KAW/EKAW/PKAW/KCAP 25th Anniversary

Knowledge Capture through the Millennia:

From Cuneiform to the Semantic Web


What is our
community
celebrating?

KAW/EKAW/PKAW/KCAP Conferences

1986	KAW 1	Canada	1993	EKAW 7	France	2001	KCAP 1	Canada
1987	KAW 2	Canada	1994	KAW 8	Canada	2002	EKAW 13	Spain
	EKAW 1	England		EKAW 8	Belgium		PKAW 10	Japan
1988	KAW 3	Canada		PKAW 5	Japan	2003	KCAP 2	USA
	EKAW 2	Germany	1995	KAW 9	Canada	2004	EKAW 14	UK
1989	KAW 4	Canada	1996	KAW 10	Canada		PKAW 11	New Zealand
	EKAW 3	France		EKAW 9	UK	2005	KCAP 3	**Canada**
1990	KAW 5	Canada		PKAW 6	Australia	2006	EKAW 15	Czech Republic
	EKAW 4	Netherlands	1997	EKAW 10	Spain		PKAW 12	China
	PKAW 1	Japan	1998	KAW 11	Canada	2007	KCAP 4	Canada
1991	KAW 6	Canada		PKAW 7	Singapore	2008	EKAW 16	Italy
	EKAW 5	Scotland	1999	KAW 12	Canada		PKAW 13	Vietnam
	PKAW 2	Australia		EKAW 11	Germany	2009	KCAP 5	USA
1992	KAW 7	Canada		PKAW 8	Australia	2010	EKAW 17	Portugal
	EKAW 6	Germany	2000	EKAW 12	France		PKAW 14	Korea
	PKAW 3	Japan		PKAW 9	Australia	2011	KCAP 6	Canada

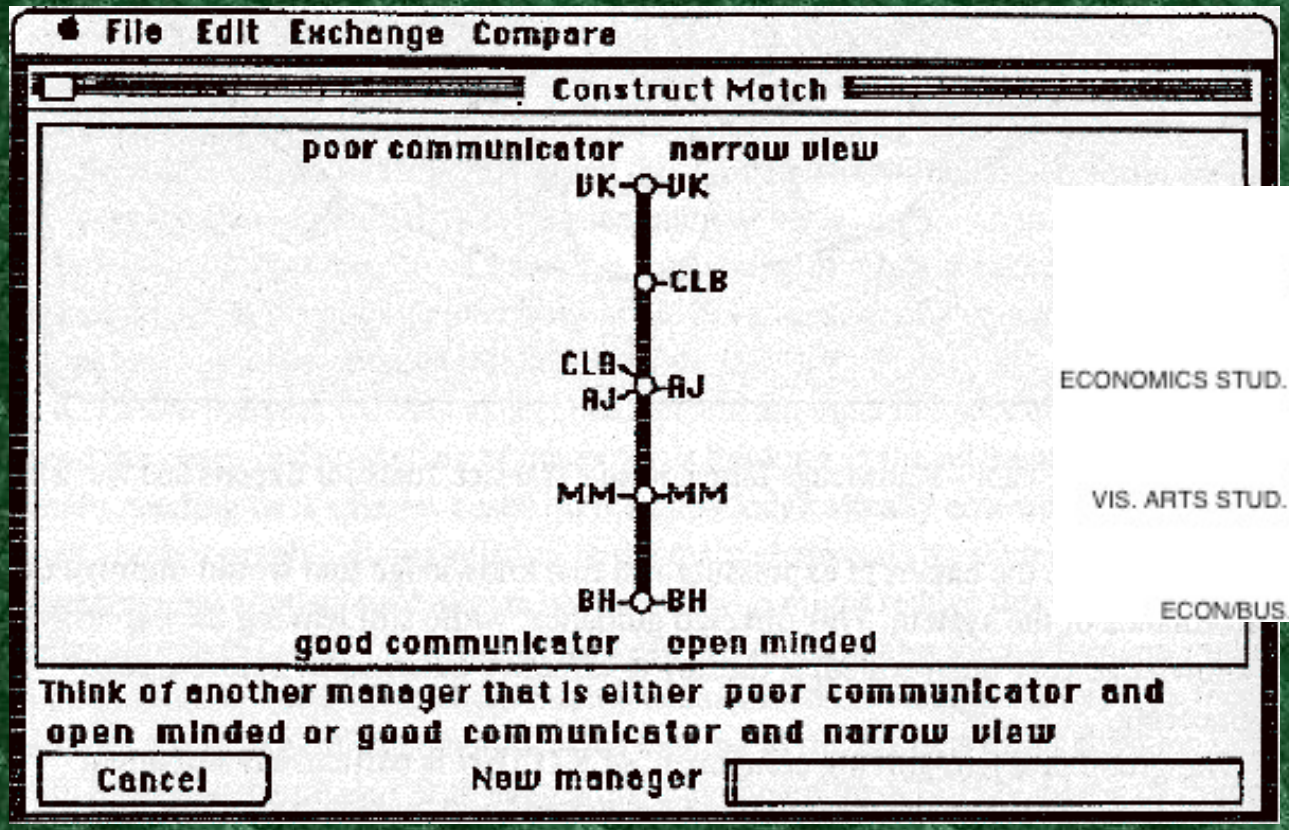
2011 KCAP 6 Banff, Canada—the 48th Conference

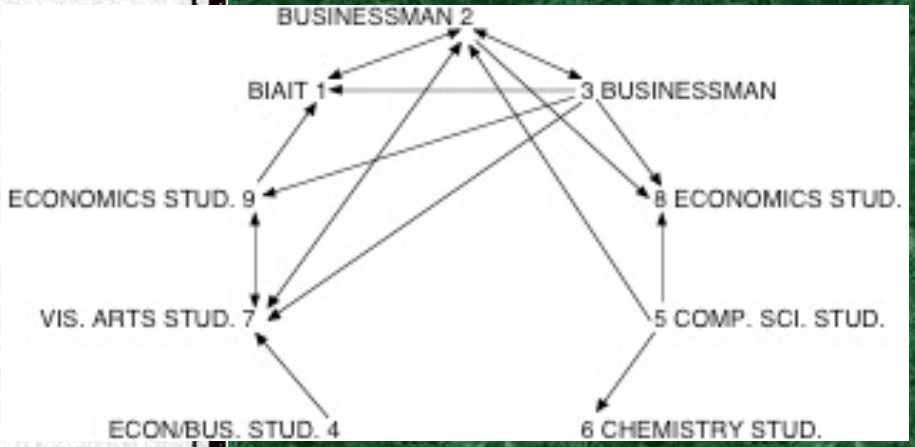
Living in Interesting Times

- 1986 First KAW Conference
- 1985-1993 Peristroika, Glasnost, dissolution of USSR, Yugoslavia, Czechoslovakia
- 1989 Fall of Berlin Wall—1990 Reunification of East and West Germany
- 1990 Hubble space telescope—major astronomical knowledge acquisition
- 1990-2003 Human genome project—major biological knowledge acquisition
- 1991 Euro introduced as new international trading currency
- 1995 Dominance of World Wide Web—Marc Andreessen, interactive forms
- 1995 Commercialization of the Internet
- 1996 Netscape 80% of browsers—2002 Microsoft 95% of browsers
- 1996 Discovery of mirror neurons
- 1997 Mars Pathfinder *Sojourner* (3 months)
- 1998 Failure of DEC ("no-one needs a computer at home"—Apollo 1989, Sun 2010)
- 2001 China joined World Trade Organization
- 2004 European Community expanded to 25 members
- 2004 Mars Exploration Pathfinder *Spirit* (6 years) *Opportunity* (7 years…)
- 2004 Google IPO—Jun-2011 market cap $157B (Apple 298, Microsoft 208)
- 2006-2010 Neanderthal genome project
- 2011 KAW/EKAW/JKAW/KCAP 25th Anniversary—48 worldwide conferences

Our research pre-KAW

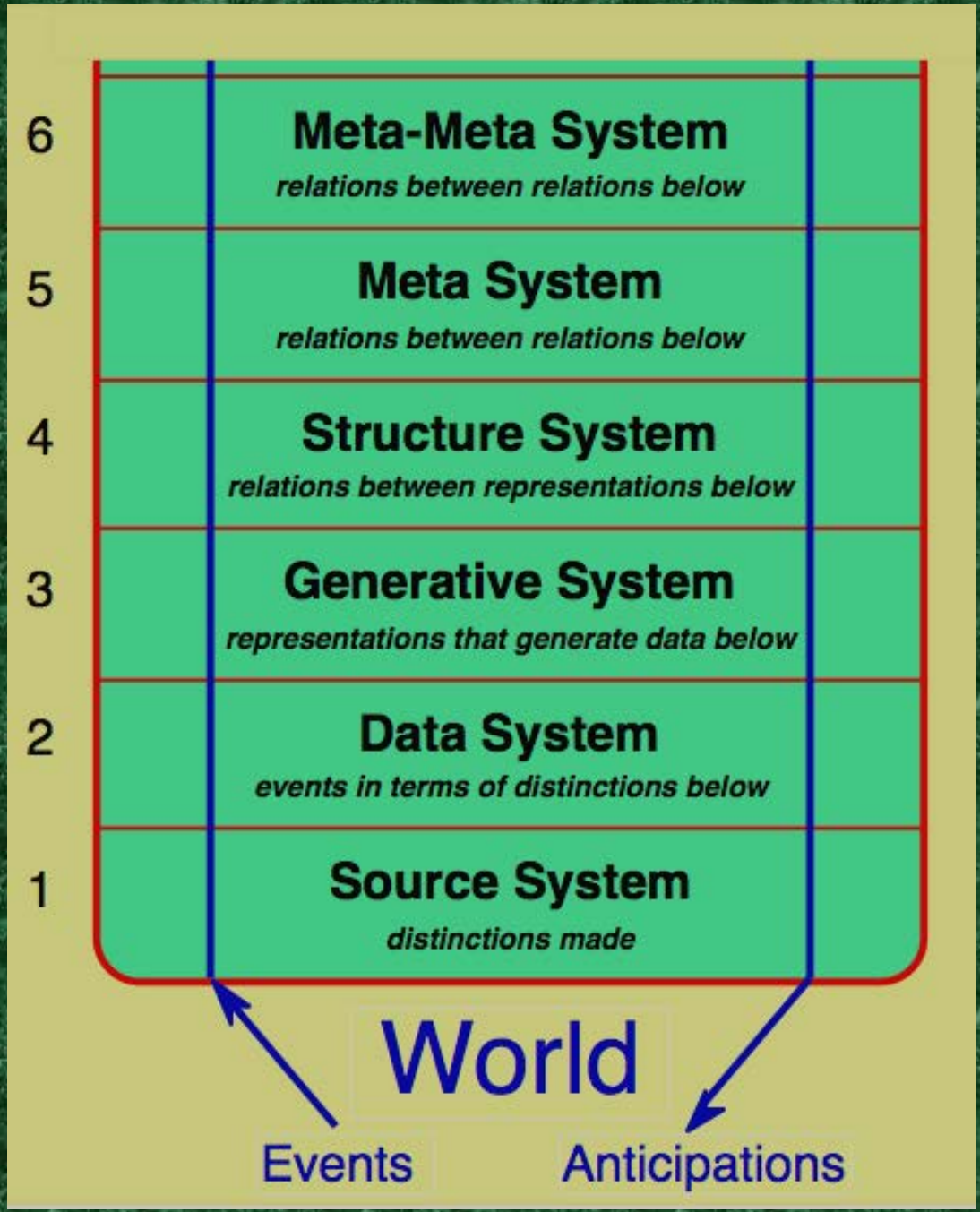
Computer-based knowledge elicitation
Using conceptual grids



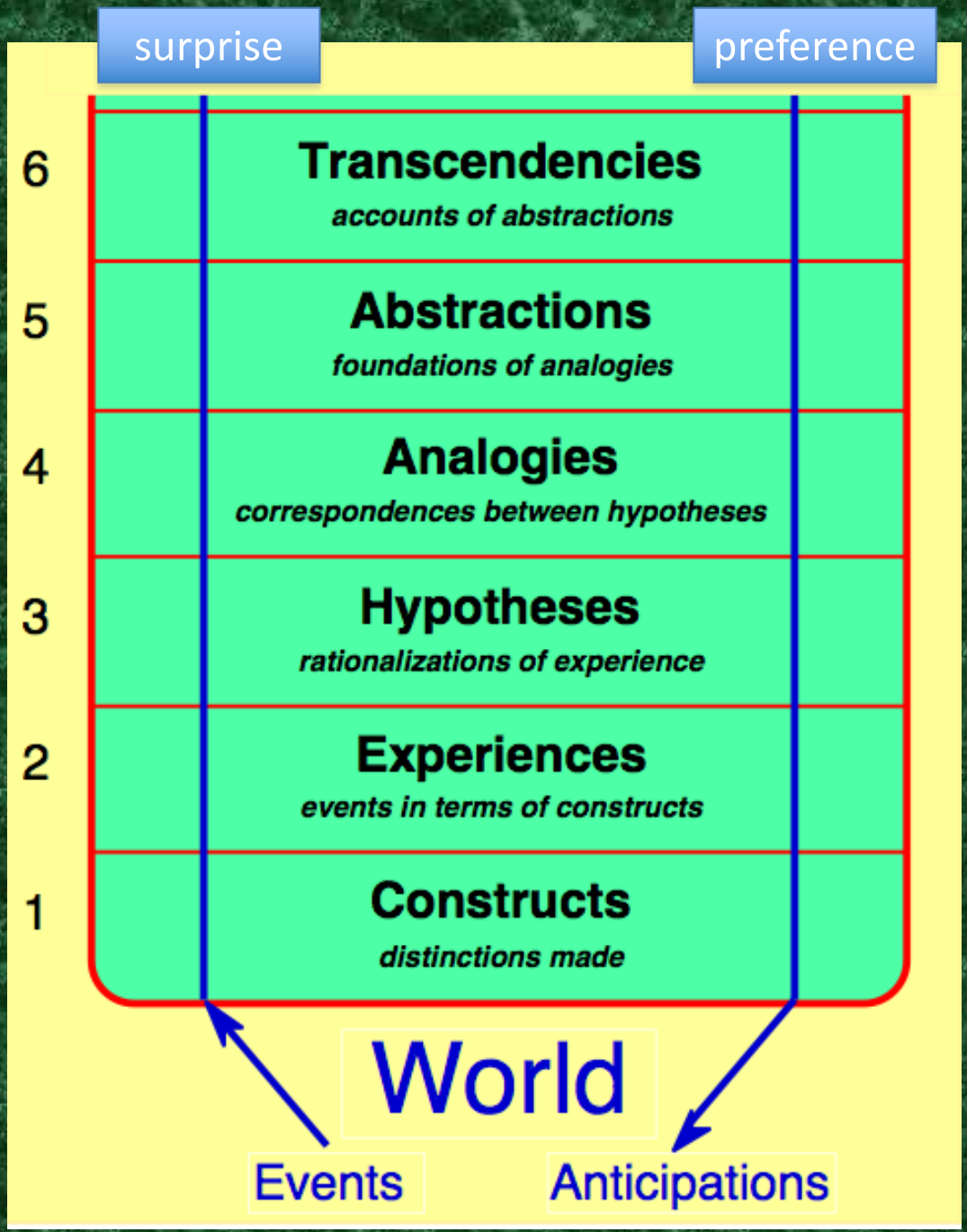


Shaw & Gaines, A computer aid to knowledge engineering, BCS Expert Systems Conference , 1983

