteme)
- practical vs. theoretical
- know-when
- know-where

**Individual**

- implicit
- tacit
- visual
- episodic
- non-propositional
- narrow
- prelim.
- complex
- procedural
- normative
- descriptive
- subjective

**collective**

- explicit
- written

**semantic**

- propositional
- wide
- durable
- simple

**declarative**

- functional
- objective

**know-how**

**know-what**

**know-who**

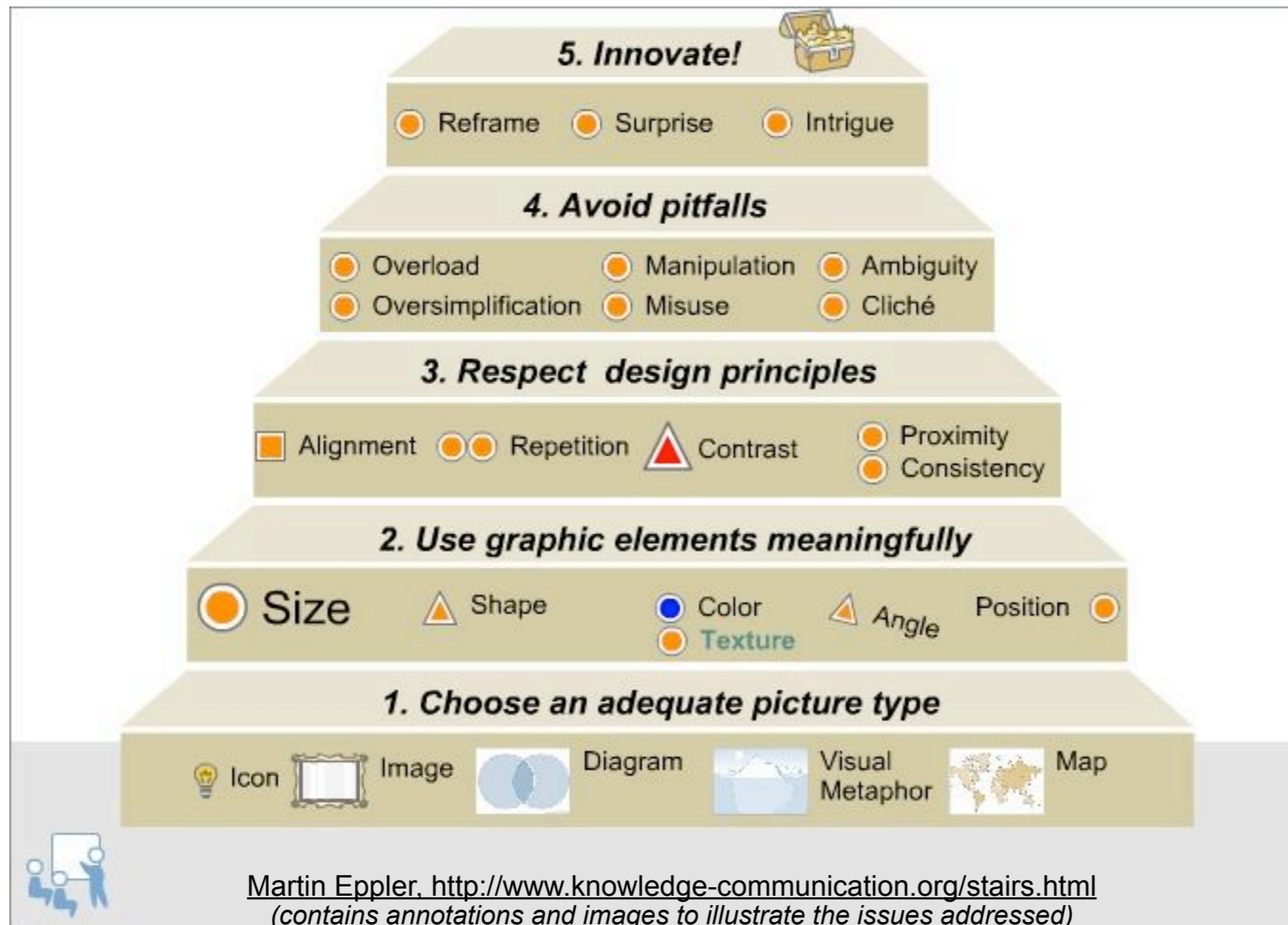
**know-why**

**IMPORTANT KNOWLEDGE TYPES / DISTINCTIONS**

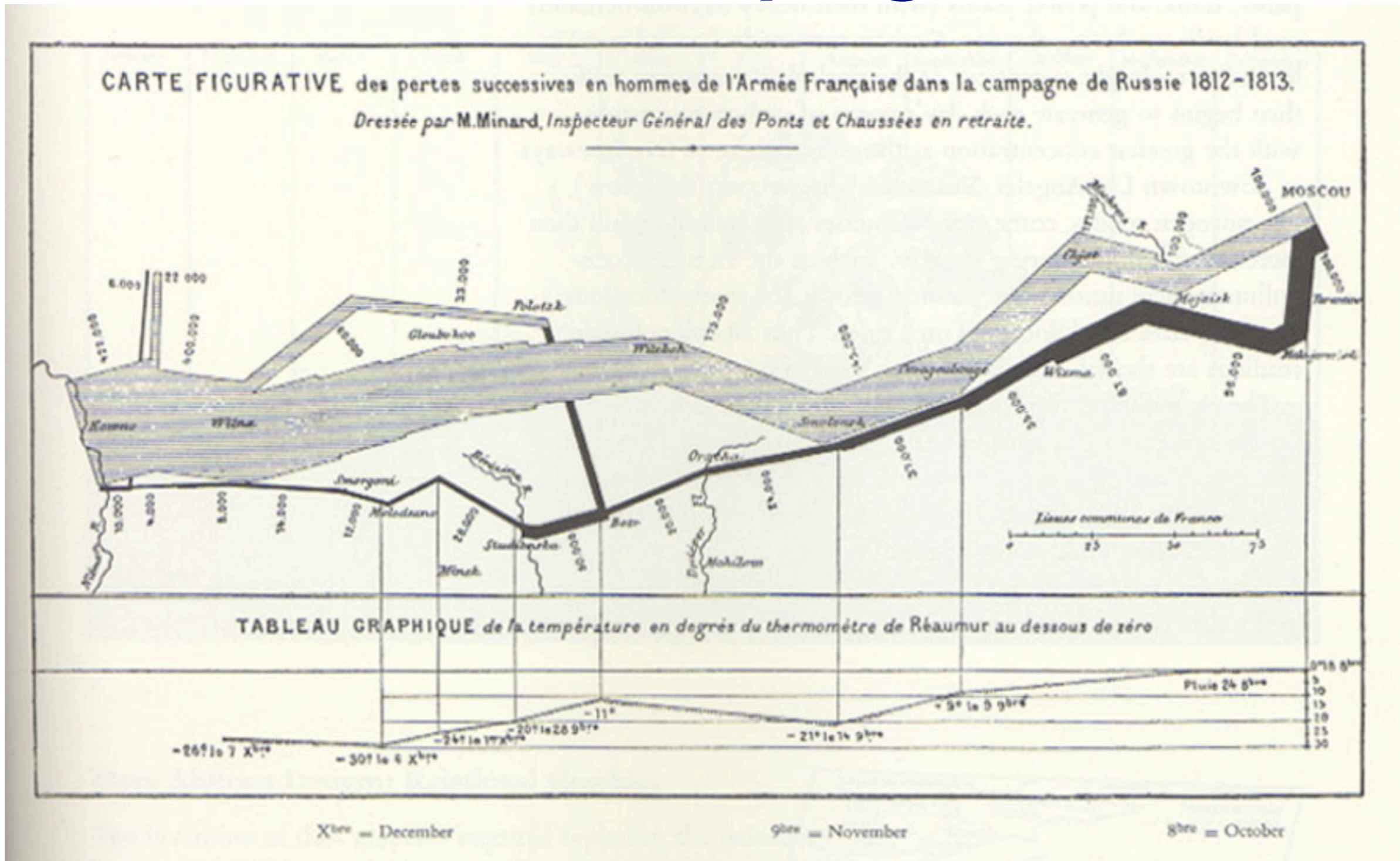
let's focus positioner

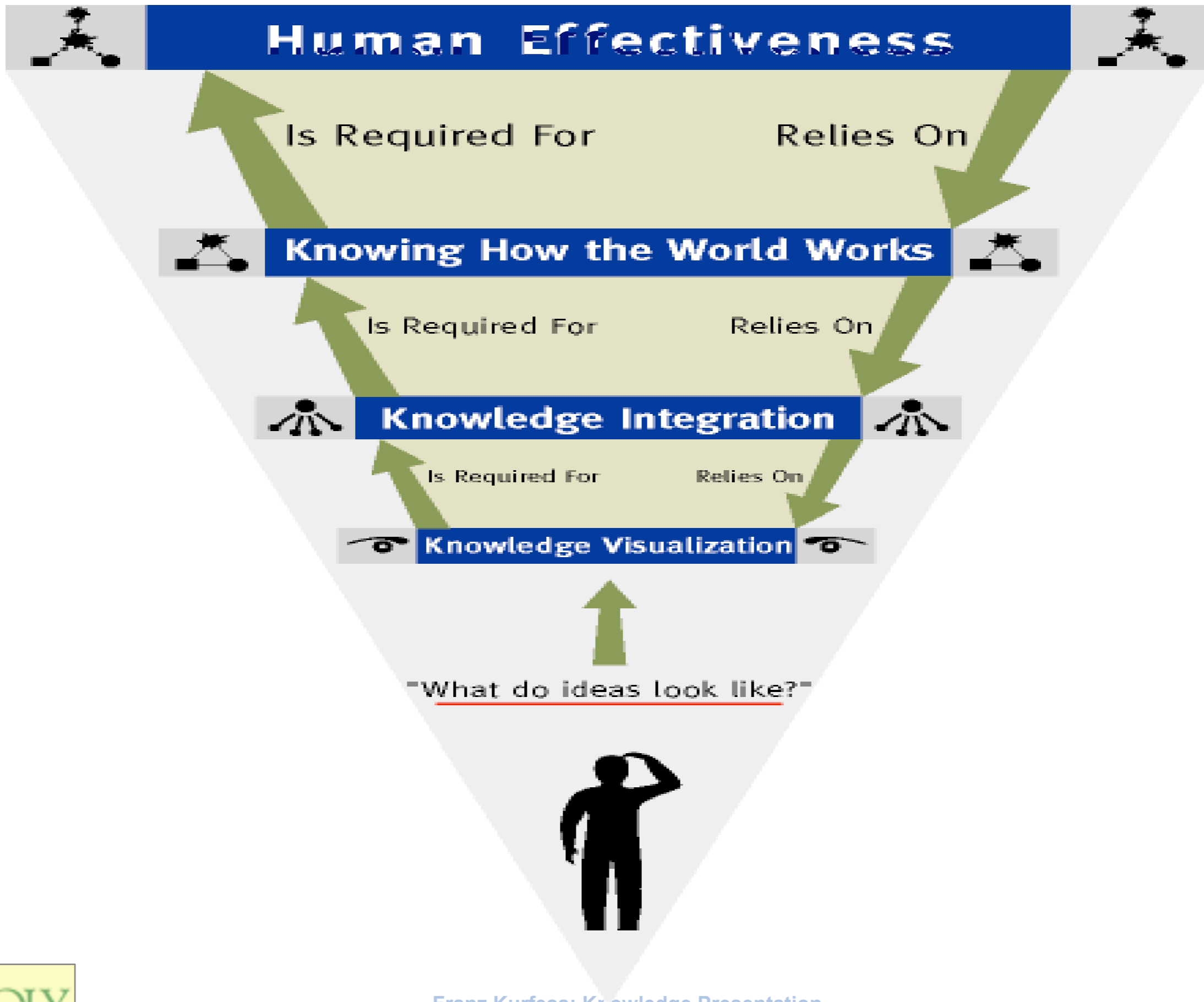
USI

# Stairs of Visualization



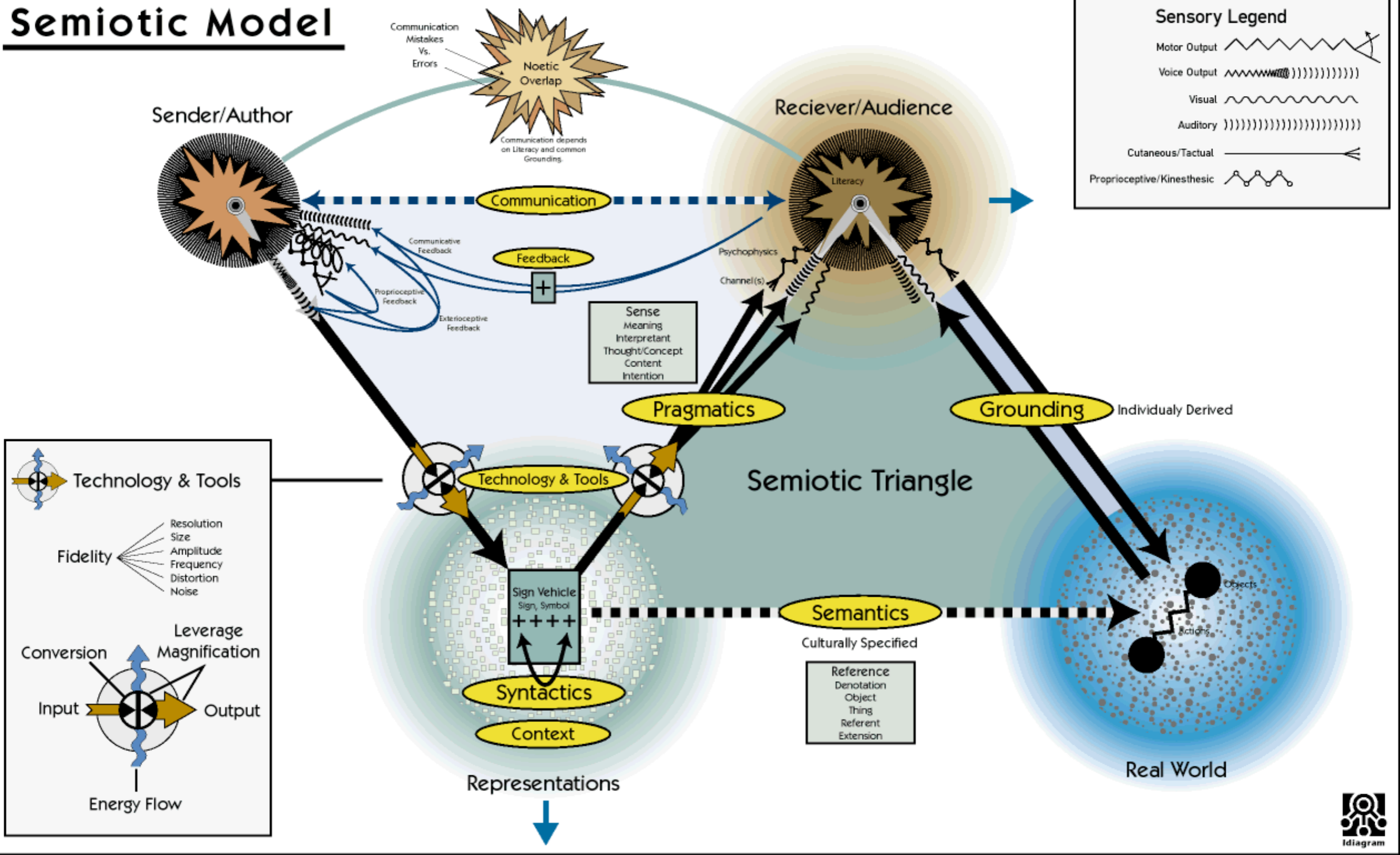
# Minard: Napoleon's Russia Campaign



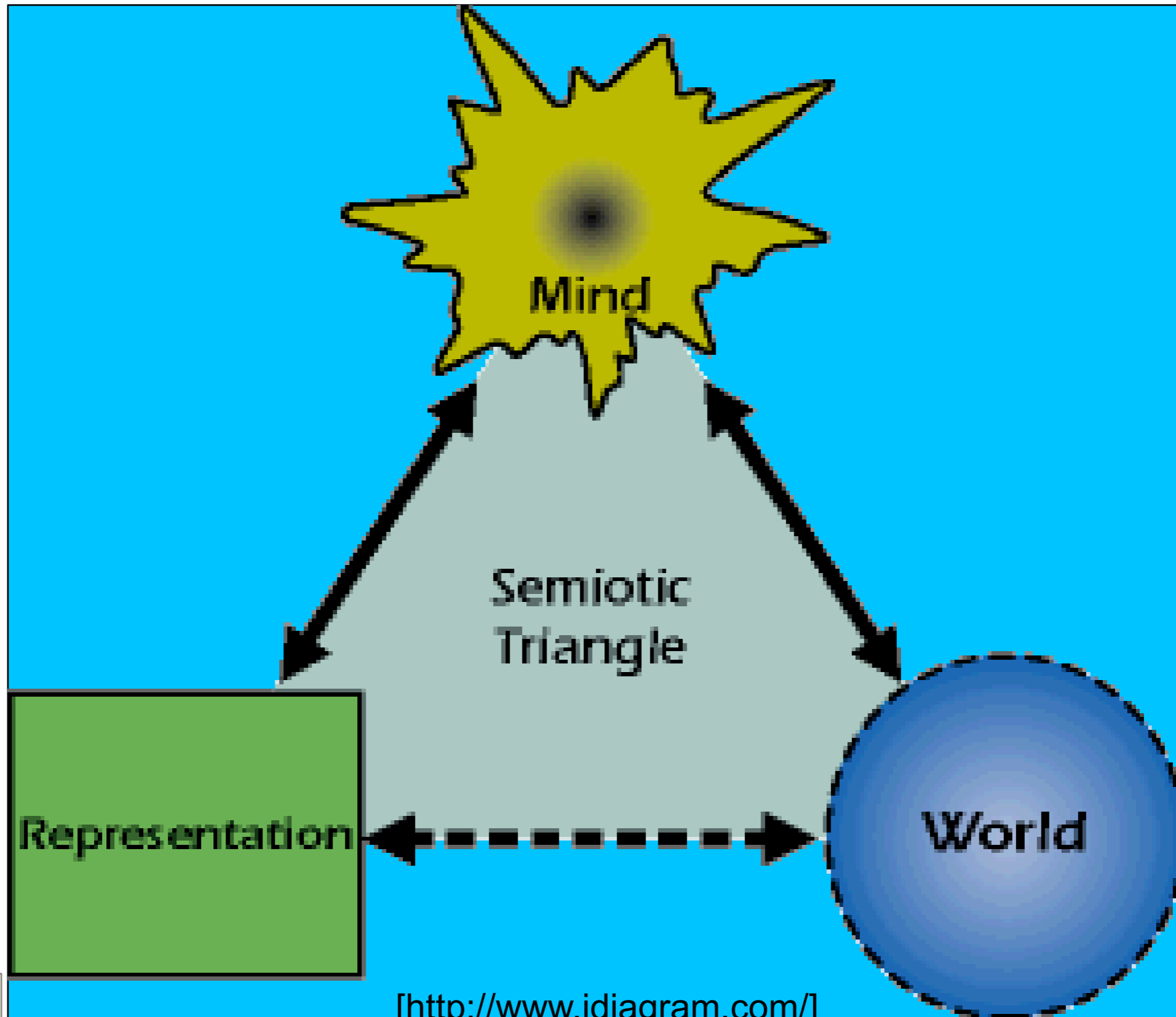


# Semiotic Model

## Semiotic Model



# Semiotic Triangle



## Knowledge Visualization

the visual explication of conceptual knowledge  
- is based on:

- Understanding the Domain Knowledge
- Applying Cognitive Principles
- Exploiting the Visual Parameters
- Encoding Salient Features Graphically
- Providing a Useful Process
- Producing Useful Output

## Information Graphics

Visualizing quantitative information with graphs and diagrams, such as:

Node-Link Diagrams  
Data Graphing  
Scientific Visualization  
Mathematical Visualization  
Technical Illustration

Information Graphics

Graphic Design

Knowledge Visualization

Cognitive Science

## Graphic Arts

The rich legacy of knowledge and techniques developed in art and illustration. Hard-won lessons of aesthetics and communication essential to exploiting the full power of visual representation.