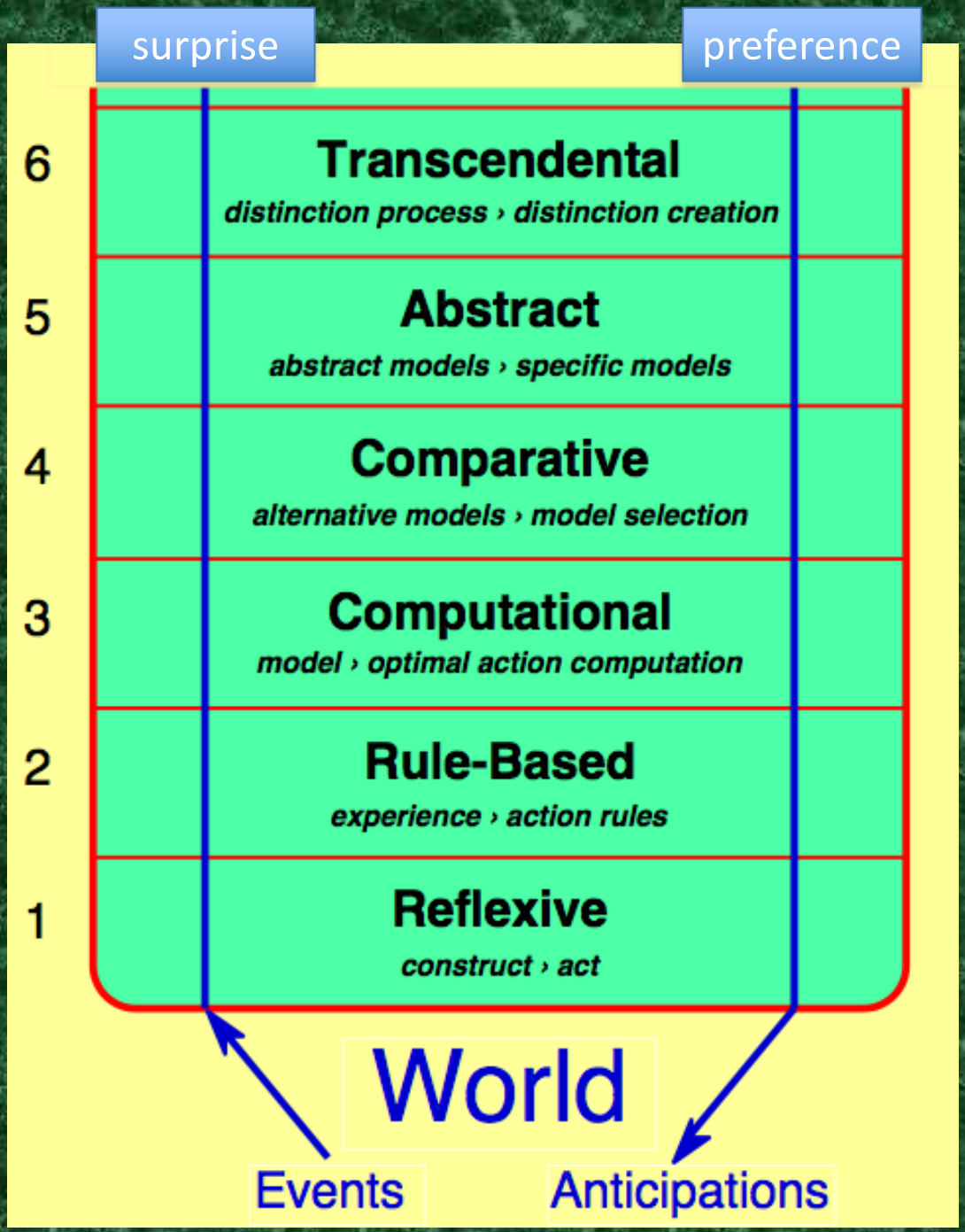
Epistemological hierarchy
(derived from "Identification of generative structures in empirical data", Klir, 1976)



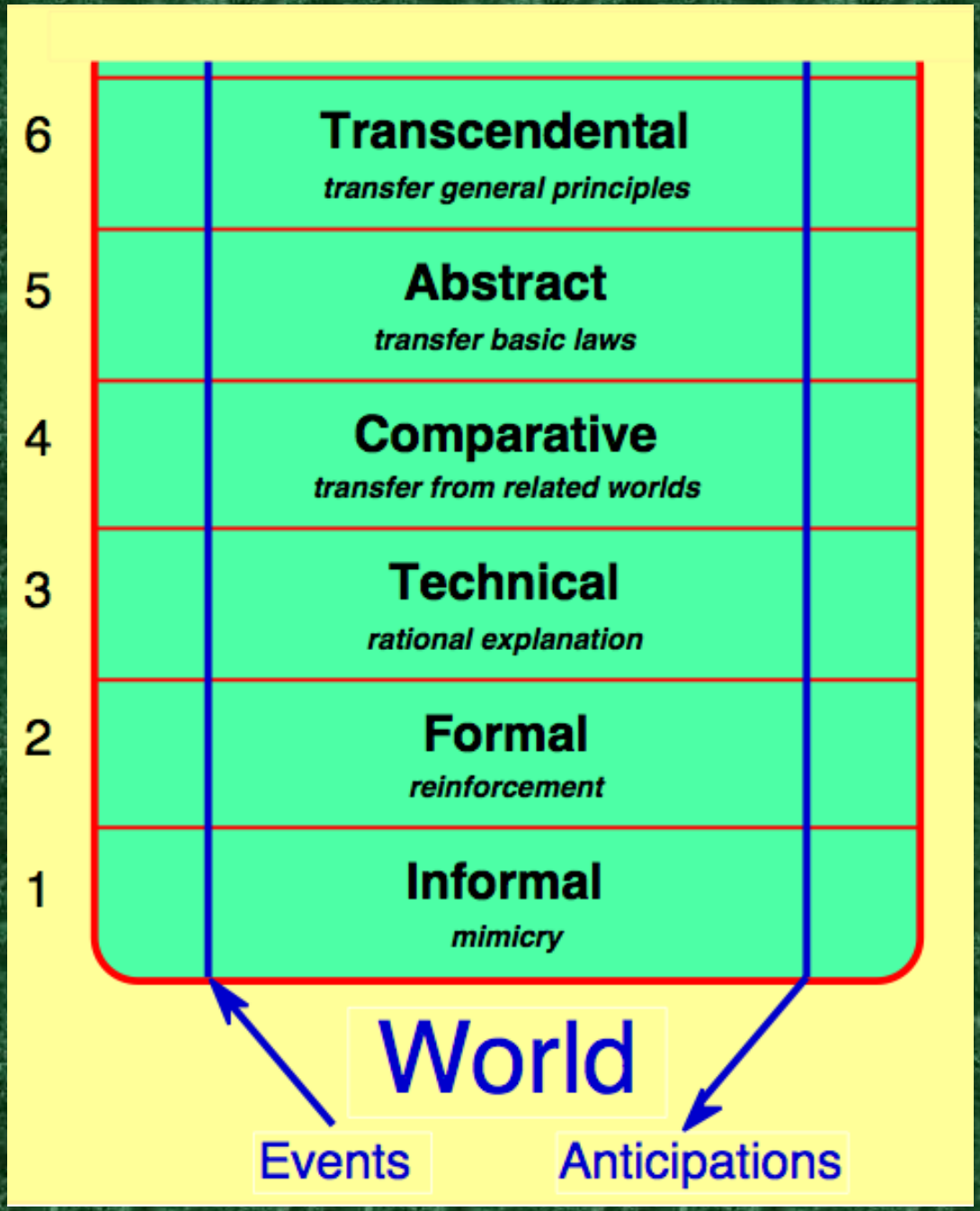
Construction hierarchy of a person modeling a world



Knowledge hierarchy of a person modeling a world



Knowledge transmission hierarchy of a community modeling a world



Number of devices on a chip

(*The learning curves underlying convergence*, Gaines, 1998)

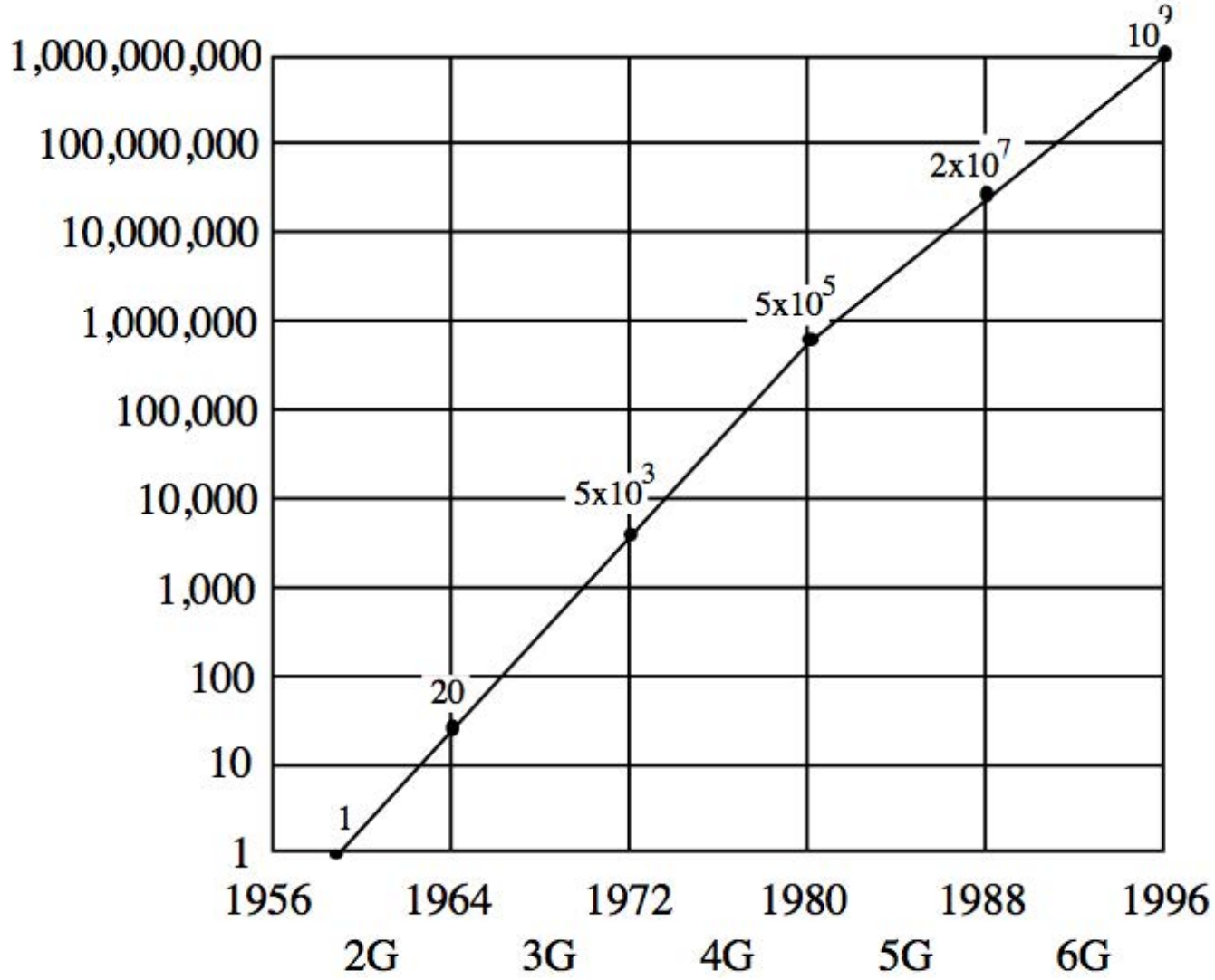
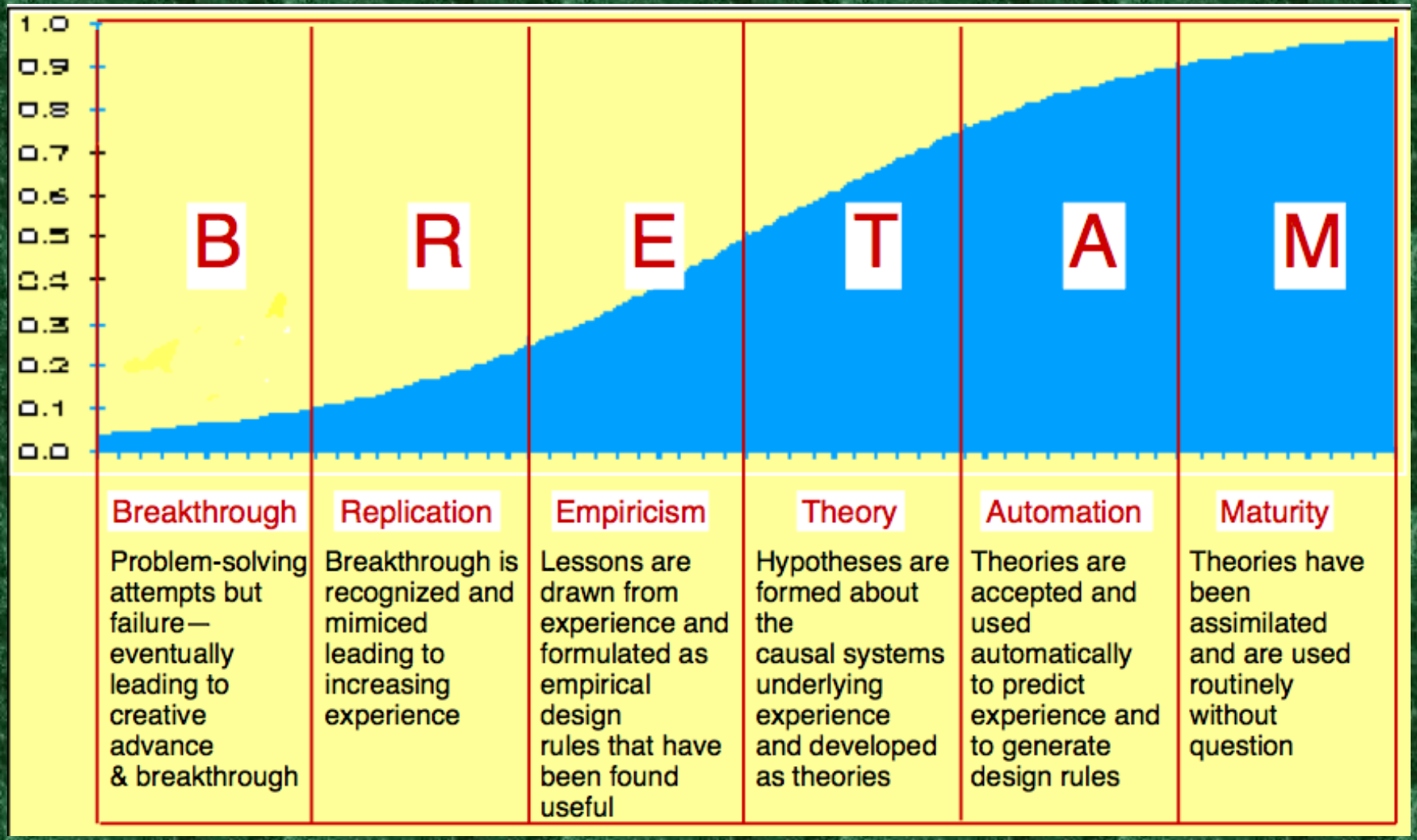


Figure 5 The number of devices on a chip

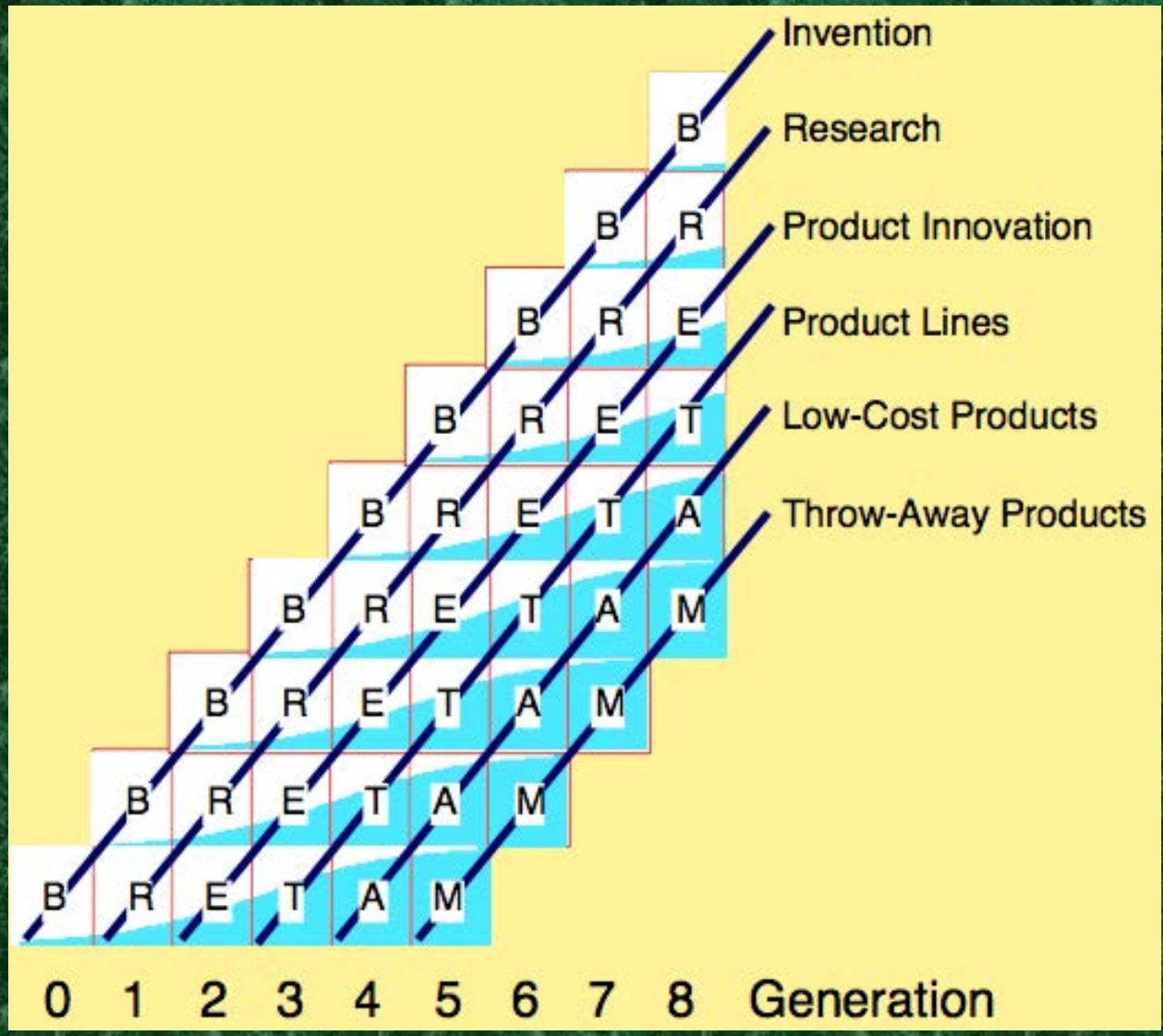
Learning curves for knowledge acquisition in a domain

(*A learning model for forecasting the future of information technology*, Gaines & Shaw, 1986)



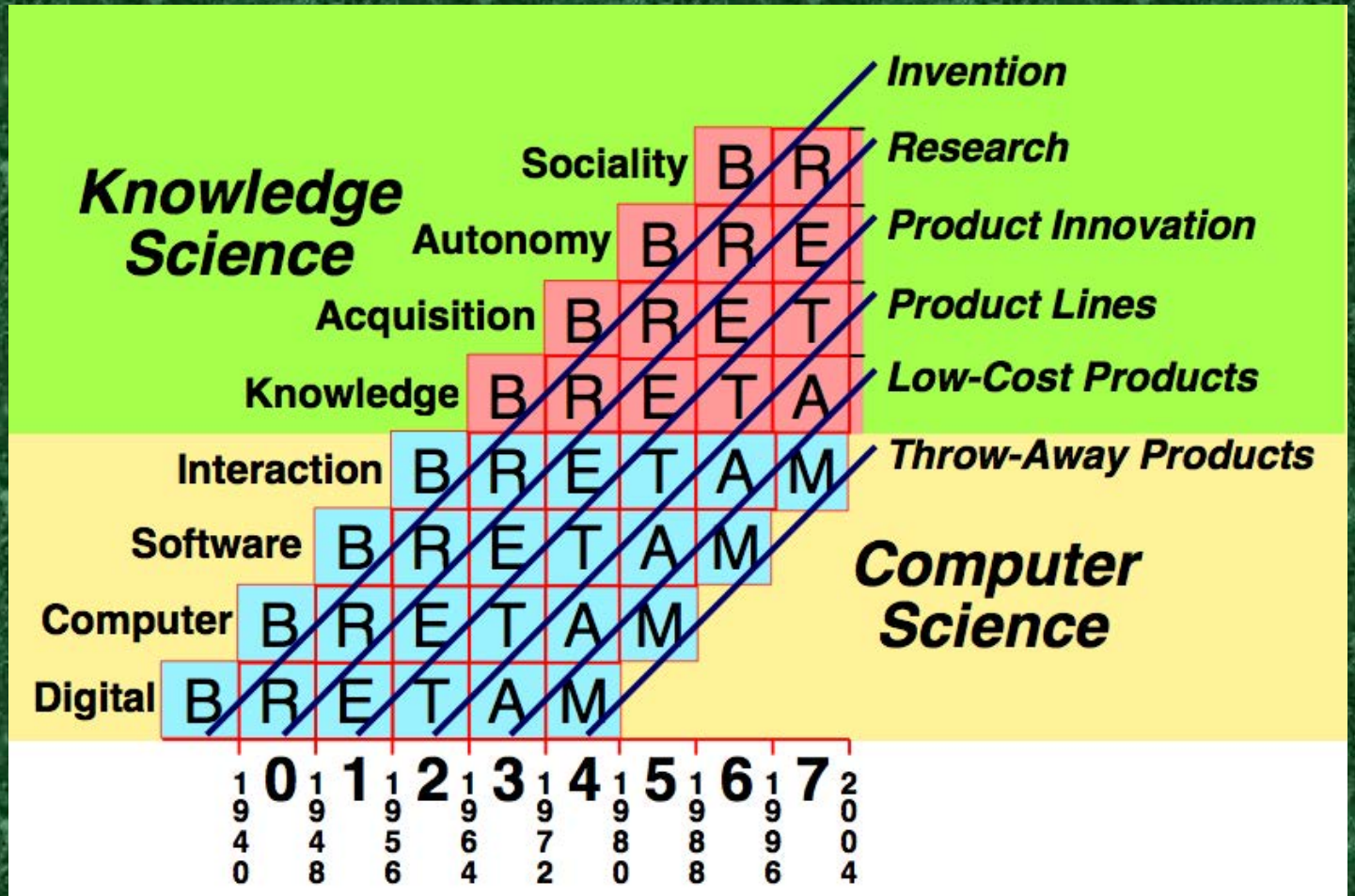
Tiered structure of earning curves for knowledge acquisition in dependent domains

(*A learning model for forecasting the future of information technology*, Gaines & Shaw, 1986)



The infrastructure of information technology

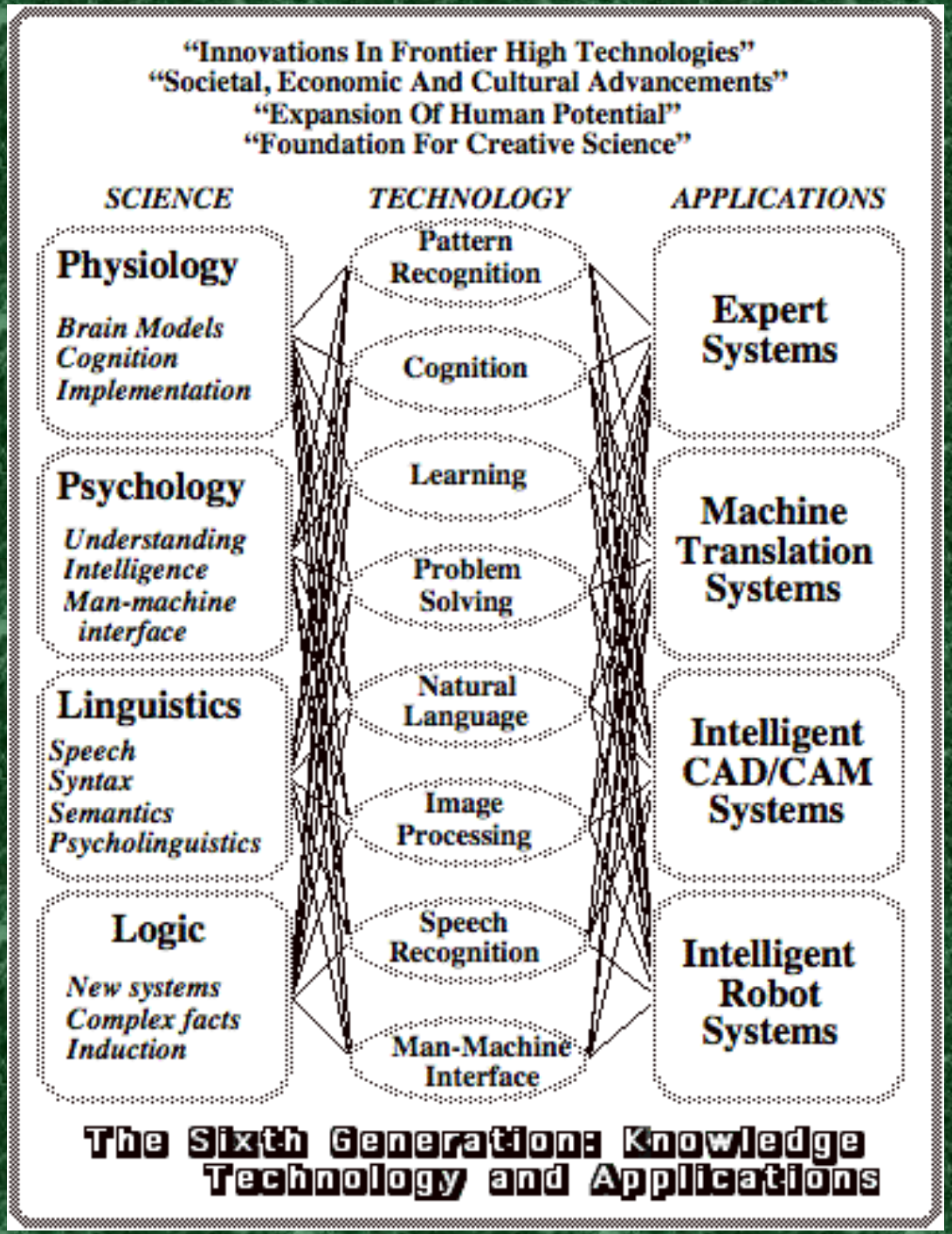
(*The learning curves underlying convergence*, Gaines, 1998)



- Breakthrough: creative advance made
- Replication period: experience gained by mimicing breakthrough
- Empirical period: design rules formulated from experience
- Theoretical period: underlying theories formulated and tested
- Automation period: theories predict experience & generate rules
- Maturity: theories become assimilated and used routinely


Knowledge
Science

MITI Sixth Generation Computing Proposal "Knowledge Science" 1985



1984 Knowledge Science Institute Proposal

The formation of a Knowledge Science Institute is proposed with the aim of facilitating the world-wide process of change to knowledge-based economies

The Institute will form a network of links with industry, government and universities and facilitate the study, dissemination and application of information on knowledge science and technology and its social and economic impacts

The Institute will facilitate the development of multi-disciplinary studies of knowledge science and technology

The Institute will undertake system development and application projects involving knowledge-based systems, and train and support others to undertake such projects

1984 KSI Action Plan

Establish a physical centre as a focus for study and discussion of issues relating to knowledge systems

Establish an international network of those concerned with issues relating to knowledge systems

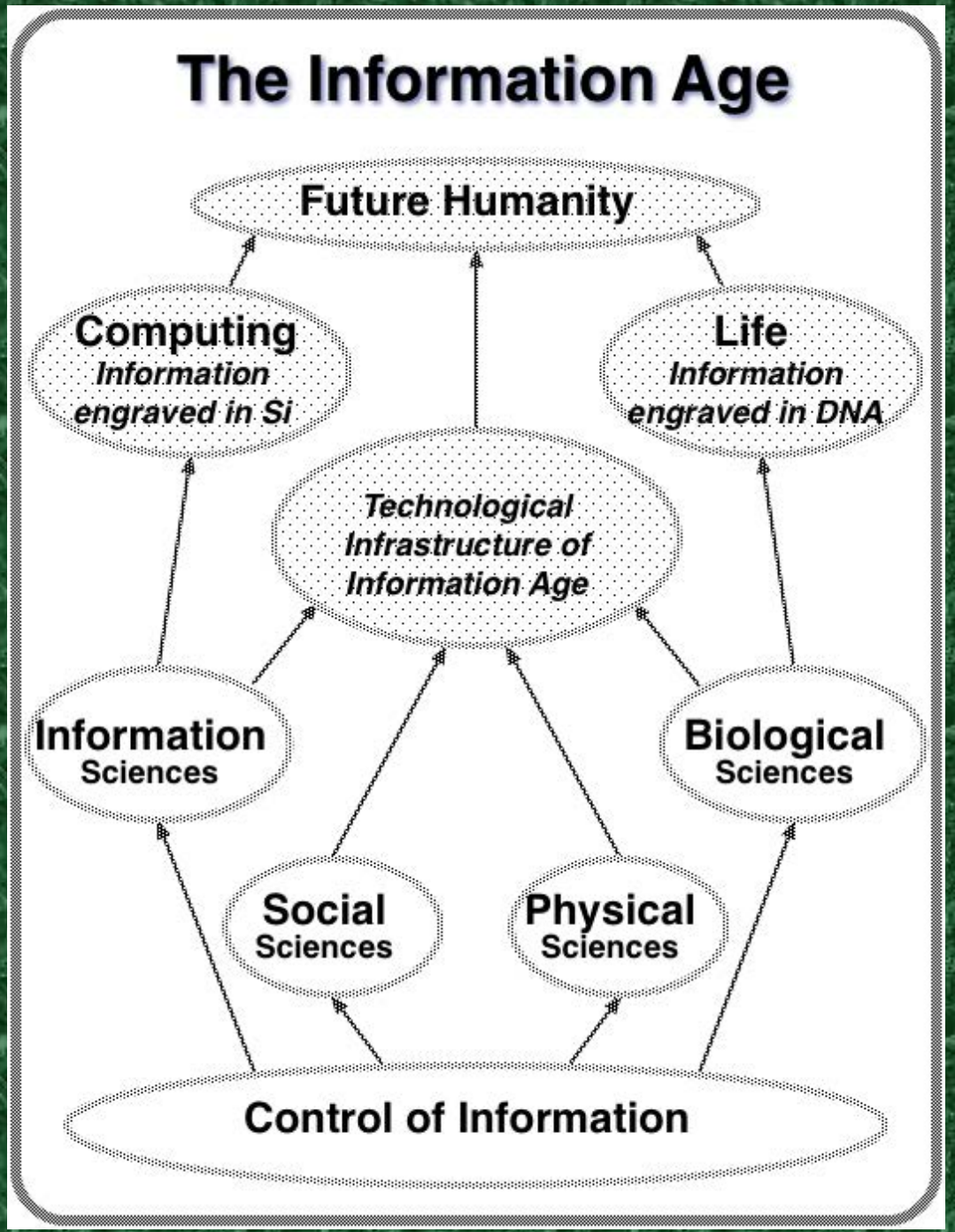
Provide facilities for visitors seconded to the Institute for varying periods of time to study, interact and pursue objectives relating to knowledge systems

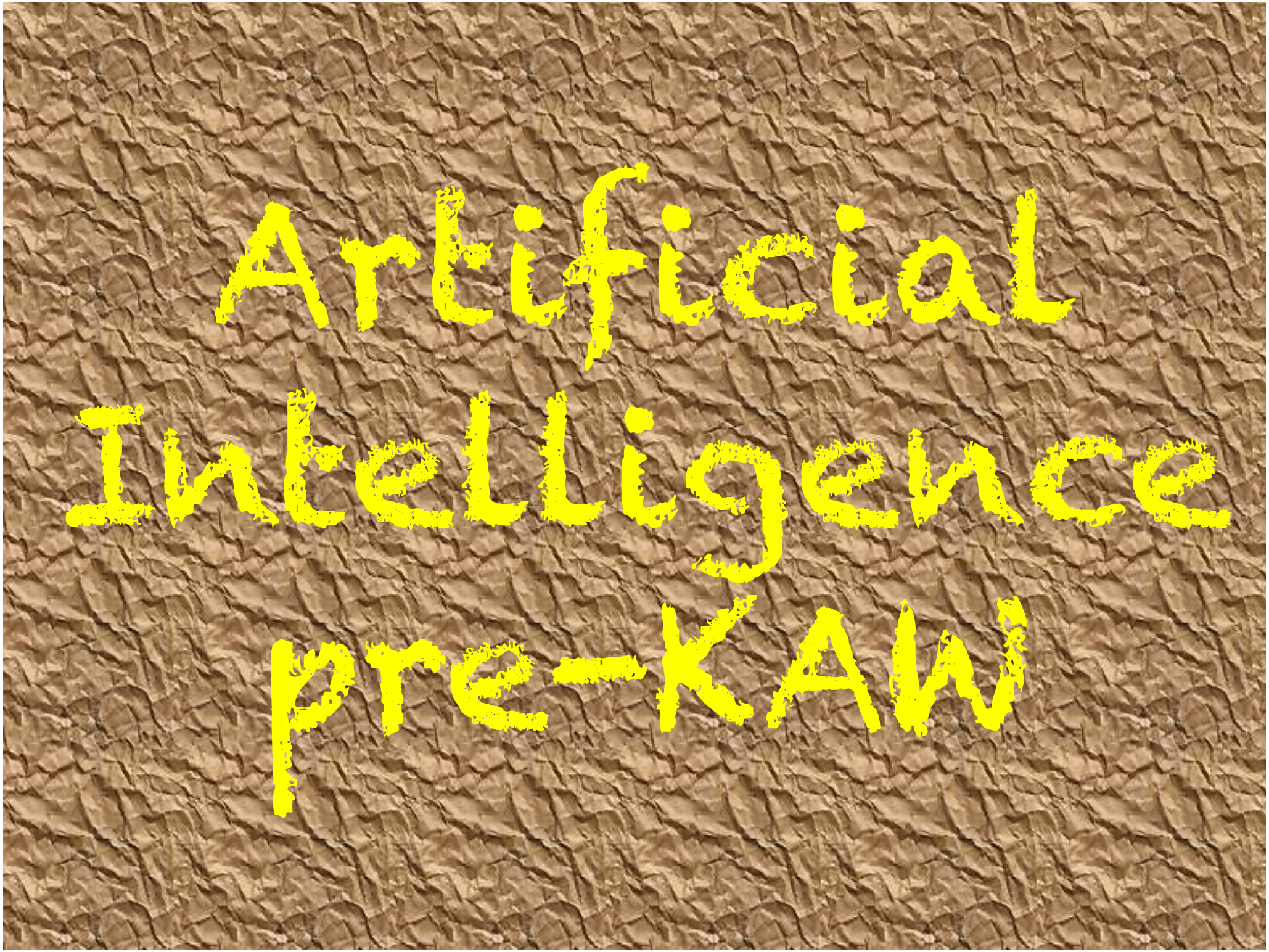
Provide courses for key personnel in government, industry and university that develop awareness of issues and skills in methodologies relating to knowledge systems

Undertake projects that develop resources within the Institute for strategic planning relating to knowledge systems

Undertake system developments in collaboration with others resulting in significant applications of knowledge-based systems

Killam Memorial Research Chair Inaugural Address 1985




Artificial
Intelligence
pre-KAI

AI Winters and Summers

- *Dartmouth Summer Project, USA 1955*
- *Mechanization of Thought Processes Symposium*, UK, 1959
- *Lighthill Report*, UK, 1973—first AI winter
- MITI *5th Generation Computing Proposal*, Japan, 1982—revived national interest in AI
- DARPA *Strategic Computing Program*, USA
- Alvey Program, UK, Esprit Program, EC
- Major industry projects—AI/ES companies
- IJCAI'85, LA, over 7,000 attendees
- Lack of significant outcomes from 5th Generation project
- Closure of USA, UK and EC programs—1987 second AI winter
- Assimilation of AI concepts and technologies into standard information technologies

Lighthill Report, 1972

It has sometimes been argued that part of the stimulus to laborious male activity in 'creative' fields of work, including pure science, is the urge to compensate for **lack of the female capability of giving birth to children.**

If this were true, then Building Robots might indeed be seen as the ideal compensation!