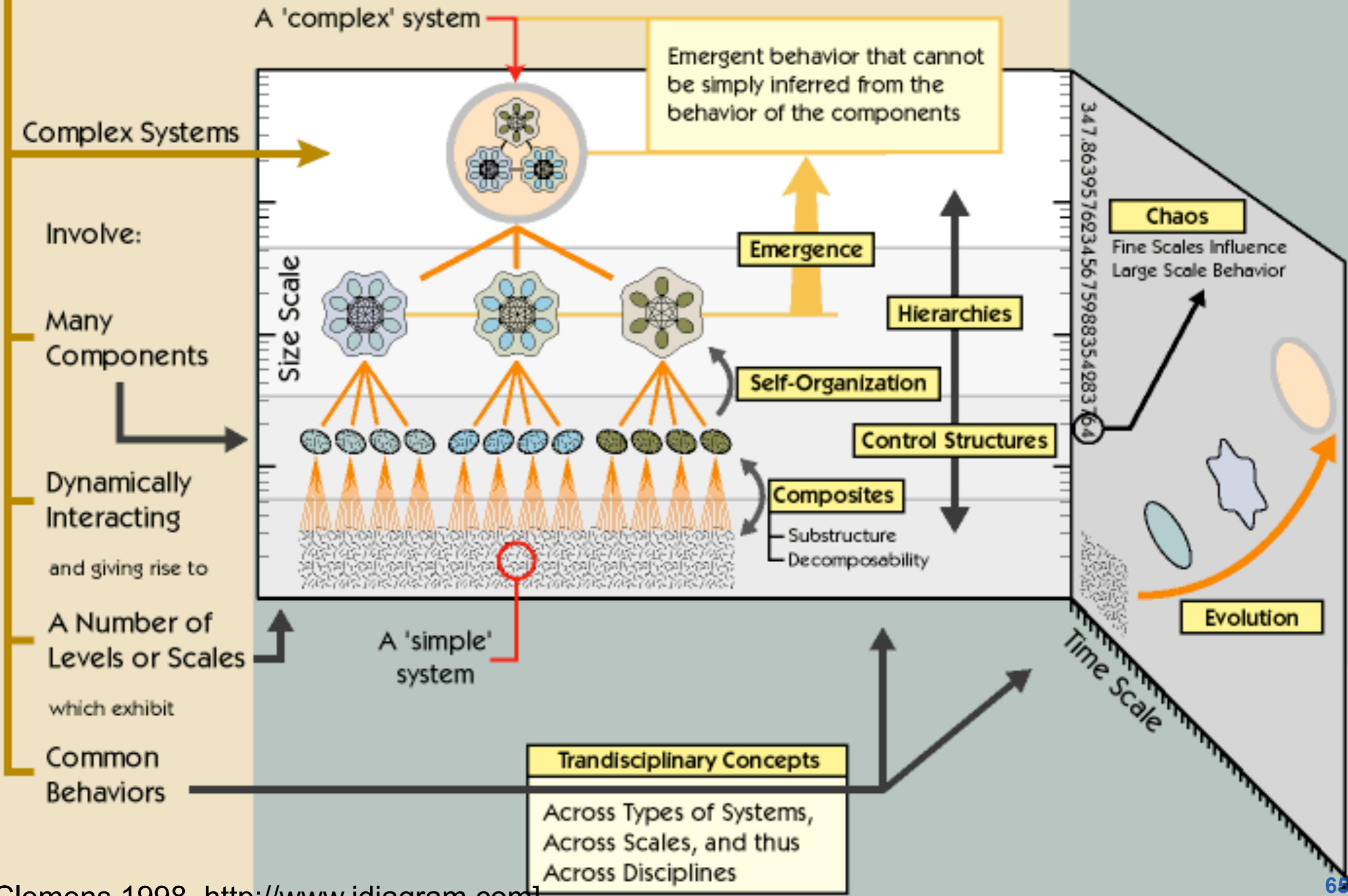
## Cognitive Science

The cognitive science relevant to knowledge elicitation, integration, and communication, and the cognitive processes underlying perception, categorization, visual and propositional reasoning, communication, creativity, and motivation.

[Clemens 1998, [http://www.idiagram.com/kv\\_venn.html](http://www.idiagram.com/kv_venn.html)]