One piece of evidence supporting that highly uncertain hypothesis: most robots are designed from the outset to operate in a world as like as possible to the conventional child's world as seen by a man; **they play games, they do puzzles, they build towers of bricks, they recognise pictures in drawing-books ('bear on rug with ball');** although the rich emotional character of the child's world is totally absent.

Builders of Robots can justly reply that while robots are still in their infancy they can mimic only pre-adult functions and a limited range of those at most, and that these will lead on to higher things.

Nevertheless, the view to which this author has tentatively but perhaps quite wrongly come is that a relationship which may be called **pseudo-maternal** rather than Pygmalion-like comes into play between a Robot and its Builder.

Projection of the artificial intelligence market in 1985 ($ millions)

Market Area	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Expert Systems	4	9	17	38	74	145	245	385	570	810
Natural Language	5	8	18	40	59	125	210	320	465	650
Visual Recognition	10	22	51	116	168	260	370	500	660	840
Voice Recognition	5	7	11	20	33	55	85	140	200	270
AI Languages	3	5	8	12	21	35	45	65	80	105
AI Computers	28	56	103	217	364	510	710	970	1250	1570
Government Contracts	20	30	40	50	95	150	150	155	175	200
Total	55	107	208	443	719	1130	1665	2380	3225	4245

Pre World Wide Web, Google, Facebook, YouTube

Google Revenues									
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
86	440	1,465	3,189	6,138	10,605	16,594	21,796	23,651	29,321

Attendance of over 7,000

Three largest tracks:-
Learning and Acquisition 31 papers
Expert Systems 28
Natural Language 28

36% of the 245 papers presented were on these themes that came to dominate the KAW meetings worldwide

Unexpectedness illustrated by the conference planning—none of the 4 keynotes and only one of the 12 panels addressed these themes

AAAI annual conference had continuing attendances above 5,000 with very large accompanying commercial exhibitions—the call for sites for the 1988 conference estimates attendance at 6,500 and exhibition space at 80,000 square fee



Proceedings of the Ninth International Joint Conference on Artificial Intelligence

18–23 August 1985, Los Angeles, California


Founding
the KAU
community

The first KAW, 1986

Planned as a small workshop for 40 attendees
120 papers submitted—over 400 requests to attend
Final attendance 60—papers 42

Program Committee

John Boose, Boeing; Brian Gaines, University of Calgary (Co-Chairs)
Jeff Bradshaw, Boeing; Bill Clancey, Stanford University
Cathy Kitto, Boeing; Janusz Kowalik, Boeing
John McDermott, Carnegie-Mellon University; Ryszard Micchalski, University of Illinois
Art Nagai, Boeing; Mildred Shaw, University of Calgary

Working Groups

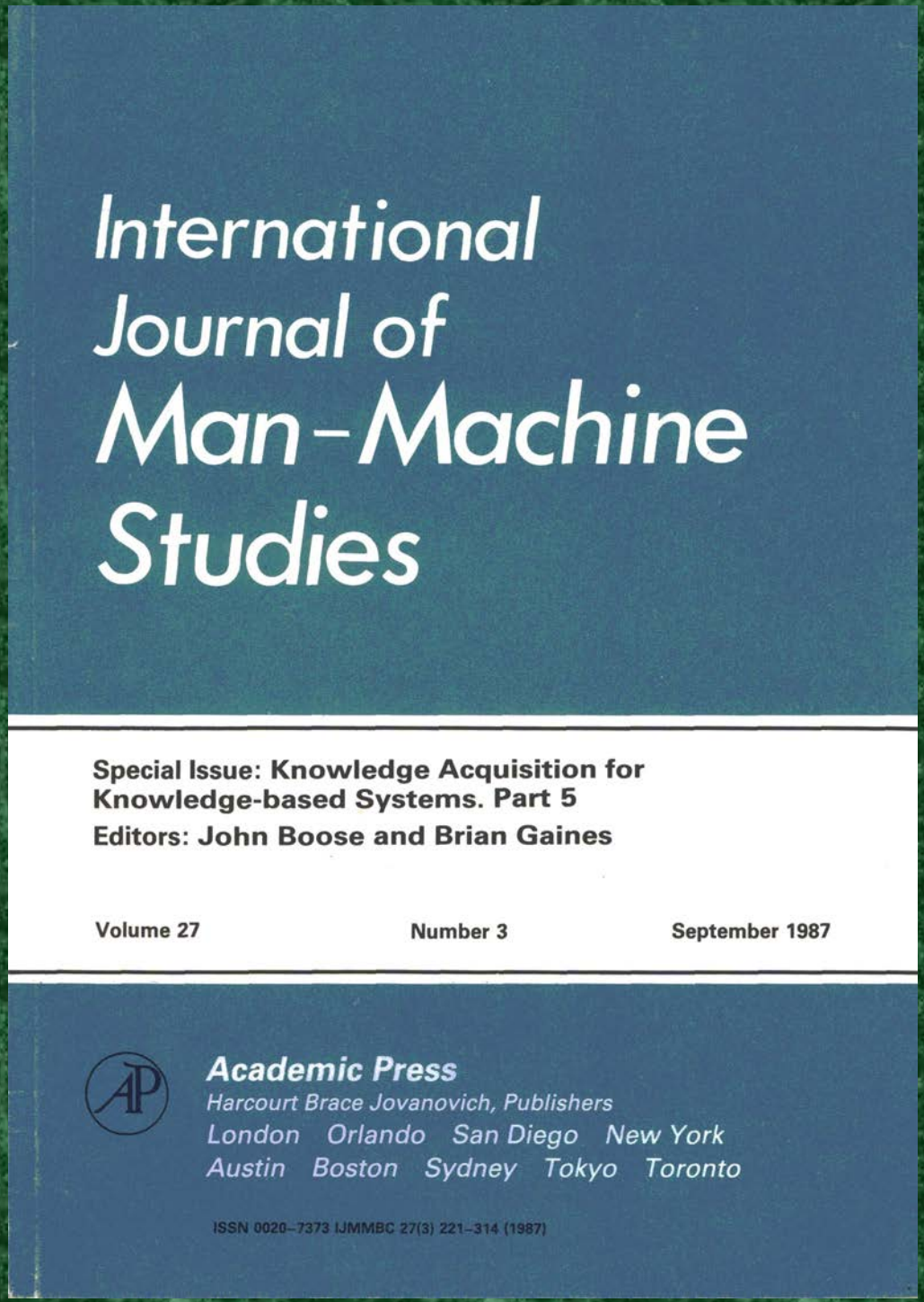
Cognition and Expertise, Bill Clancey *et al*
Interactive Interviewing Tools I, John McDermott *et al*
Interactive Interviewing Tools II, John Boose *et al*
Approaches to Analysis of Knowledge Structures, Gavriel Salvedy *et al*
Learning, Ryszard Micchalski *et al*
Knowledge Acquisition Methodology and Training, Chandrasekaran *et al*
Reasoning with Uncertainty & Knowledge Acquisition, Brian Gaines, Ross Quinlan, *et al*

Proceedings of the KNOWLEDGE ACQUISITION FOR KNOWLEDGE-BASED SYSTEMS WORKSHOP

Banff Conference Centre
Banff, Alberta, Canada
November 2-7, 1986

Sponsored by the
American Association for
Artificial Intelligence

Workshop Co-chairs:
John H. Boose, Boeing Computer Services
Brian R. Gaines, University of Calgary


International
Journal of
Man-Machine
Studies
Special Issue: Knowledge Acquisition for
Knowledge-based Systems. Part 5
Editors: John Boose and Brian Gaines
Volume 27
Number 3
September 1987
Academic Press
Harcourt Brace Jovanovich, Publishers
London Orlando San Diego New York
Austin Boston Sydney Tokyo Toronto
ISSN 0020-7373 IJMMBC 27(3) 221-314 (1987)

KNOWLEDGE ACQUISITION *for* KNOWLEDGE-BASED SYSTEMS

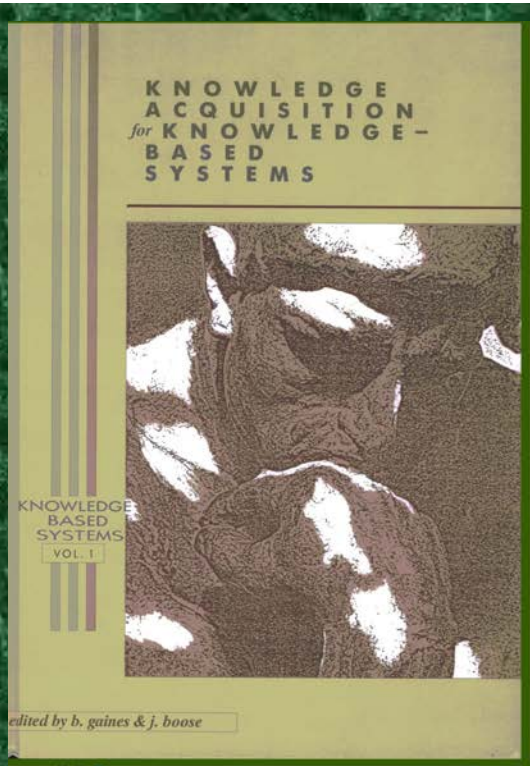


KNOWLEDGE BASED SYSTEMS

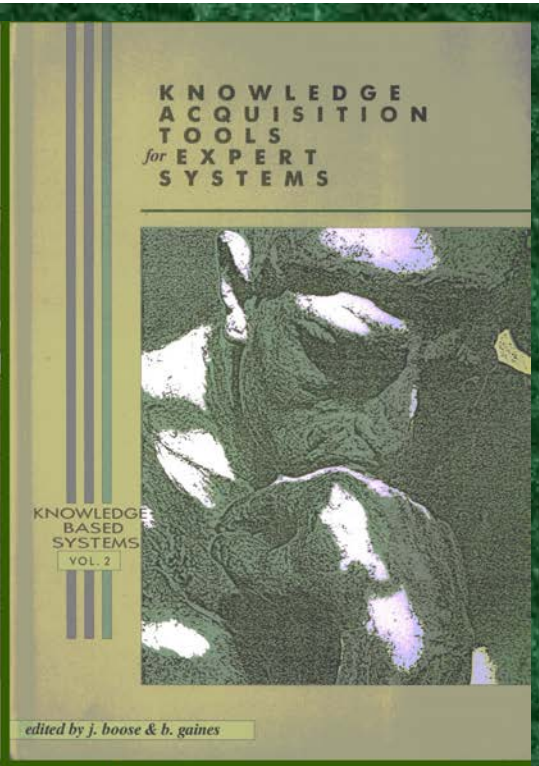
VOL. 1

edited by b. gaines & j. boose

V1 1988



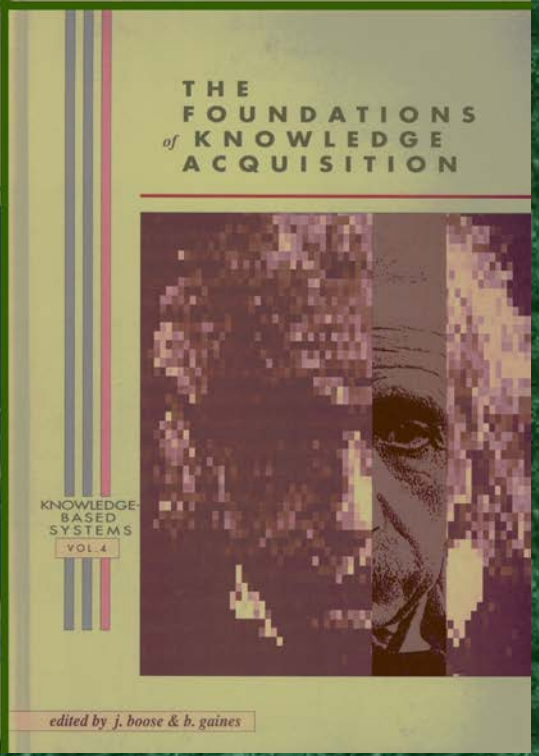
V2 1988



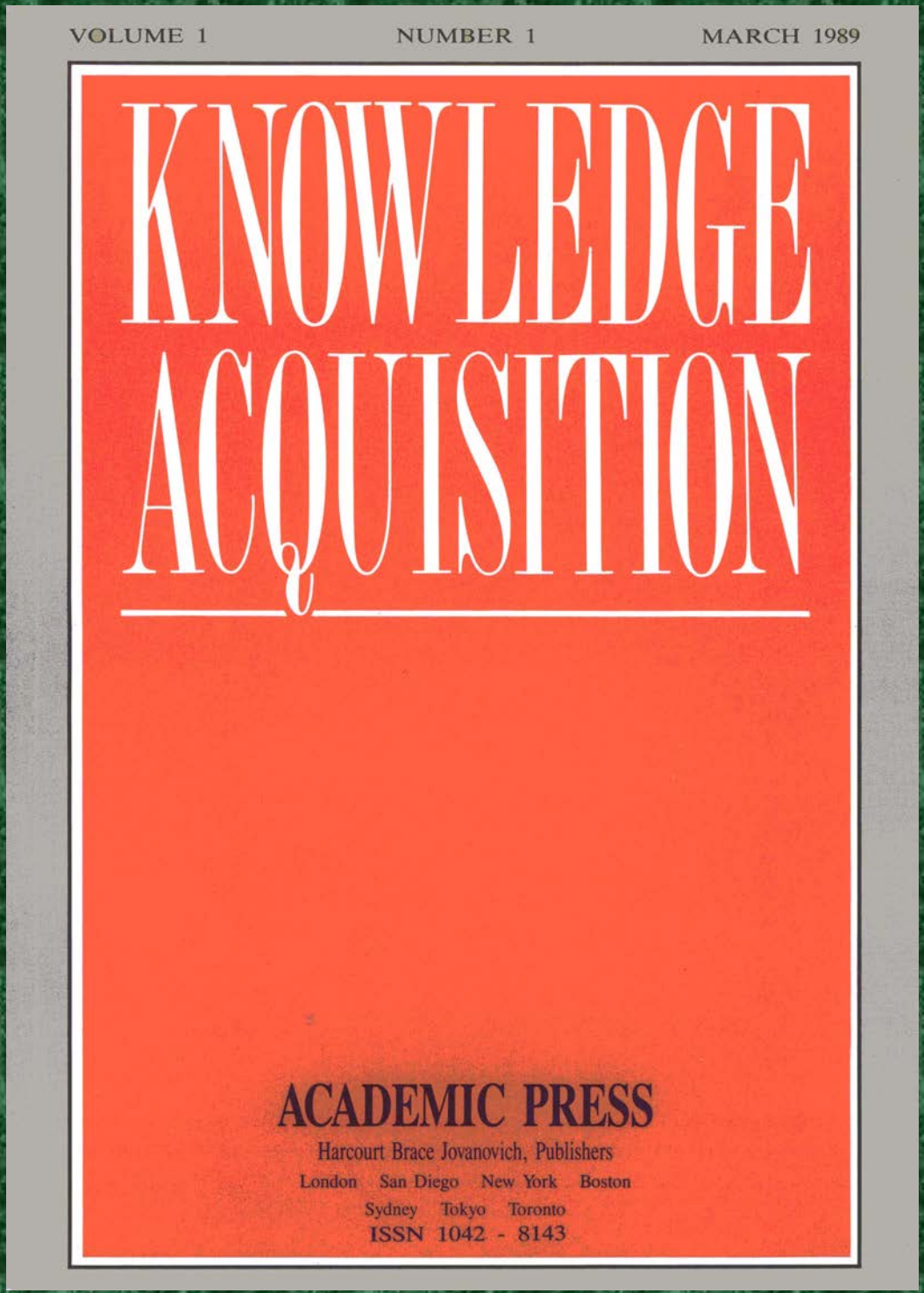
V3 1990



V4 1990



V1-6 1989-1994
Merged with
IJHCS in 1995

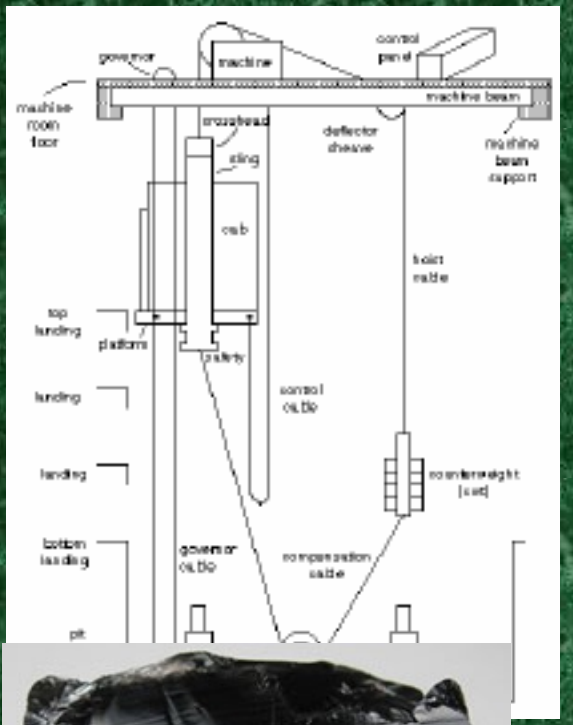


Brian Gaines
retired as
Editor in Chief
of IJHCS/KA
for V61 July 2004
handing over to
Enrico Motta &
Susan Wiedenbeck