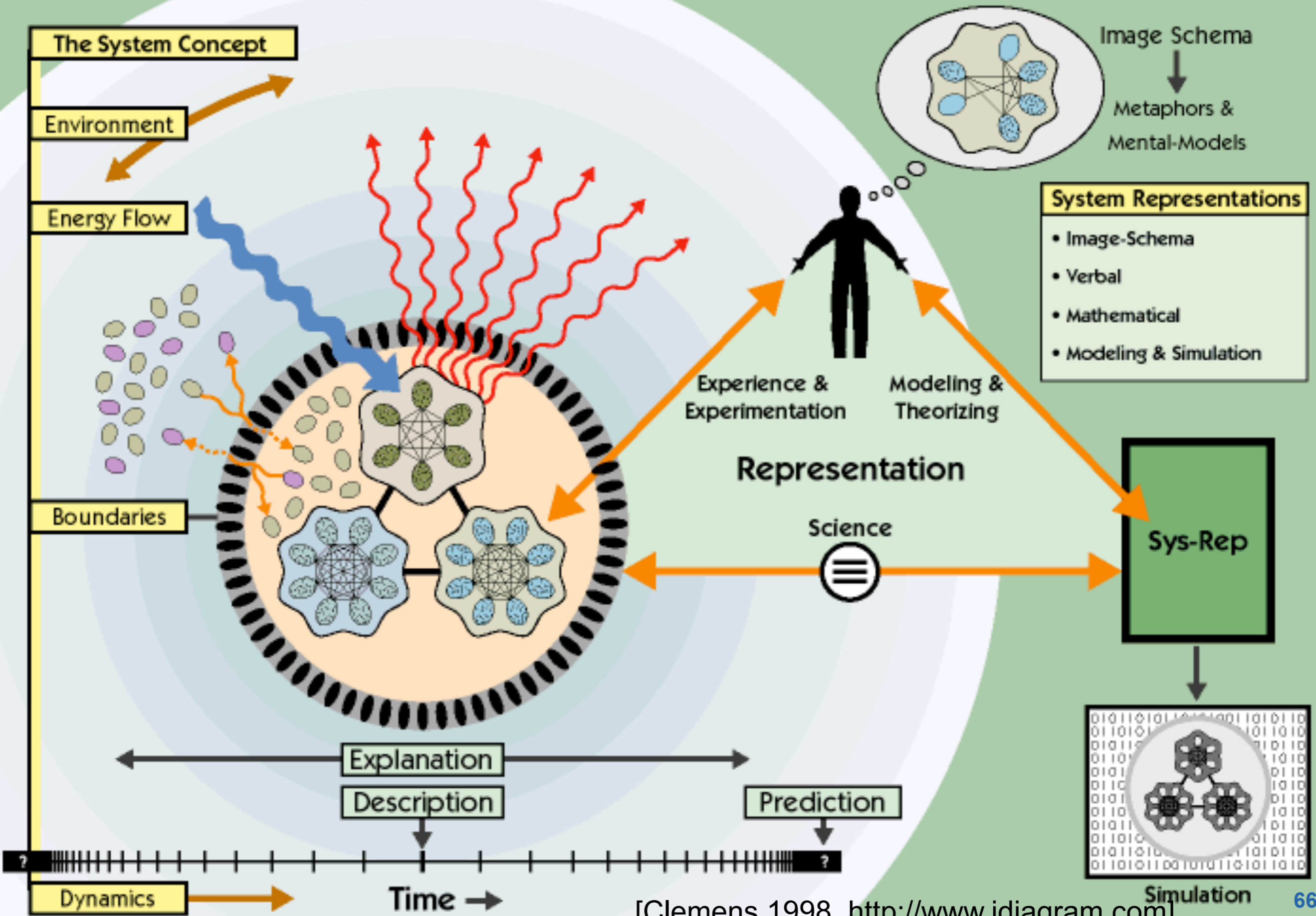


# Characteristics of Complex Systems



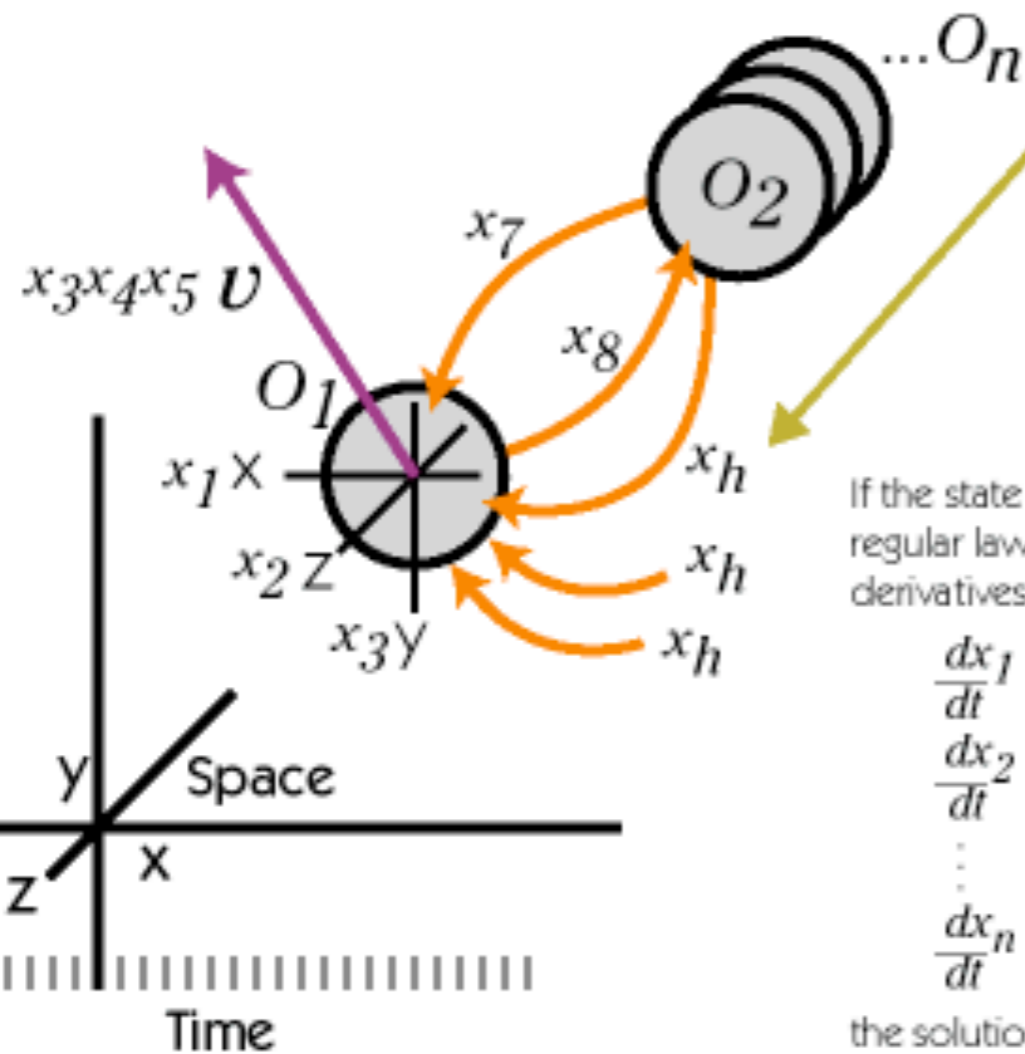
[Clemens 1998, <http://www.idiagram.com>]

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

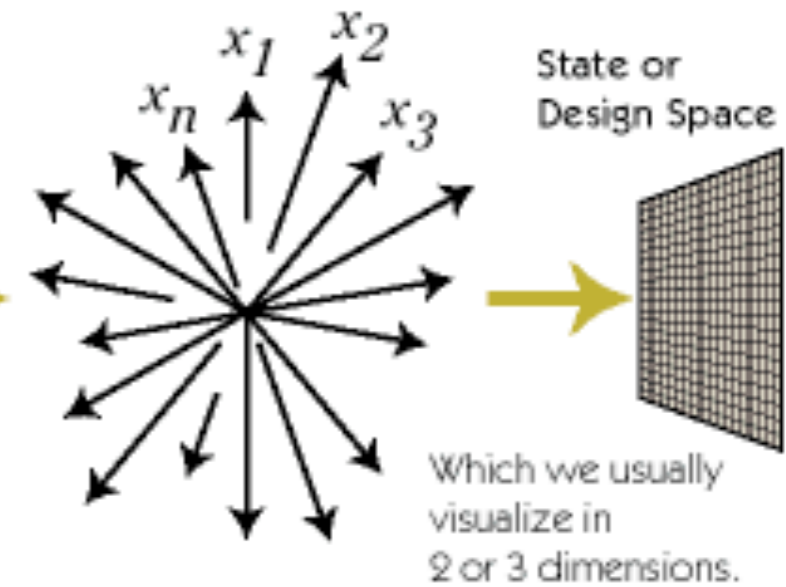


[Clemens 1998, <http://www.idiagram.com>]

# System Dynamics: State & Phase Space



For each of  $N$  objects,  $O$ , we define  $n$  **State Variables**  $\{x_1, x_2, x_3 \dots x_n\}$  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.



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

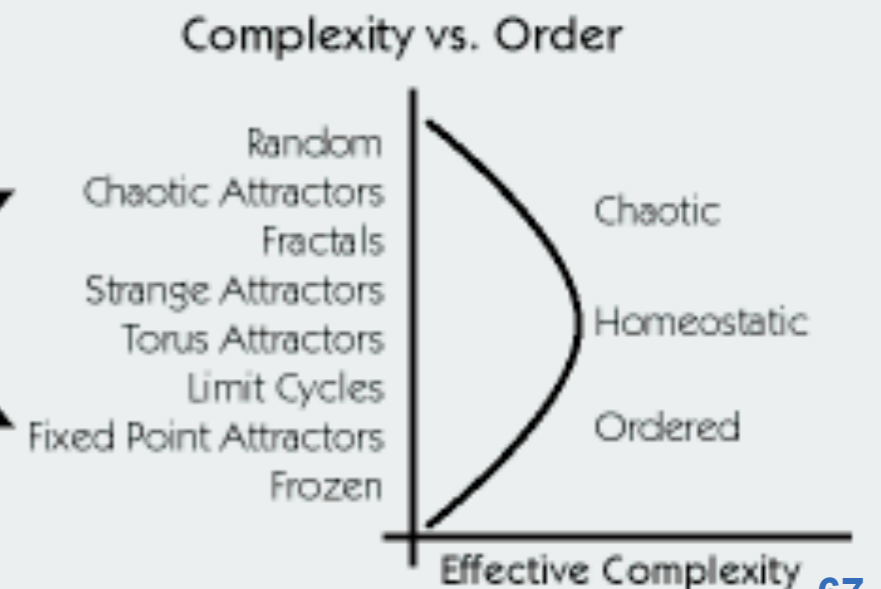
$$\begin{aligned} \frac{dx_1}{dt} &= f_1(x_1, x_2, x_3 \dots x_{Nn}) \\ \frac{dx_2}{dt} &= f_2(x_1, x_2, x_3 \dots x_{Nn}) \\ &\vdots \\ \frac{dx_n}{dt} &= f_n(x_1, x_2, x_3 \dots x_{Nn}) \end{aligned}$$

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

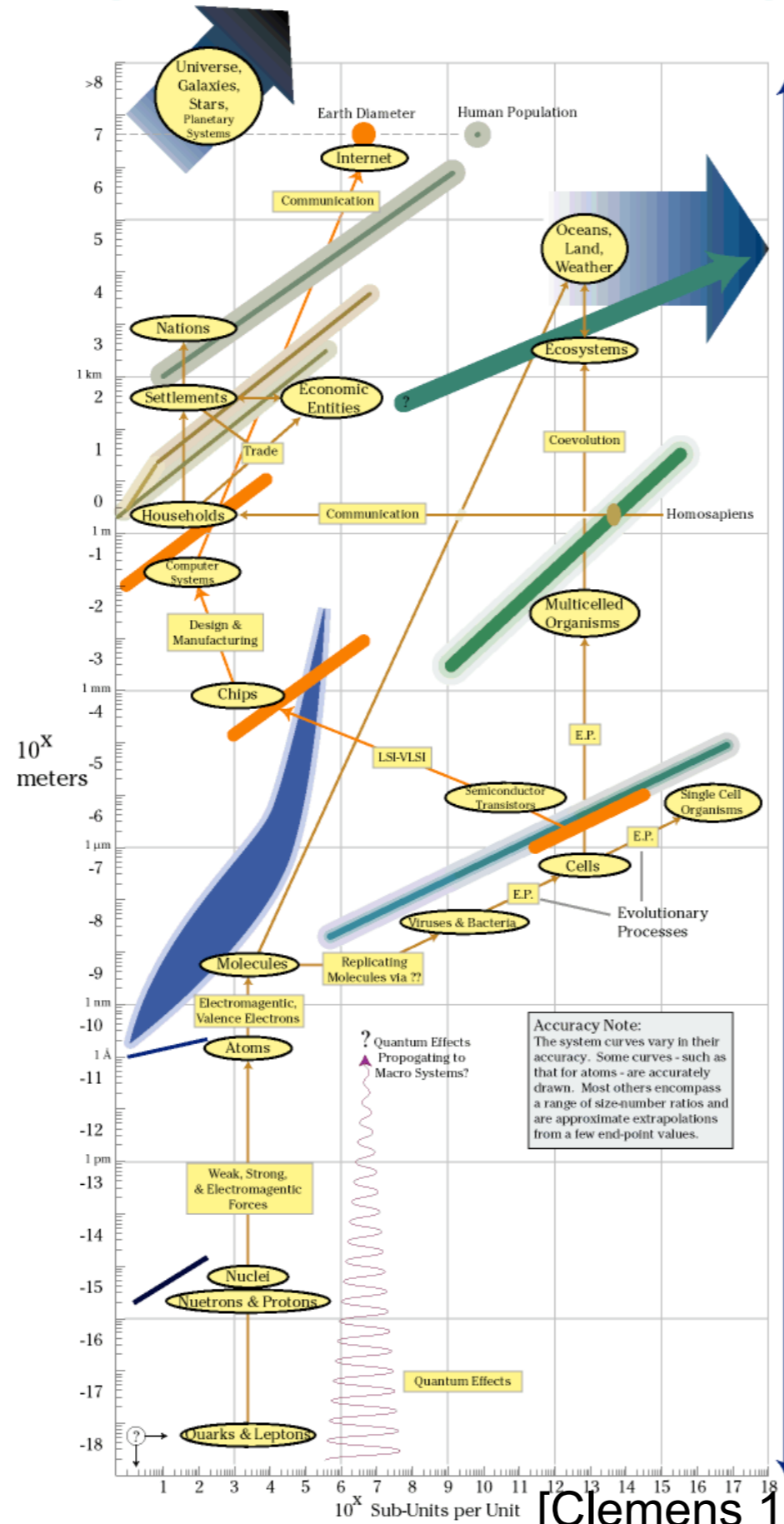
## Statistical Approaches:

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.

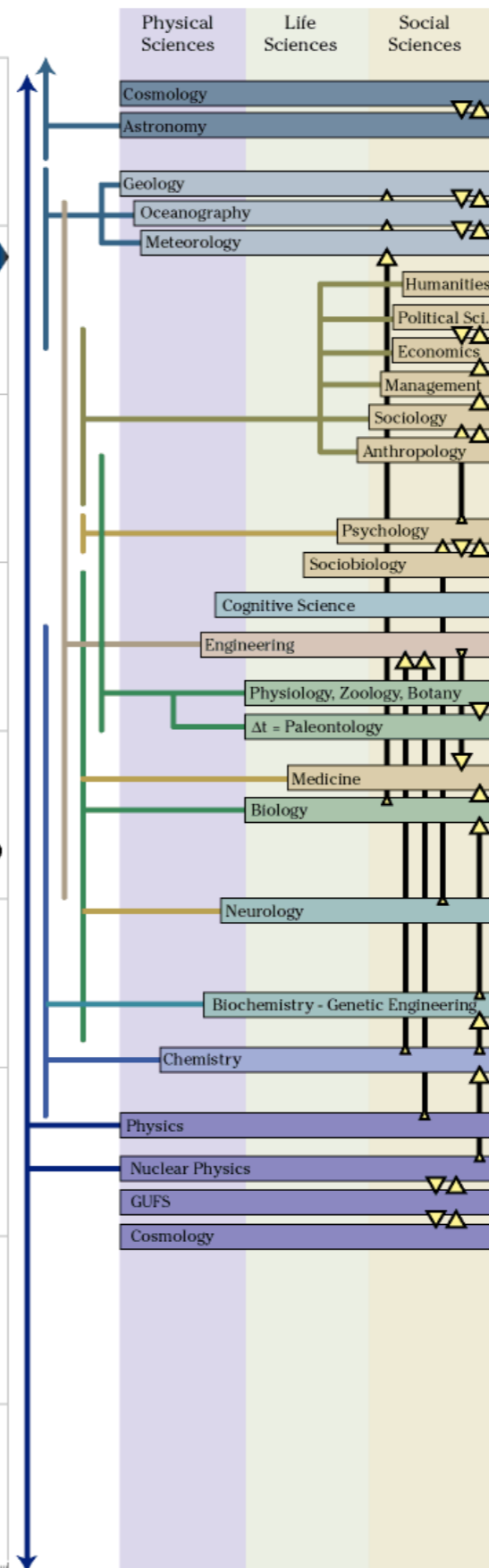
Some Types of Trajectories



# Some Physical Systems

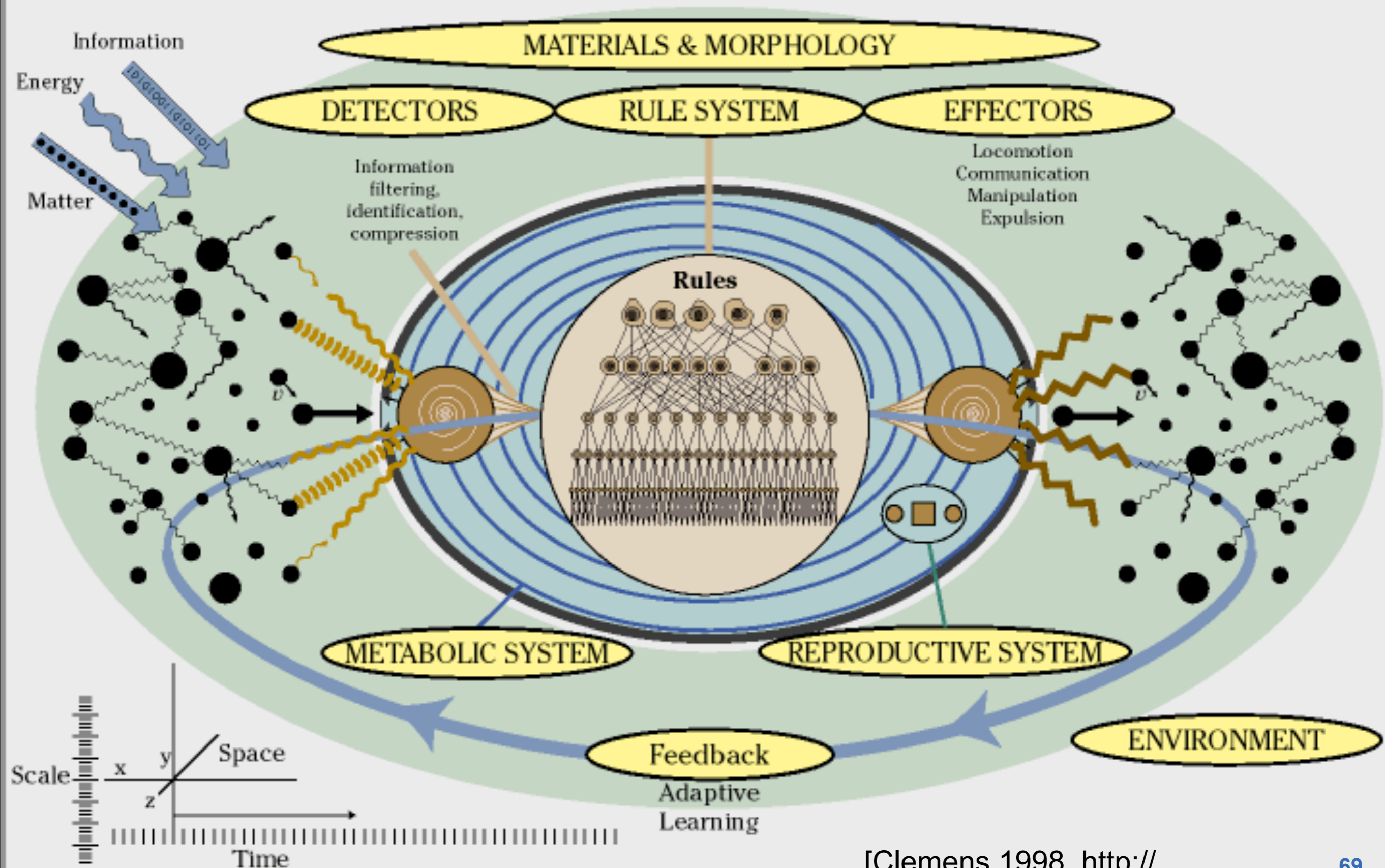


# Some Systems of Human Knowledge



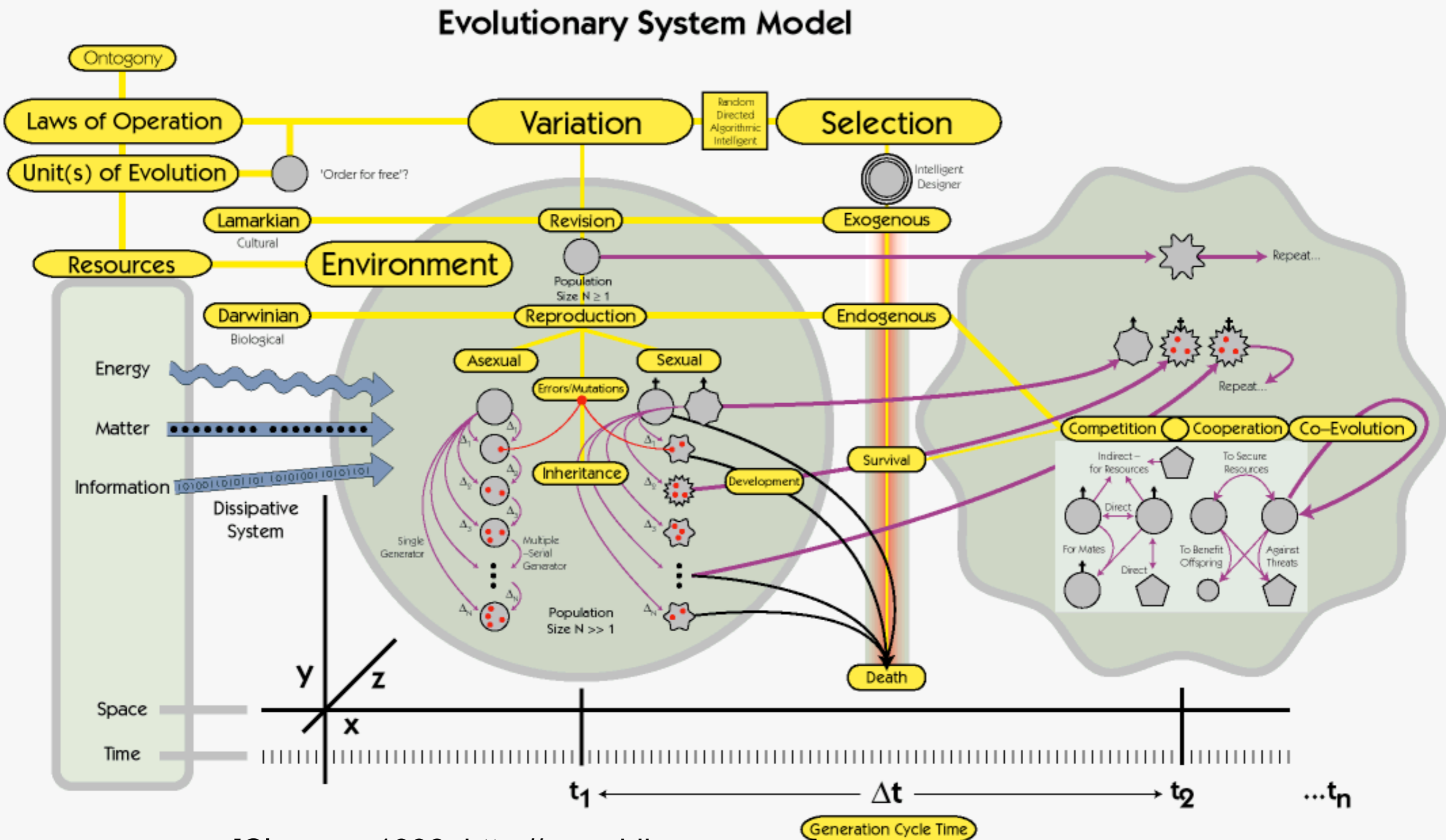
[Clemens 1998, <http://www.idiagram.com>]