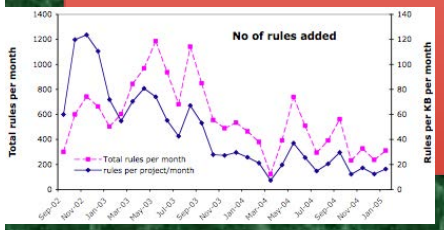
Sisyphus Projects—provide benchmarks, encourage collaboration

- **I: Room allocation problem**
- **II: Elevator configuration**
- **III: Igneous rock classification**
- **IV: Integrate KA tools through web**
  - Porting tools to different environments difficult
  - Integrating tools from other sites difficult
  - Supporting multiple sites problematic
  - Method of use not well-defined by originators
  - Tools OK for originators—ineffective for others





WebGrid: repgrid.com
WebProtégé: protege.stanford.edu
RDR: www.cse.unsw.edu.au/~compton/
Siri: siri.com/

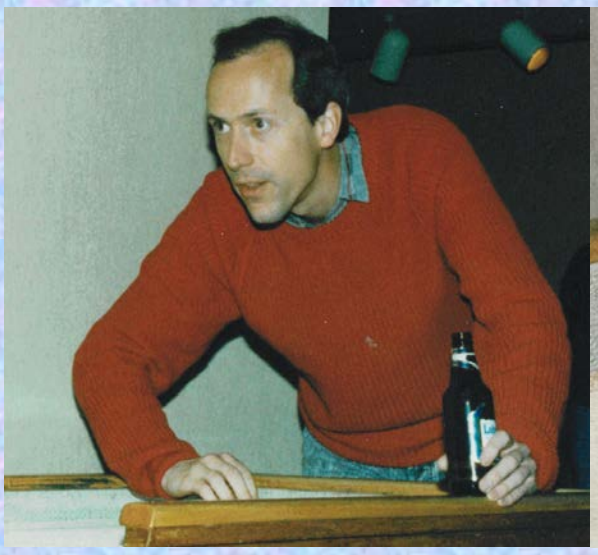






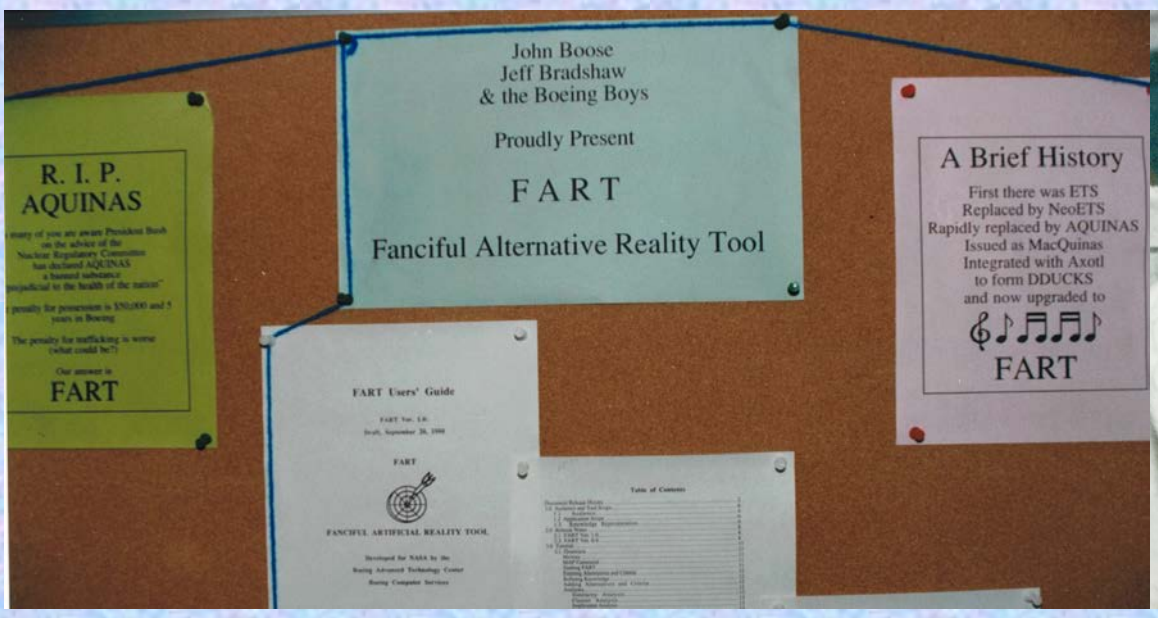






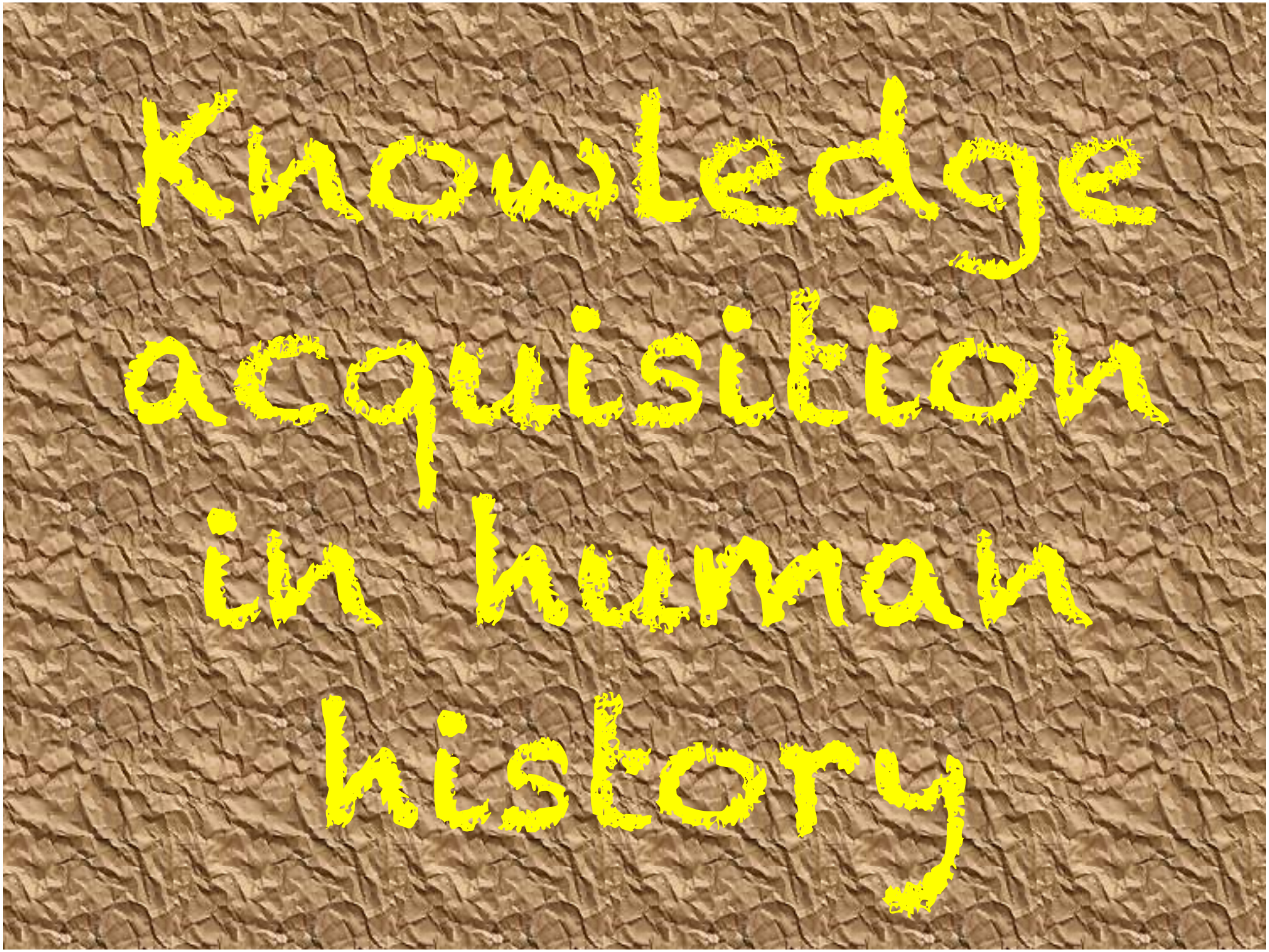





John Boose
Jeff Bradshaw
& the Boeing Boys
Proudly Present
FART
Fanciful Alternative Reality Tool
R. I. P.
AQUINAS
FART
FART Users' Guide
FART
FANCIFUL ARTIFICIAL REALITY TOOL
A Brief History
First there was ETS
Replaced by NeoETS
Rapidly replaced by AQUINAS
Issued as MacQuinas
Integrated with Axotl
to form DDUCKS
and now upgraded to
FART



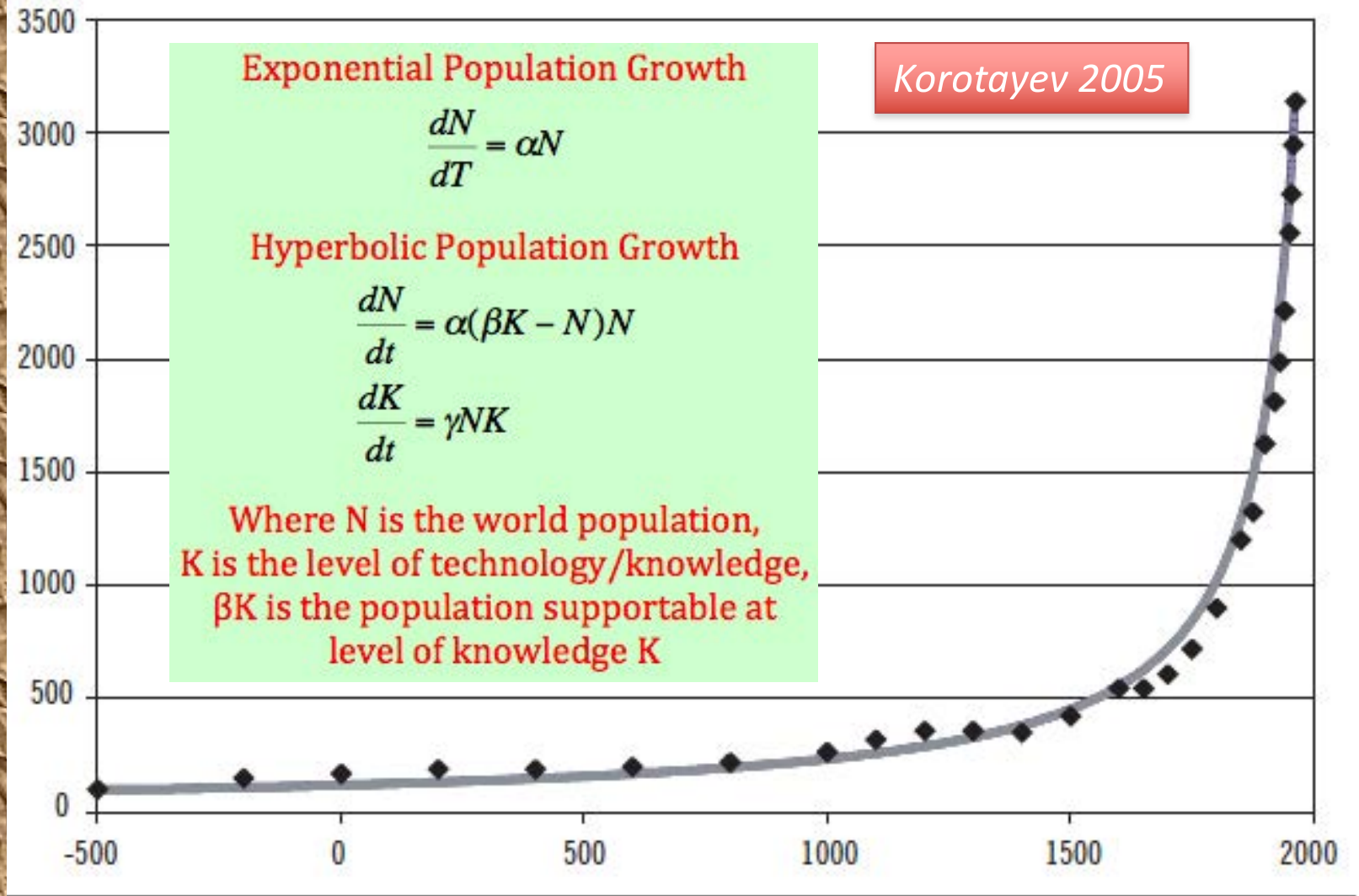

Markey & the Protegés
Nigelo, Pauley, Bobbo & Milly


Knowledge
acquisition
in human
history

Knowledge and Evolution

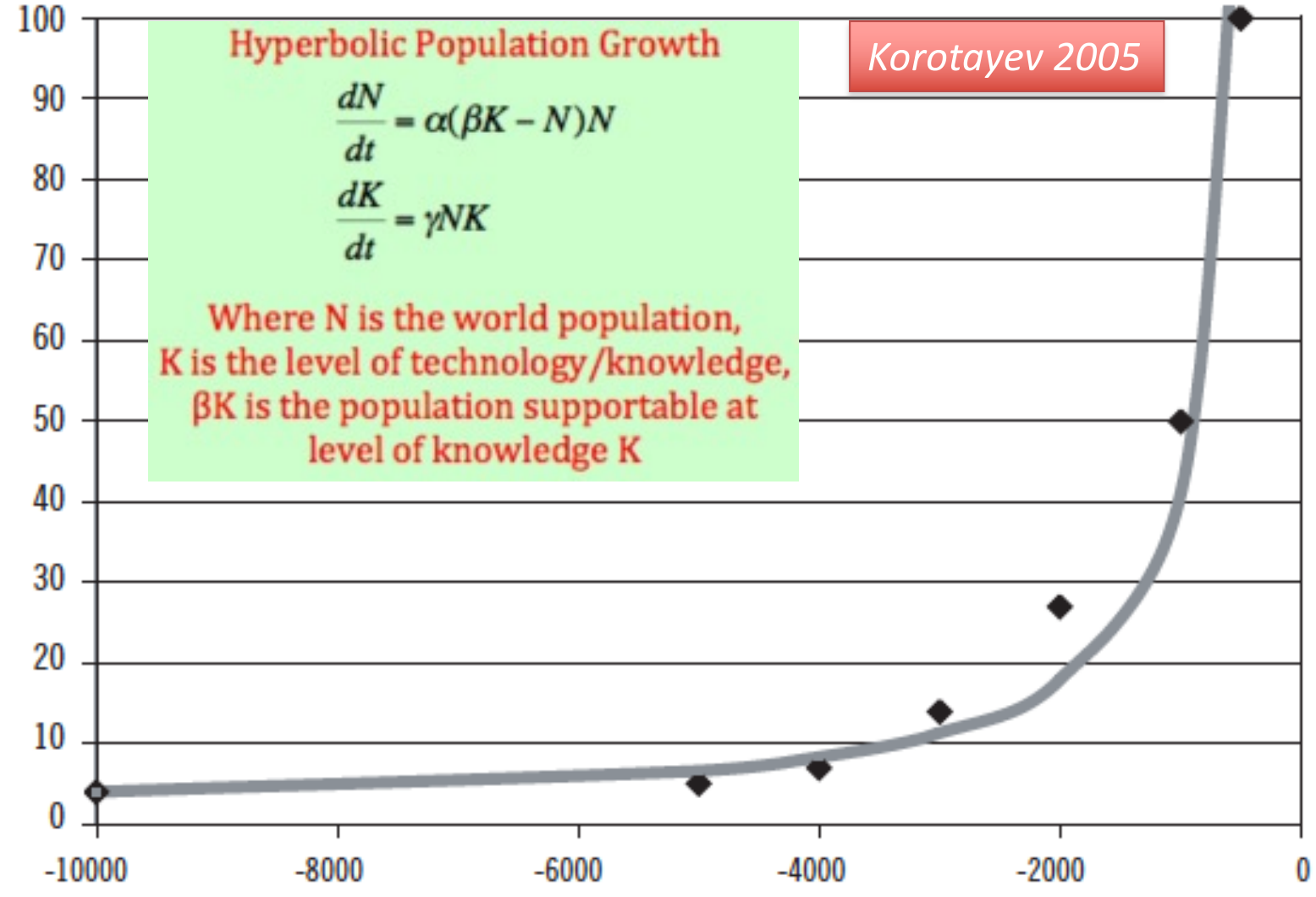
- Homo sapiens sapiens diverged from:
  - homo erectus 500,000 years ago
  - Homo sapiens neanderthalis 300,000 years ago
- Reduced to 3,000 in Africa 50,000 years ago
- Migrated through Levant world-wide
- Communities/agriculture 10,000 years ago
  - “humans became behaviourally modern when they could reliably transmit accumulated informational capital to the next generation, and transmit it with sufficient precision for innovations to be preserved and accumulated” (Sterelny, Phil. Trans. Royal Society, 2011)

Figure 3 – Predicted and Observed Dynamics of World Population Growth, in Millions (500 BCE – 1962 CE)



Note: The solid grey curve has been generated by the model; black markers correspond to the estimates of world population by Kremer (1993) for the pre-1950 period, and US Bureau of Census world population data for 1950–1962.