# Complex Adaptive System Model



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

# Evolutionary System Model



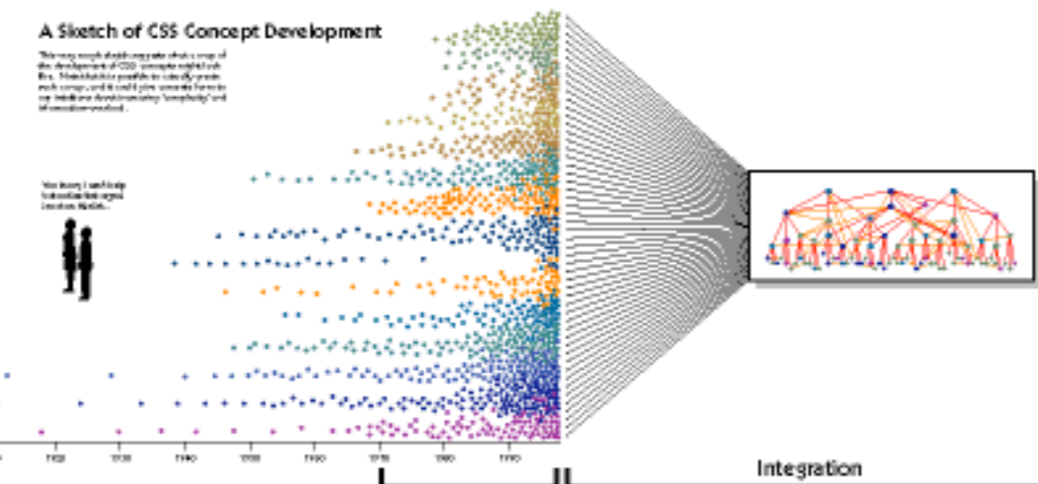
[Clemens 1998. <http://www.idiagram.com>]

# Visualizing Complex Systems Science (CSS)

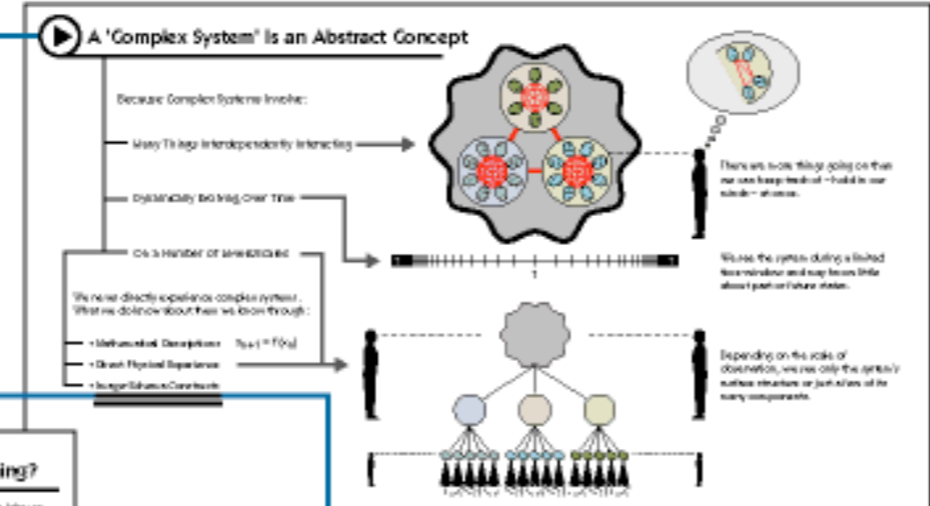
Why is Complexity Complicated?

**Abstract**  
Applying CSS – is a set of concepts that come from the physical world & biological systems – to organizational science and management practice to solve unique challenges. Because the only the and features of CSS make it relatively difficult to understand, how we bring this, represent, and communicate CSS however particularly important. We look at why doing so is a challenge and how to do it better.

- Economics
- Biology
- Anthropology
- Psychology
- Cognitive Science
- Sciences
- Artificial Intelligence
- Cybernetics
- Operations Research
- Game Theory
- Mathematics
- Physics
- Philosophy



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



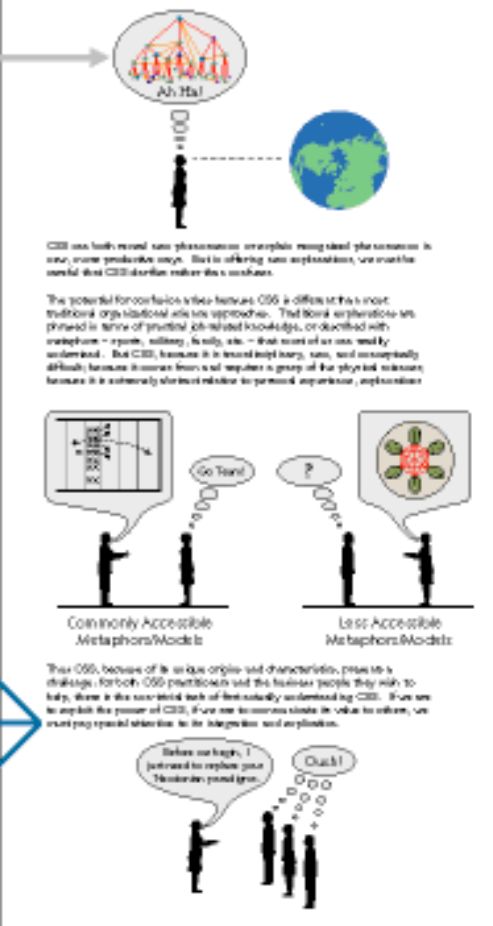
**Visualizing CSS & Management**  
CSS have an interesting set of concepts that offer new models and metaphors of organization or independent business-technological-economic-political systems. In so much as CSS concepts are used as tools for planning and predicting what is really going on in the world, i.e. for providing new mental models that enable more accurate or productive analysis and actions, they should be useful to managers. If indeed CSS provide a framework through which to view the world – as even as you realize it is probably false – for a CSS application should

One way to connect knowledge and expertise is to employ the knowledge compression afforded by abstraction, or formulation of general principles. Compressing for decreasing complex bodies of detailed knowledge down to a manageable number of core concepts – which, through appropriate means, may be expanded to recover the details – is one way of grouping more knowledge by retaining fewer facts.  
Knowledge integration is a process of abstraction, the isolation of a few general concepts or principles from many specific examples. The result is of a hierarchy a hierarchy of concepts – from general to specific – and the functional relationships between the concepts. Because the structure is "conceptually complex" and the properties of elements and the functional relationships between the concepts (other than the details), appropriate representation is a complex matter. While necessary to capture details – one only imply the overall structure of the integrated knowledge structure. Diagrammatic representations can explicitly show the structure and we have access to the full of creating and understanding integrated bodies of knowledge.

## Integration & Diagrams

## Conceptual Complexity & Diagrams

Due to the limited capacity of our working memory – 7 +/- 2 "chunks" of information – we cannot hold in our minds concepts, separately, or produce the details of more than 10 or 15 at once or relationships. This cognitive limitation severely restricts our ability to hold about complex things like complex systems. However, we can do what we often do: extend our intellectual abilities with external representations.  
The particular effectiveness of diagrams in representation – is ability to show many details and relations (to make it an ideal external aid for thinking about complex problems) is, in our view, more than 7 objects or relationships. Diagrams provide an external memory bank, enabling us to use complex relationships and quickly move between various related groups of things.  
Representation is a natural result of our cognitive need to make things like the material world. CSS, as a system against intuition, requires a wide variety of tools to help people understand that which they can't think about.  
For example, even a simple model of evolution is more than a red herring.



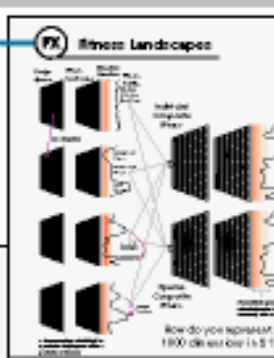
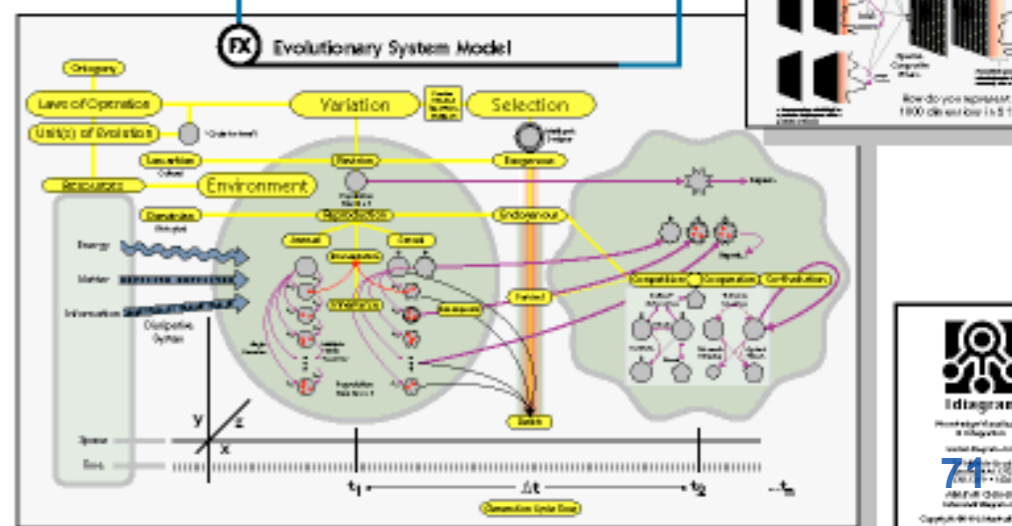
## Why Use Verbal & Visual Representations of?

As we often would in any verbal representation we to abstract concepts and the relationships on which they are based. Language follows with complexity and representation?  
Verbal: Language represents with words  
Visual: Diagrams help with the complex world  
Visual representations can be used to represent complex systems and relationships in a way that is more accessible and understandable than text.  
Visual representations can be used to represent complex systems and relationships in a way that is more accessible and understandable than text.