Figure 5 – Predicted and Observed Dynamics of World Population Growth, in Millions (10000 – 500 BCE)



Note: The solid grey curve has been generated by the model; black markers correspond to the estimates of world population by McEvedy and Jones (1978) and Kremer (1993).

Dynamics of Knowledge

- Smith, The Theory of Moral Sentiments
- Ayres, Information, Entropy and Progress
- Snooks, The Laws of History
- Wojciechoski, Ecology of Knowledge
- Arrow, Becker, Romer, Kitcher, etc—economics of knowledge
- Loasby, Knowledge, Institutions and Evolution in Economics
- Kurweil, The Singularity is Near: When Humans Transcend Biology

Knowledge Acquisition through Reinforcement and Mimicry (*The Theory of Moral Sentiments,* Adam Smith, 1759)

Nature, when she formed man for society, endowed him with an original desire to please, and an original aversion to offend his brethren

But this desire of the approbation, and this aversion to the disapprobation of his brethren, would not alone have rendered him fit for that society for which he was made.

Nature, accordingly, has endowed him not only with a desire of being approved of, but of being what ought to be approved of; or of being what he himself approves in other men.

Laws of Knowledge
(*Ecology of Knowledge,* Wojciechowski, 2001)

I. The number and variety of causes of stress are proportional to the amount of knowledge
II. The perception of the complexity of the consequences of knowledge is proportional to the development of knowledge
III. The knowledge of knowledge is a function of the general development of knowledge
IV. The size and complexity of the problematic of knowledge is proportional to the development of knowledge
V. Thought induces change
VI. Human's ability to determine the development of humanity is proportional to their knowledge
VII. All other things being equal, the complexity of involvement of the individual with external reality is proportional to the amoun t of knowledge he or she possesses
VIII. Physical mastery of nature is proportional to the active intellectual subordination to it
IX. …….

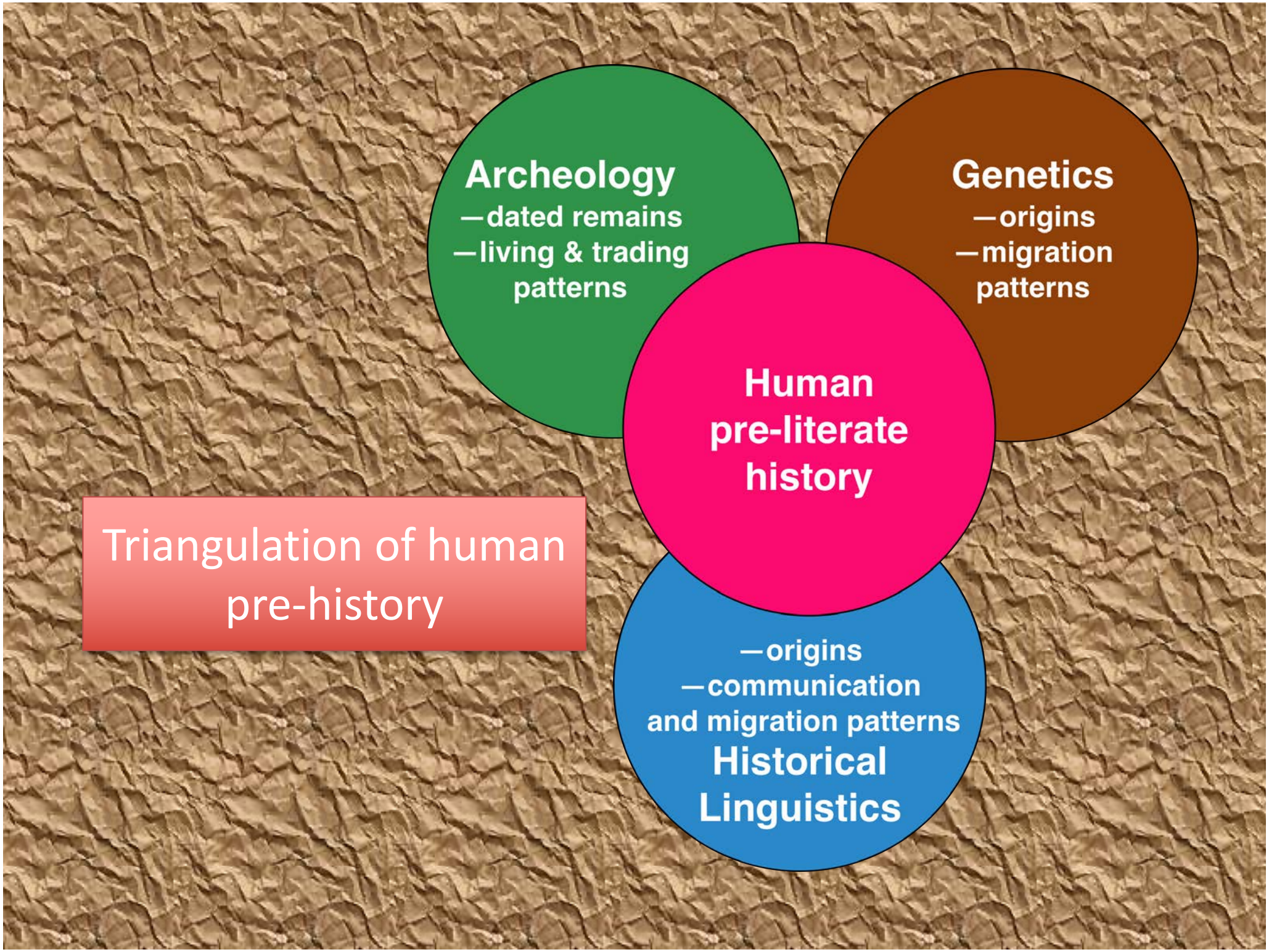
Social Strategies for Resource Acquisition (*Laws of History,* Snooks 1998)

Dominant Strategy	Political System	Economic System	Property Rights
Family multiplication	Hunting band Tribal kingdom Head of family	Subsistence Barter	Traditional rights of land use Tribal force
Conquest	Kingdom Empire	Centralized systems —feudal/manorial	Right of conquest Elite rights Military protection
Commerce	City state Nation state Empire	State-controlled —market systems	Extensive rights for middle class Limited protection of law
Technological	Nation state Mega state Parliamentary democracy	Free market —various forms of state intervention	Universal property rights Universal protection of law


Earliest
Recorded
Knowledge

Problem of limited life of recorded knowledge

- Linguistic knowledge exchange may date to 100,000 B.P.
  - In Africa records in any media deteriorate rapidly
- Most material from Greek enlightenment 2,400 B.P. lost
  - Anaxagoras' scientific work lost, but known through later commentary
  - Ptolemy's library at Alexandria destroyed by war
  - Aristotle's library survived two generations, then eaten
  - Partially regenerated in Arab enlightenment 1,300 B.P.
- Invention of printing 570 B.P.
  - Allowed knowledge to be reproduced and widely disseminated
  - Scattering many copies world-wide makes it likely at least one survives
- Digital Media
  - Do not provide improved longevity
  - But 100% accurate digital reproduction allows continual regeneration


Archeology
—dated remains
—living & trading patterns
Genetics
—origins
—migration patterns
Human pre-literate history
—origins
—communication and migration patterns
Historical Linguistics
Triangulation of human pre-history

Chauvet Cave Paintings, c.30,000 years ago







With earthworks (of volume) 1,30,0 I shall seize a city hostile to Marduk. From the base of the earthwork, I went a length of 32 up to my front. The height of the earthwork is 36. What length must I stamp in order to seize the city? What is the length from the front of the *ḫurḫurum*[9]? You, take the reciprocal of 32 and you see 0;1,52,30. Multiply 0;1,52,30 by the height, 36, and you see 1;7,30. Take the reciprocal of 6, the width of the earthwork and you see 0;10. Multiply 1,30,0 by 0;10 and you see 15,0. Double 15,0 and you see 30,0. Multiply 1;7,30 by 30,0 and you see 33,45. What is the square root of 33,45? The root is 45. 45 is the height of the wall. How much does 45, the height of the wall, exceed 36, the height of the earthwork? It exceeds it by 9. Take the reciprocal of 1;7,30 and you see 0;53,20. Multiply 0;53,20 by 9 and you see 8. 8, the length in front of you, you stamp.

Earthworks (Melville & Melville, 2001)

The problem BM 85194, rev. I.33–43[11] deals with a circle and a chord – see Figure 3. The perimeter of the circle is told to be Γ NINDAN, from which the diameter D is seen without calculation to be 20 NINDAN; moreover, the arrow is $d = 2$ NINDAN. The chord is then found as

$$\sqrt{D^2-(D-2d)^2}$$

– or rather, if we express ourselves in terms that correspond to the text, as the "equalside" (íB.SI$_8$, the side of the area if laid out as a square) of $\square(D)-\square(D-2d)$.[12] Once again the calculation presupposes the Pythagorean rule, but it is based on a more sophisticated consideration – see the diagram. In lines 39-43, the arrow is determined instead from the diameter and the chord.

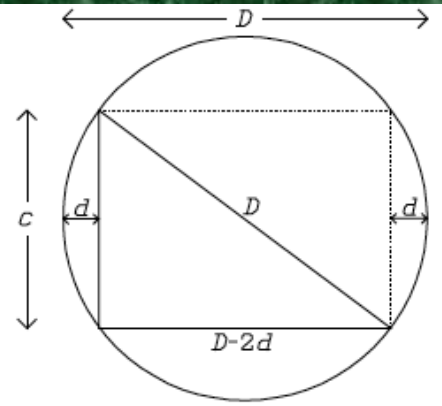
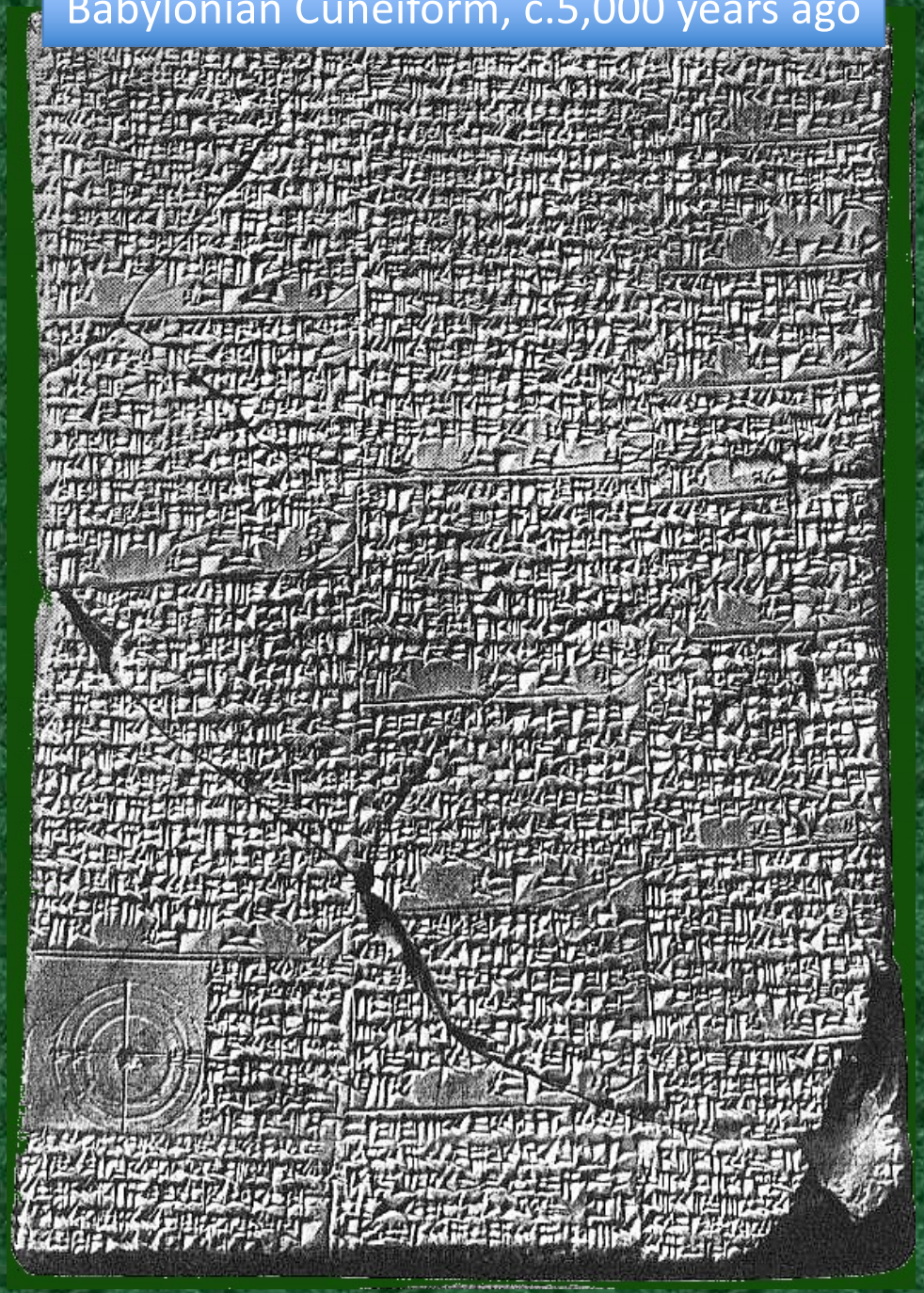


Figure 3. The circle of BM 85194 rev. I 33–43, with chord and descent.

Chord of circle (Høyrup, 1999)