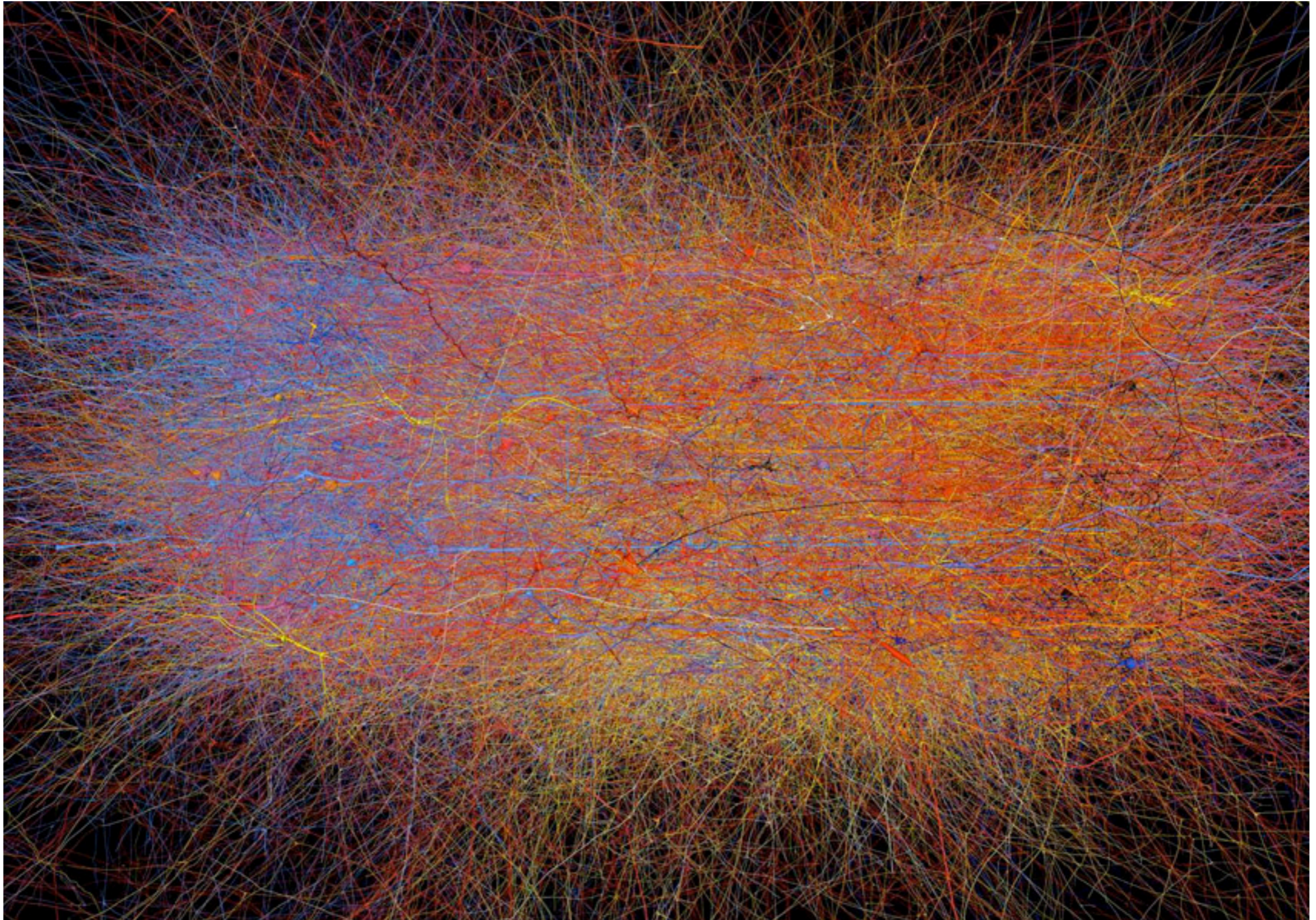
## How Do We Know Anything?

In the account pioneered by George Lakoff and Mark Johnson, all human understanding is grounded in physical experience and in the general dynamics of those experiences. Images, metaphors, and other forms of embodied knowledge, rather than being found in propositional language constructs, is seen as being based in experience and their extension through the imaginative power of metaphor.  
It is through metaphorical projection from the concrete to the abstract that our abstract, non-sensory sense of meaning is formed. Because propositions and their relationships are grounded in embodied knowledge, they contain (or extend) inherent and revealing in fundamental and important ways. Because abstract thought is structured in terms of images, metaphors, and other forms of embodied knowledge, the kinds of metaphors or relationships we perform with them, reflect the quality and extent of our meaning.  
Of course quality isn't quantity. It's not about how many things you know, but about how well you know them. It's about the quality of your knowledge, not the quantity.

**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. As we **ARE** the things. Other than mathematical models, and very limited direct experience, they embody what 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 **deliberately** visual conceptions – are accurate and productive.  
How do arguments have points?



# Mammalian Neocortical Column



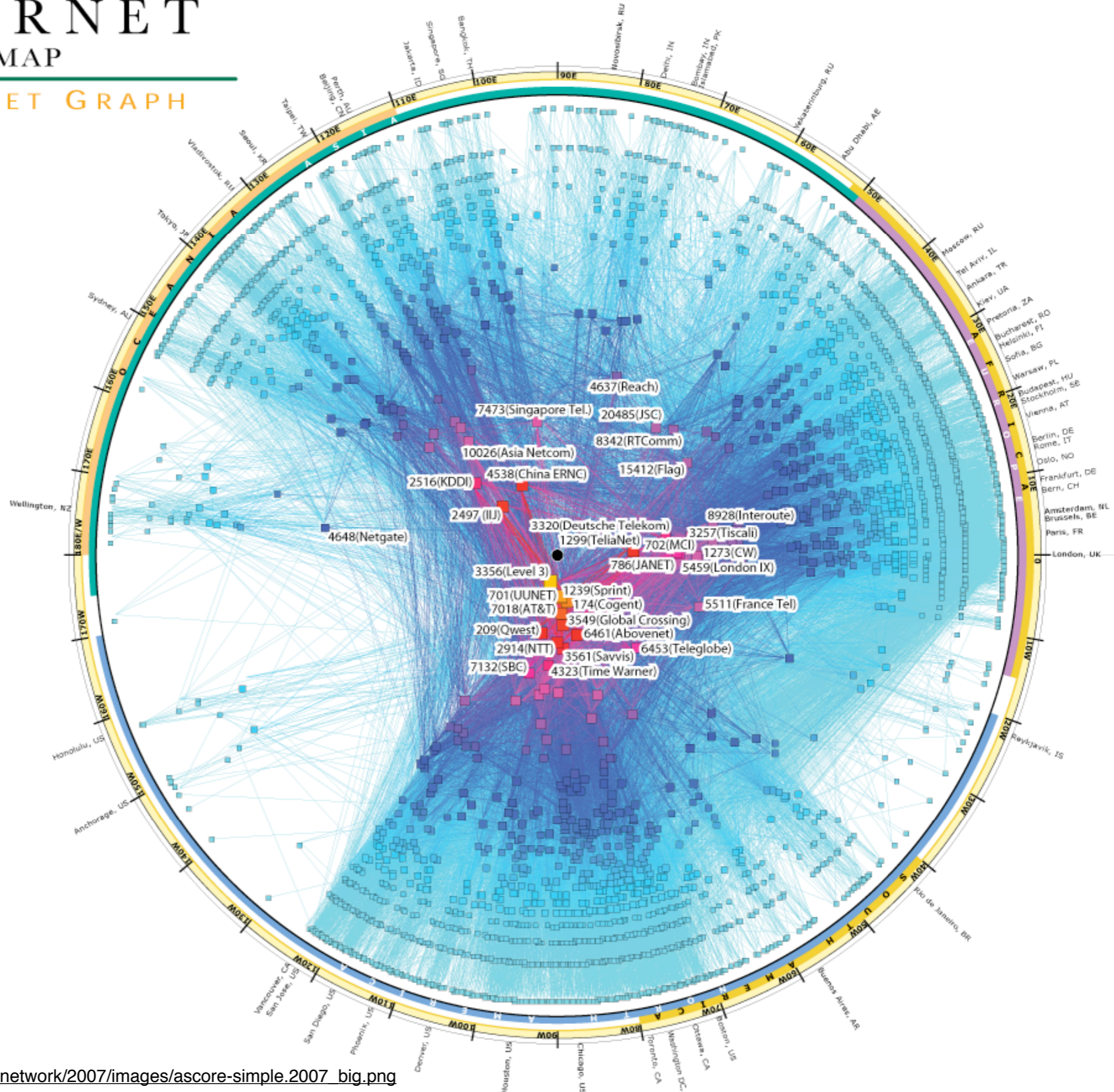
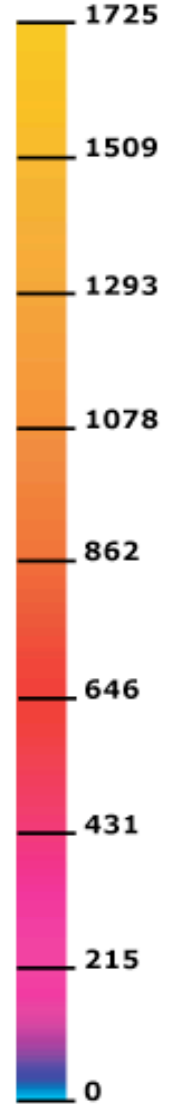


# IPv4 INTERNET TOPOLOGY MAP

copyright ©2007 UC Regents. all rights reserved.