Babylonian Cuneiform, c.5,000 years ago

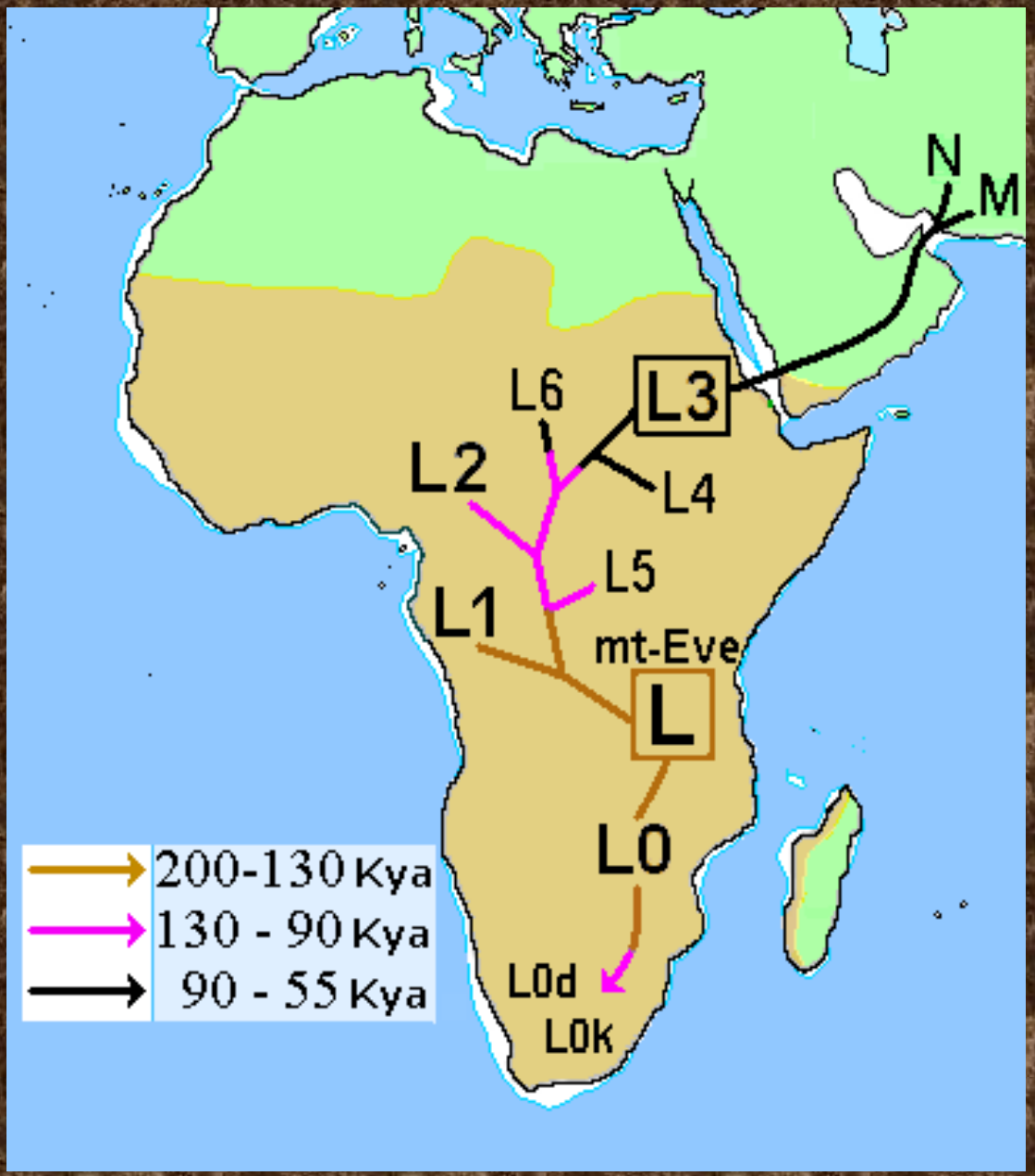


bm85194

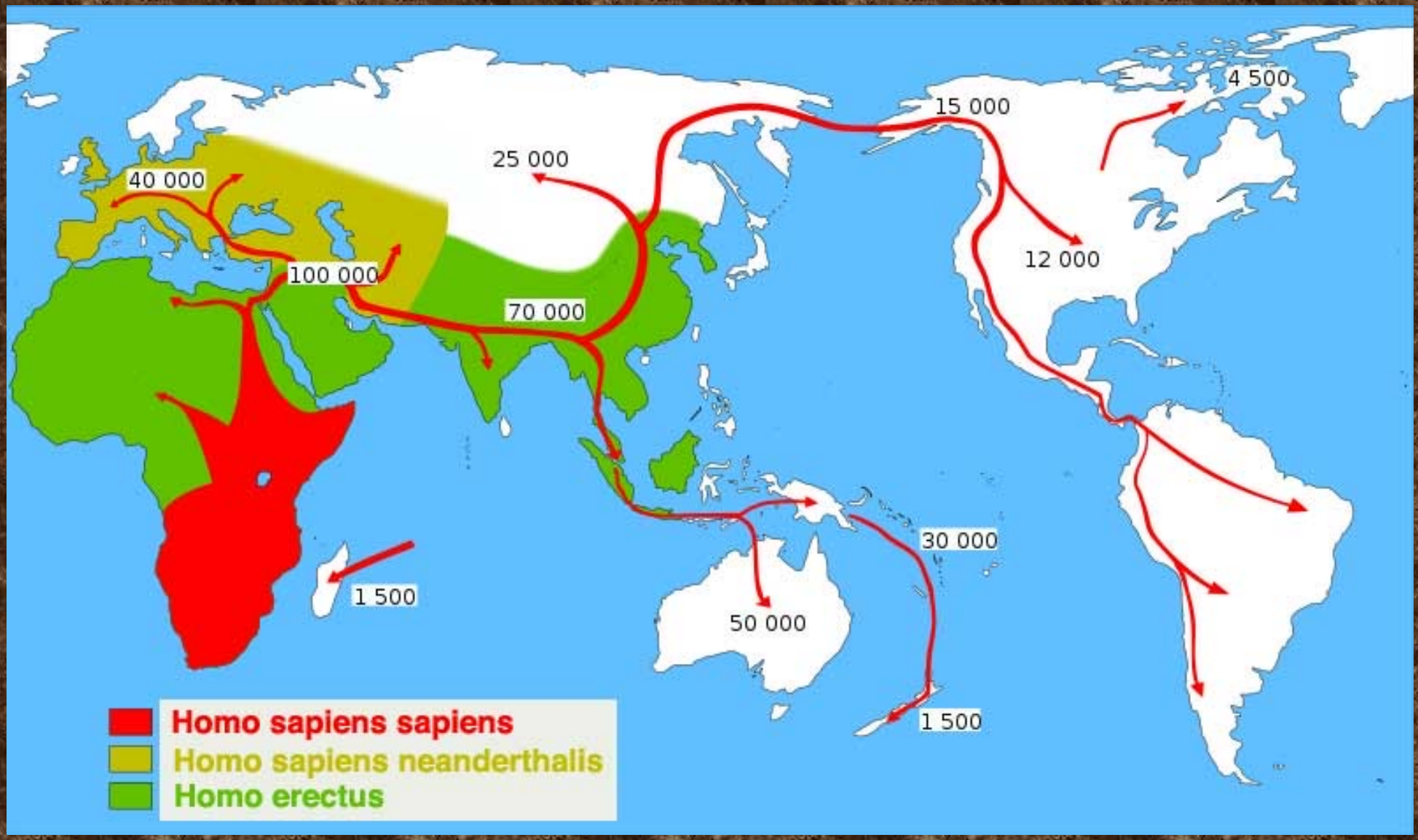
Parallels between knowledge capture technologies

- The environmental stress of warfare was addressed with cuneiform tablets detailing siege techniques
  - the first digital computers were developed under the stress of the Second World War for purposes of code breaking and ballistics computations
- The cuneiform tablets supported administrative record keeping
  - IBM adopted computer technology postwar to enhance its existing card-based census and business record-keeping systems
- Cuneiform tablets captured the surprisingly sophisticated mathematical algorithms of that era
  - computers made operational those of our era

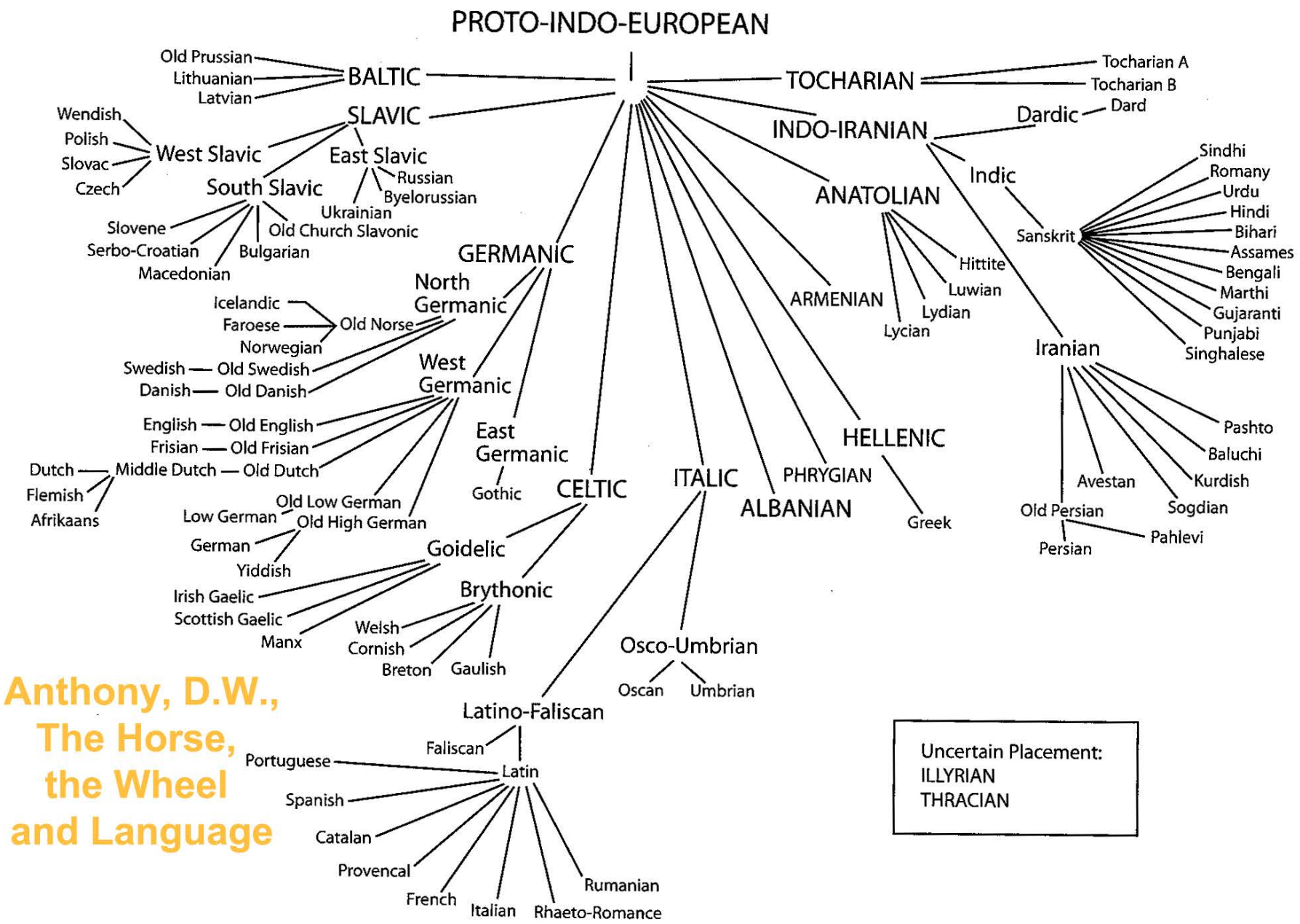
Mitochondrial Eve



Genetically traced patterns of *homo sapiens sapiens* diffusion



Tracing the origins of Indo-European languages



Anthony, D.W., The Horse, the Wheel and Language

Origin and Diffusion of Indo-European Languages

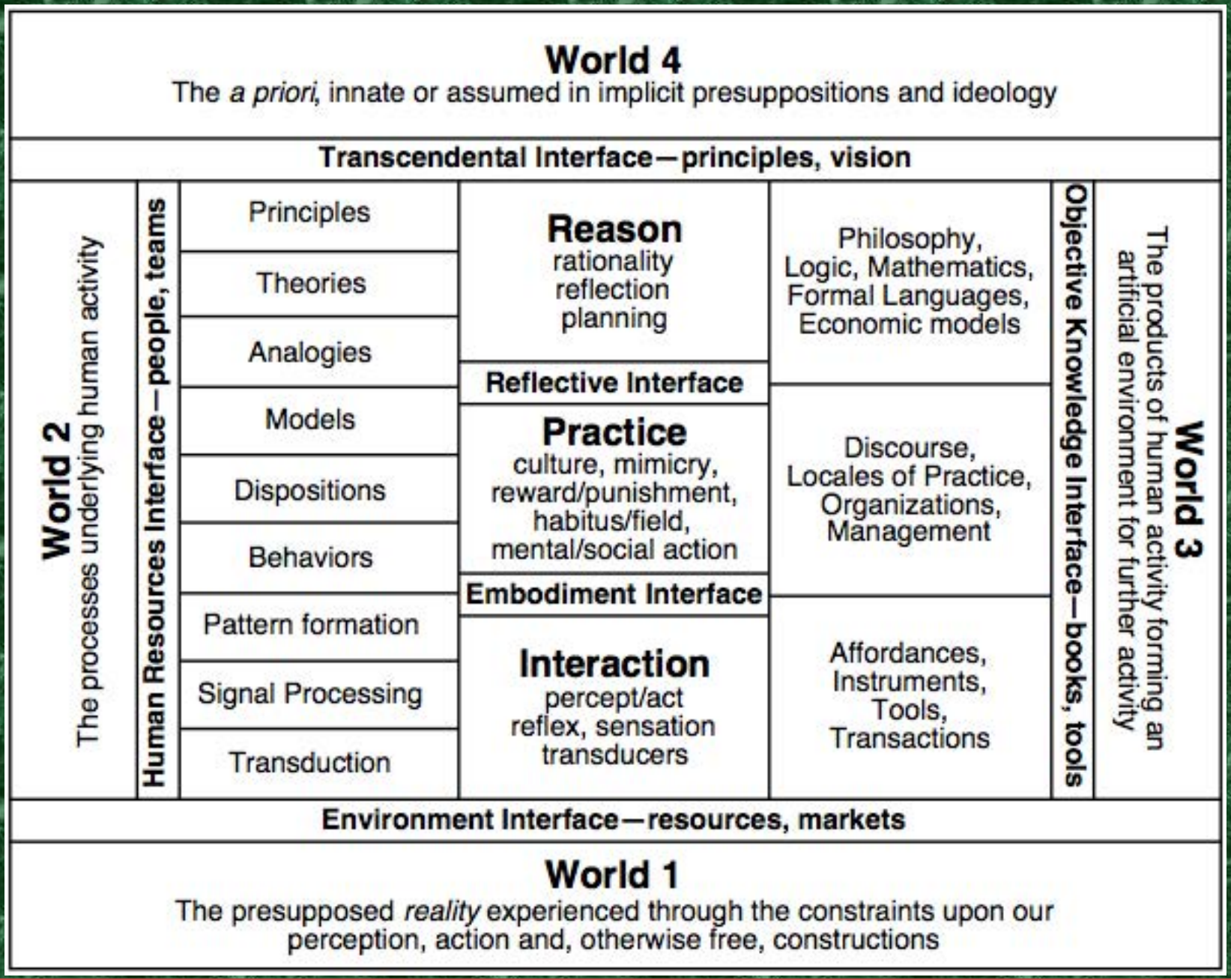



Where are
we now?

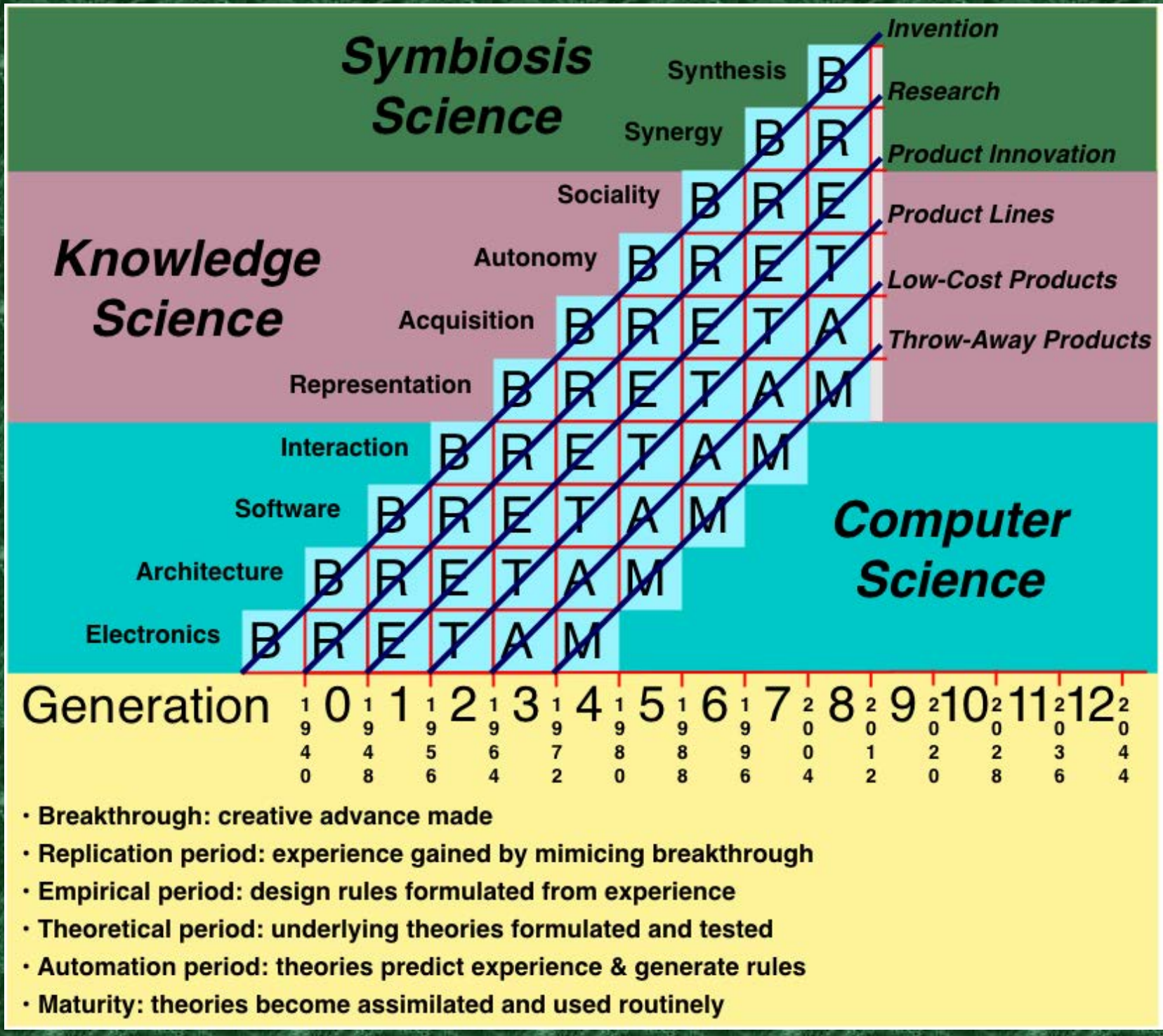
"Figure 25 is a light-hearted summary of the themes of this presentation, extrapolating the evolution of information technology way beyond any reasonable forecasting methodology. Its main weakness is that it does not take into account advances in genetic engineering and the space program that will make humanity in 2012 rather different from that of today." (*Engineering knowledge: artificial intelligence, robotics and future society*, Gaines, 1987)

	Evolution	Definition	Buzzwords	Our view of computers	Computers' view of us
1956	**Data**	Uninterpreted numbers	Data processing	Fast, accurate & reliable	Slow, inaccurate & unreliable
1964	**Information**	Structured data	Information technology	Keep track of complex structures	Easily swamped by complexity
1972	**Decision**	Selecting information	Decision support	Always correct but rigid	Sometimes wrong but flexible
1980	**Knowledge**	Reasoning underlying decision	Knowledge science	First baby thoughts	How do they know so much?
1988	**Learning**	Acquiring knowledge	Inductive inference	Slow, inaccurate & unreliable	Slow and social but necessarily so
1996	**Purpose**	Directing learning	Autonomous systems	No sense of direction	How do they know what they want?
2004	**Power**	Achieving purpose	?	Not in my lifetime	Their ultimate goal
2012	**Wisdom**	Applying power reasonably	?	They don't have it	They don't have it