## AS-level INTERNET GRAPH

Peering:  
OutDegree



# Visual Thesaurus

The screenshot displays the Visual Thesaurus interface for the word "retrograde". The search bar at the top contains "retrograde" and the "LOOK IT UP" button is highlighted. The interface includes navigation buttons (BACK, FORWARD), search options (SEARCH: EN, DISPLAY: EN), and utility buttons (EDIT, PRINT, SHARE, HELP). The main area features a network diagram with "retrograde" at the center, connected to various related terms. A tooltip for "retrograde" explains its meaning: "move in a direction contrary to the usual one" and provides the example "retrograding planets". The diagram shows connections to "travel move", "locomote", "go", "retral", "hash over", "rehash", "regress", "retrogress", "orbit", "revolve", "direct", "anterograde", and "temporal relation". The right sidebar shows a list of related terms categorized by part of speech: NOUNS, ADJECTIVES, VERBS, and ADVERBS. The NOUNS category is currently selected and shows several definitions, including "a relation involving time" and "moving from east to west on the celestial sphere". The VERBS category shows "move backward in an orbit, of celestial bodies" and "move in a direction contrary to the usual one".

retrograde

travel move

locomote

go

retral

hash over

rehash

regress

retrogress

orbit

revolve

direct

anterograde

temporal relation

move in a direction contrary to the usual one  
"retrograding planets"

a relation involving time

moving from east to west on the celestial sphere; or--for planets--around the sun in a direction opposite to that of the Earth

of amnesia; affecting time immediately preceding trauma

going from better to worse

move backward in an orbit, of celestial bodies

move in a direction contrary to the usual one

move back

go back over

VISUAL THESAURUS (R) VERSION 3 | CREATED USING THINKMAP (R) | COPYRIGHT 2007 THINKMAP INC.

<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

**VISIBLE BODY** *beta*

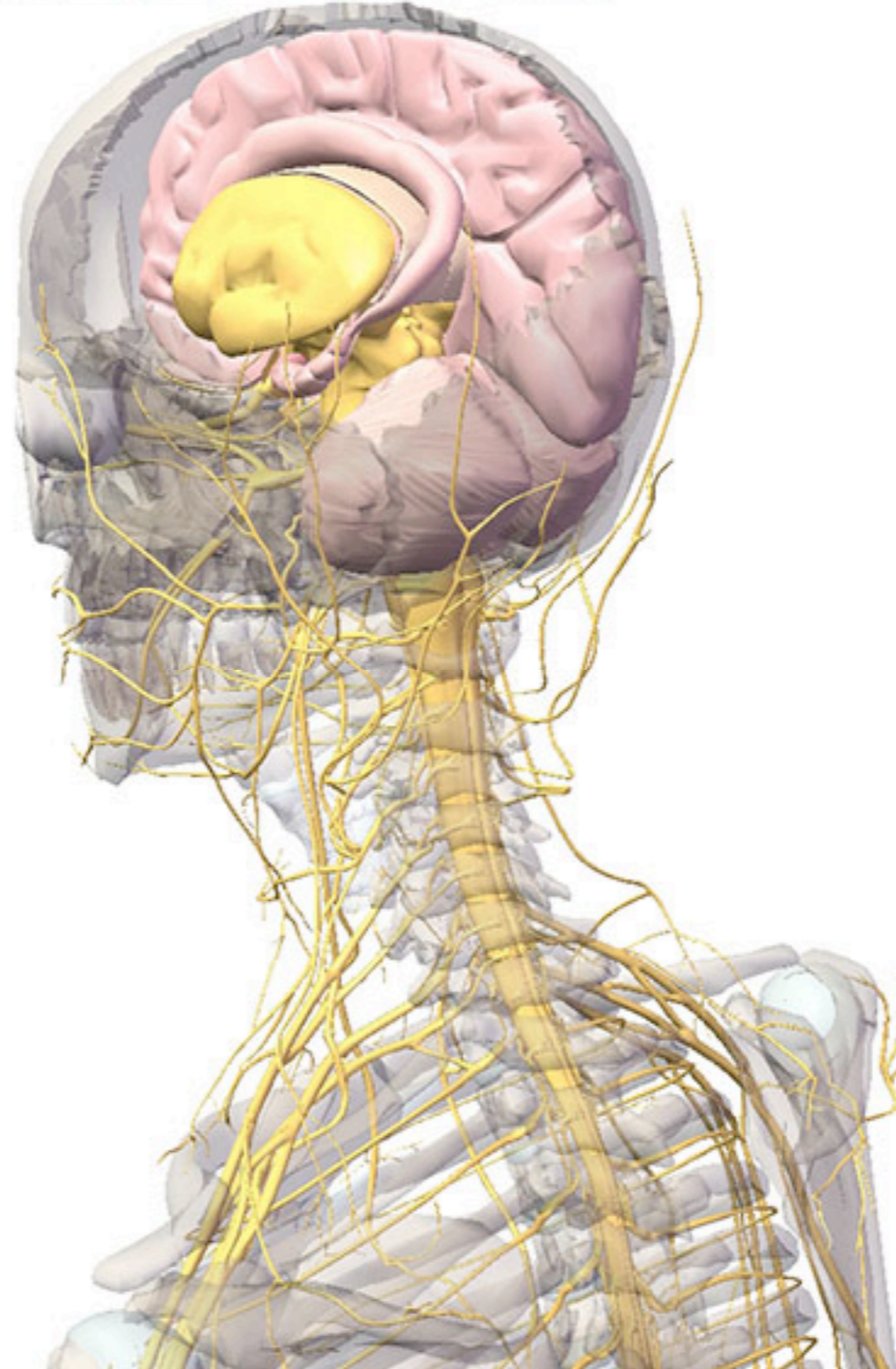
Explore Learn Help

Enter keywords to search

- Circulatory (Cardiovascular) System
- Digestive System
- Endocrine System Add
- Integumentary System Add
- Lymphatic System Add
- Muscular System Add
- Nervous System
  - Central
    - Brain
      - Limbic system
      - Midbrain (mesencephalon)
      - Forebrain (prosencephalon)
        - Cerebrum (telencephalon)
          - Cerebrum, L
            - Temporal lobe, L
            - Pre-central gyrus, L
            - Post-central gyrus, L
            - Parieto-occipital sulcus, L
            - Parietal lobe, L
            - Occipital lobe, L
            - Limbic lobe, L
            - Lateral sulcus, L
            - Frontal lobe, L
            - Central sulcus, L
          - Cerebrum, R
            - Corpus callosum, right side
            - Corpus callosum, left side
            - Anterior commissure, right side
            - Anterior commissure, left side

Nervous System > Central > Brain > Forebrain (prosencephalon) > Cerebrum (telencephalon) > Cerebrum, L > Temporal lobe, L

Show  
Hide Others  
Transparent  
Show All  
Reset View  
Reset All



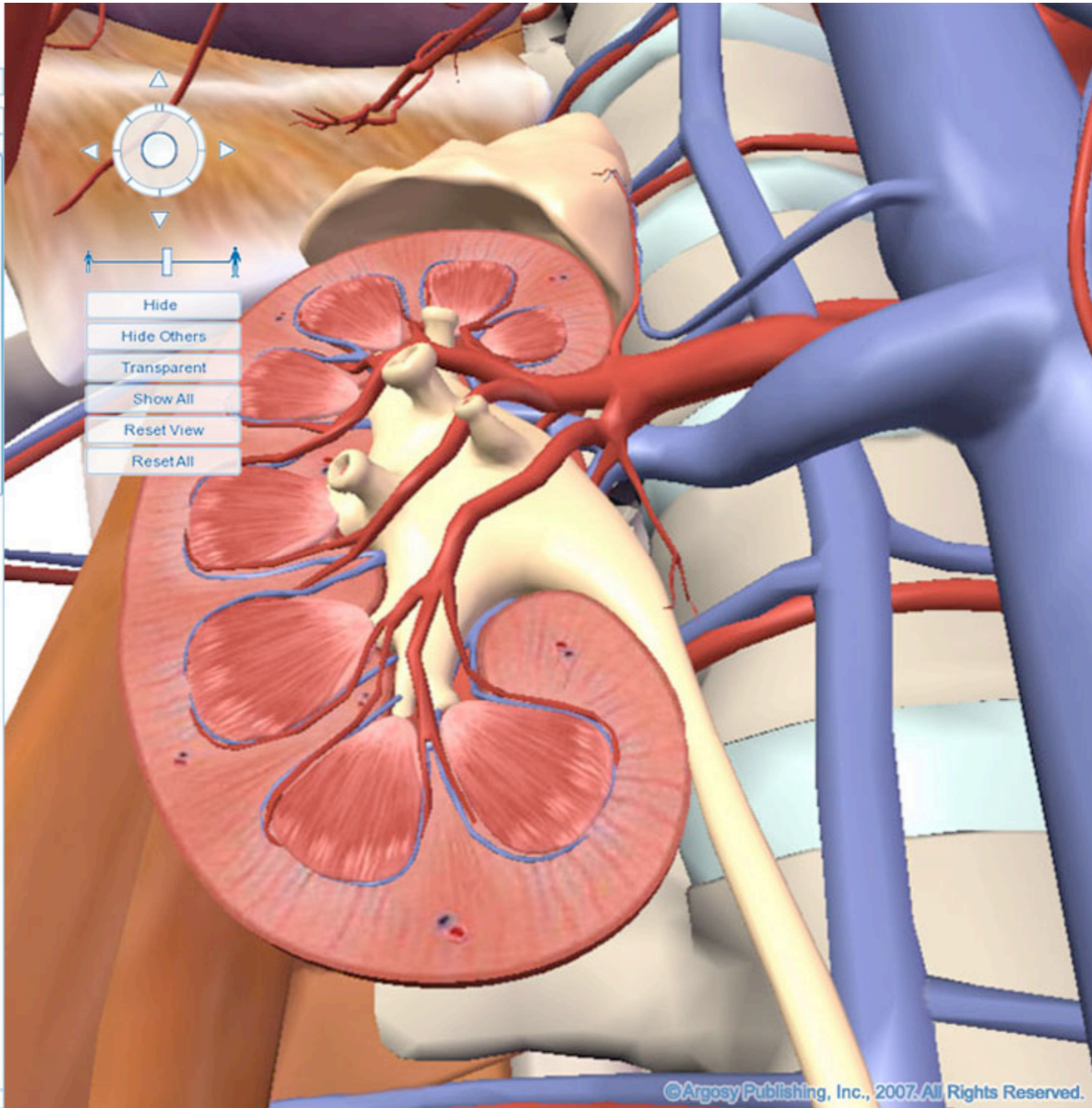
© Argosy Publishing, Inc., 2007. All Rights Reserved

[http://www.visiblebody.com/nervous\\_system2.html](http://www.visiblebody.com/nervous_system2.html)

Franz Kurfess: Knowledge Presentation

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.