Figure 25 Evolution from data processing to knowledge processing and beyond

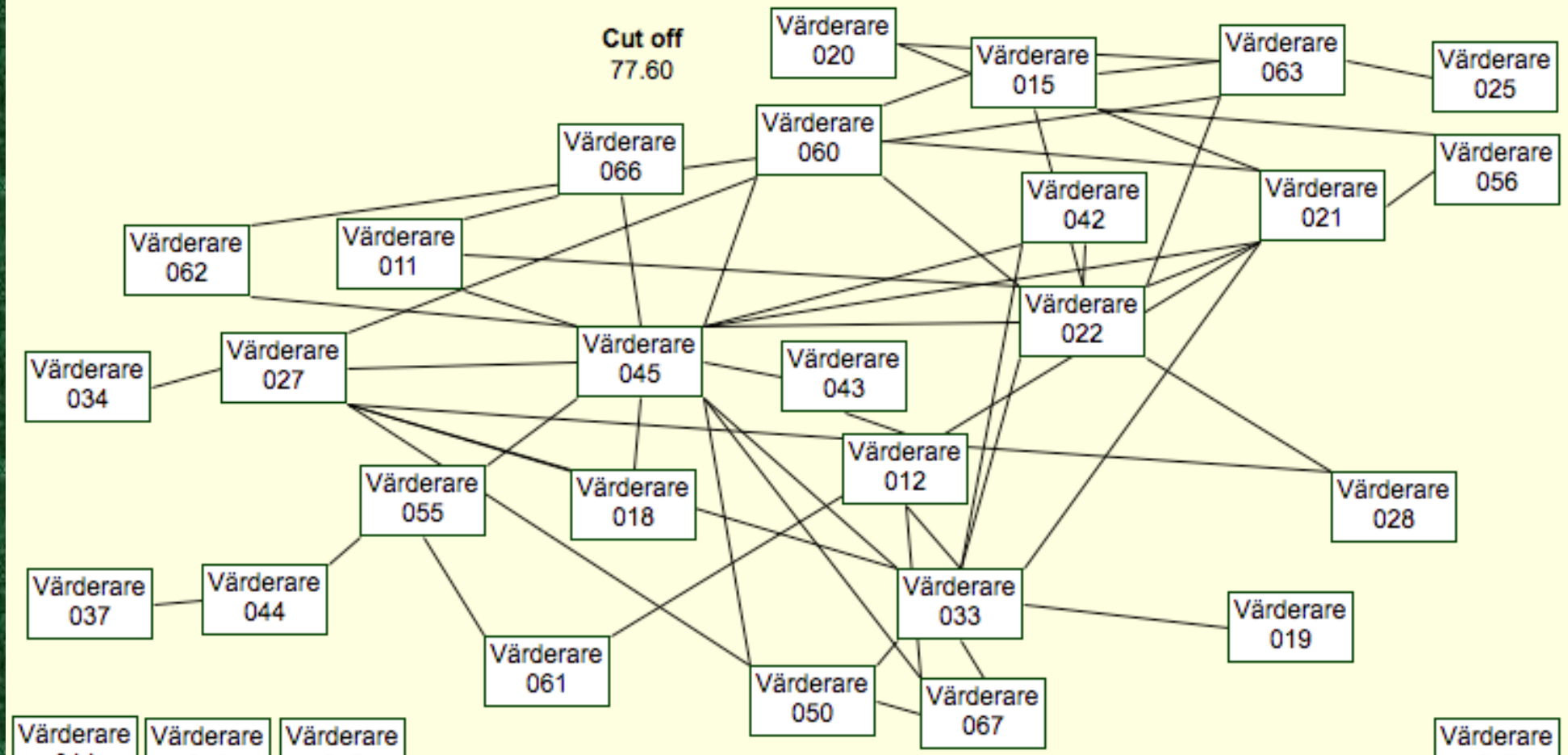


Organizational knowledge acquisition, *Handbook of Knowledge Management*, Gaines, 2003



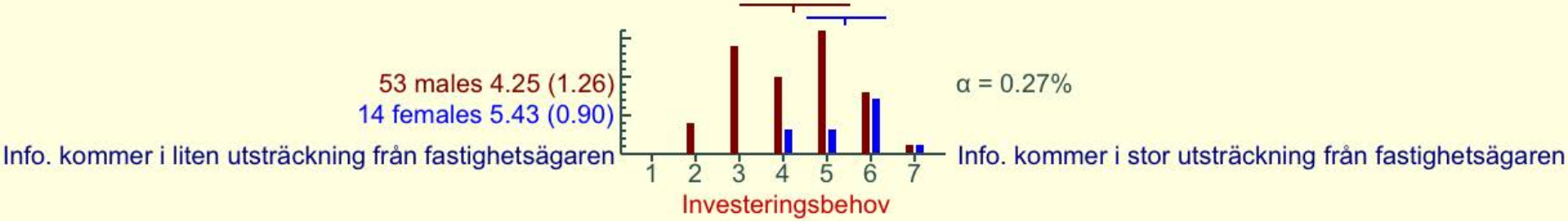
- Breakthrough: creative advance made
- Replication period: experience gained by mimicing breakthrough
- Empirical period: design rules formulated from experience
- Theoretical period: underlying theories formulated and tested
- Automation period: theories predict experience & generate rules
- Maturity: theories become assimilated and used routinely

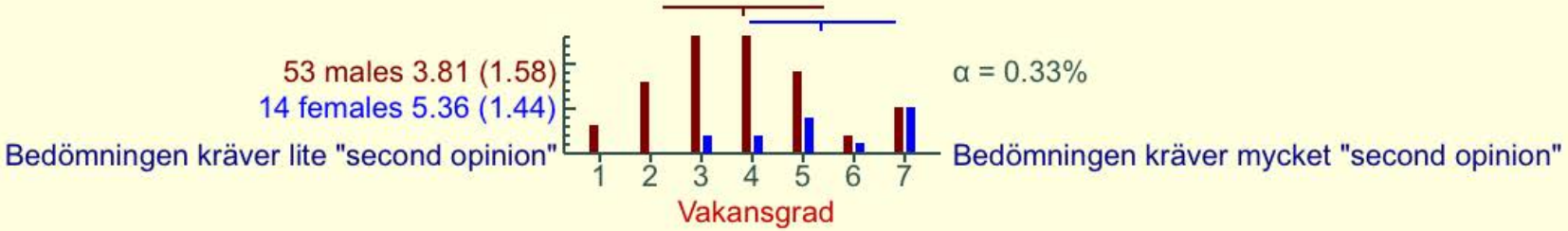
Socionets Certified appraisers
"Huvudstudie Auktoriserad värderare"
67 grids with 13 elements and 17 constructs in common
All 2211 links drawn at 60.94, all linked to at least one other at 71.72, no links at 80.93

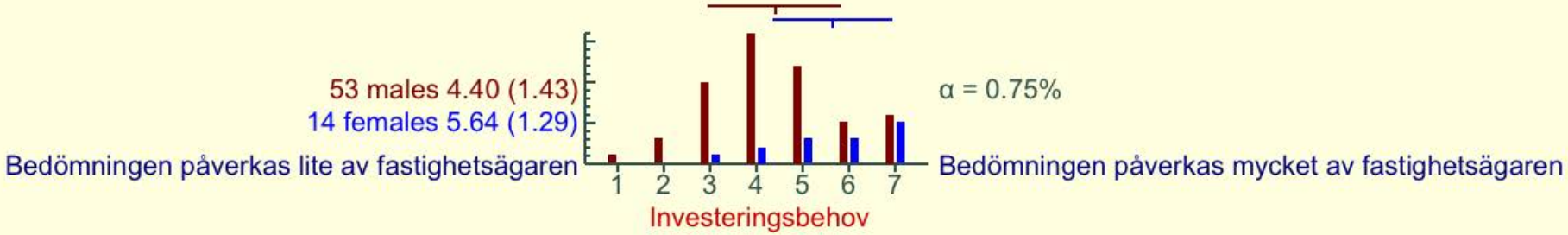


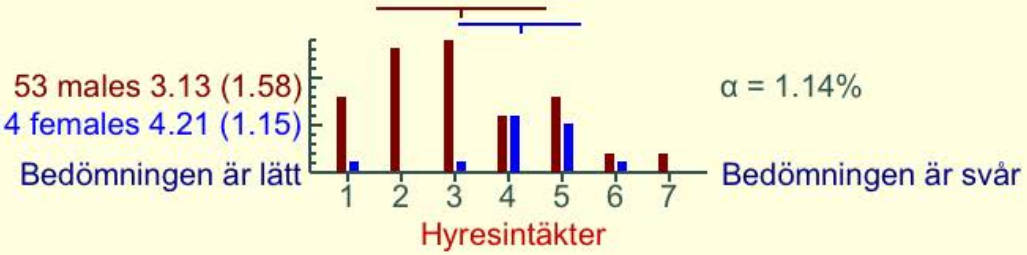
Värderare 014	Värderare 016	Värderare 017									Värderare 057
Värderare 048	Värderare 047	Värderare 039	Värderare 054	Värderare 035	Värderare 064	Värderare 058	Värderare 068	Värderare 036	Värderare 038	Värderare 001	Värderare 002
Värderare 003	Värderare 004	Värderare 005	Värderare 006	Värderare 007	Värderare 008	Värderare 009	Värderare 041	Värderare 010	Värderare 049	Värderare 051	Värderare 052
Värderare 053	Värderare 040	Värderare 023	Värderare 059	Värderare 065	Värderare 013	Värderare 026	Värderare 024	Värderare 031	Värderare 032	Värderare 030	Värderare 029

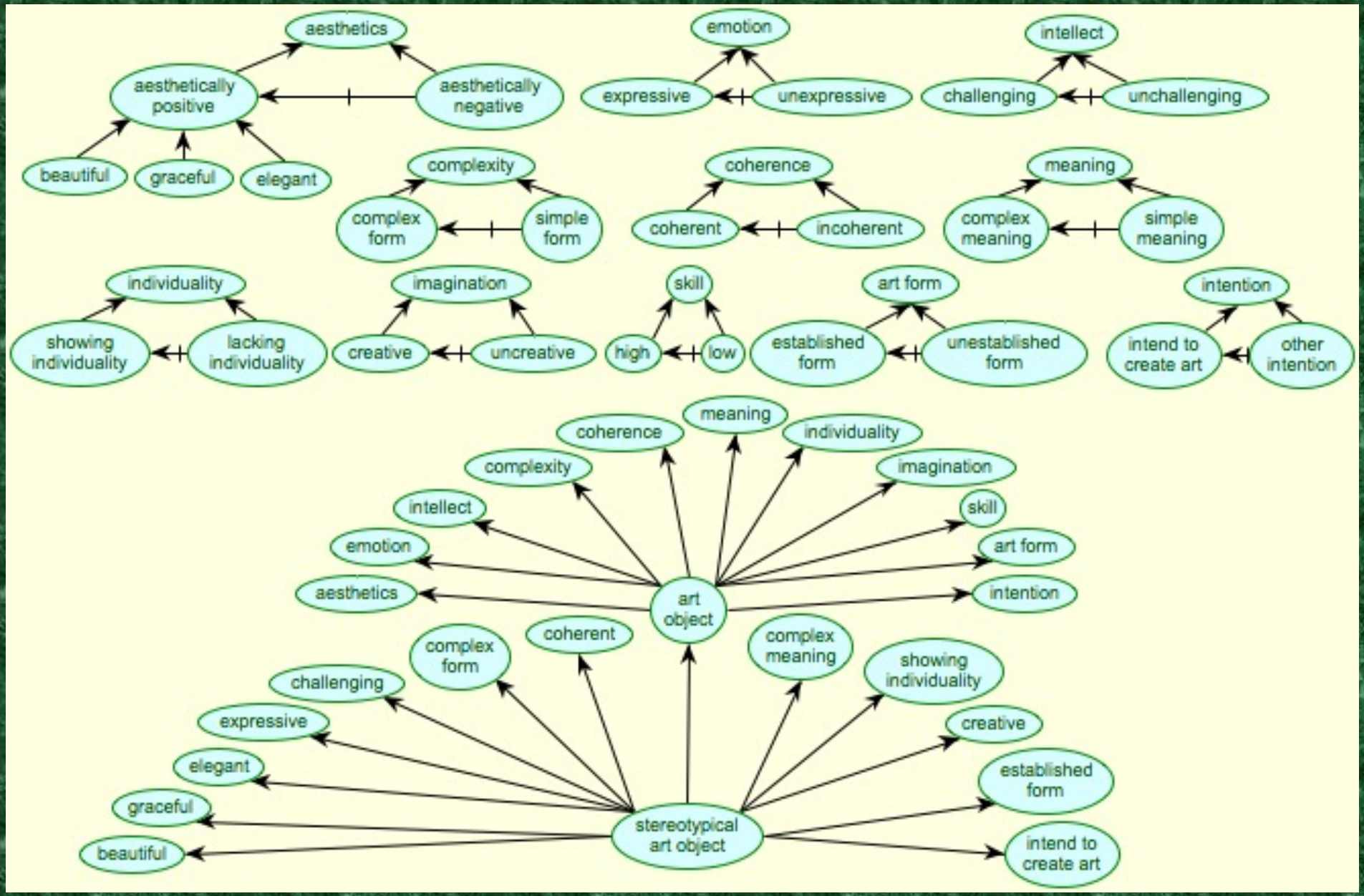
Distribution of "males" and "females" ratings (α ≤ 2.50% two-sided)



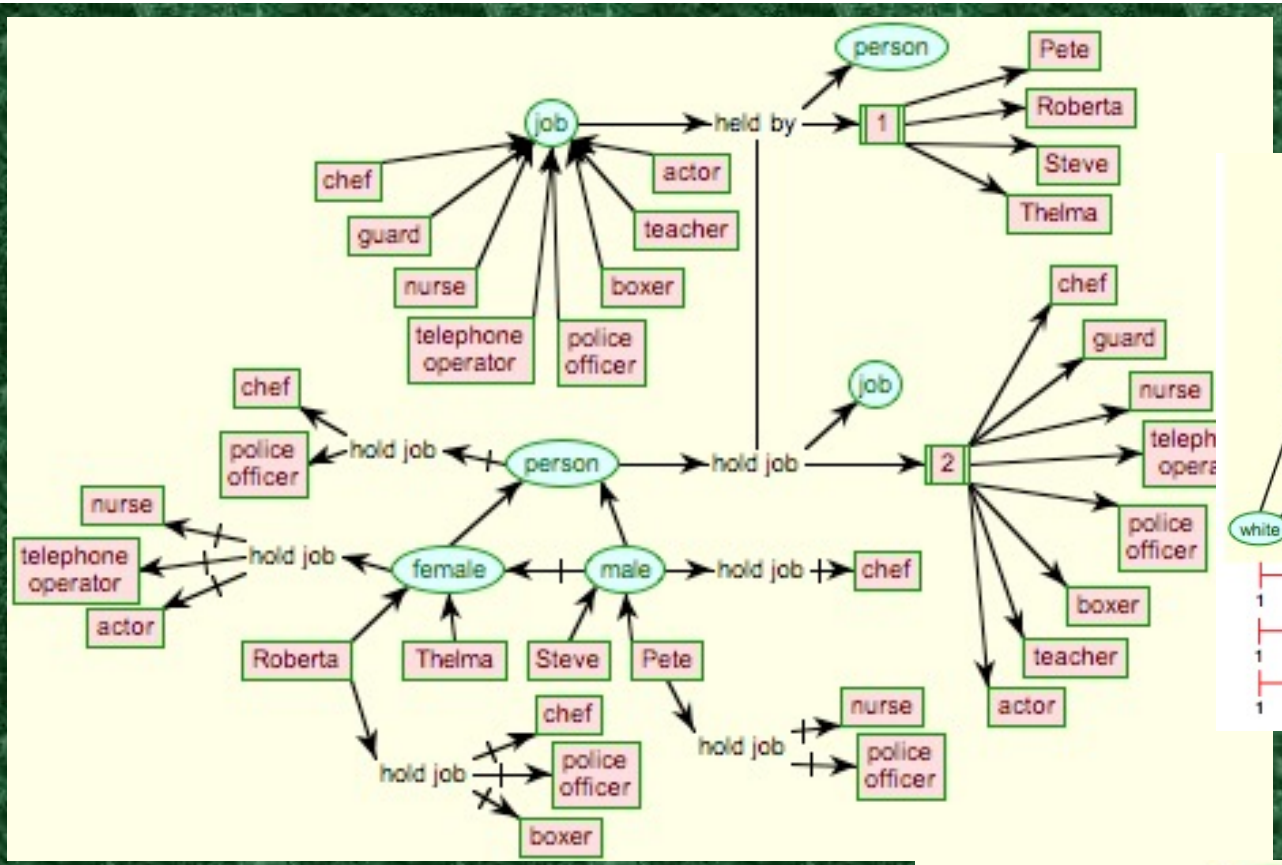


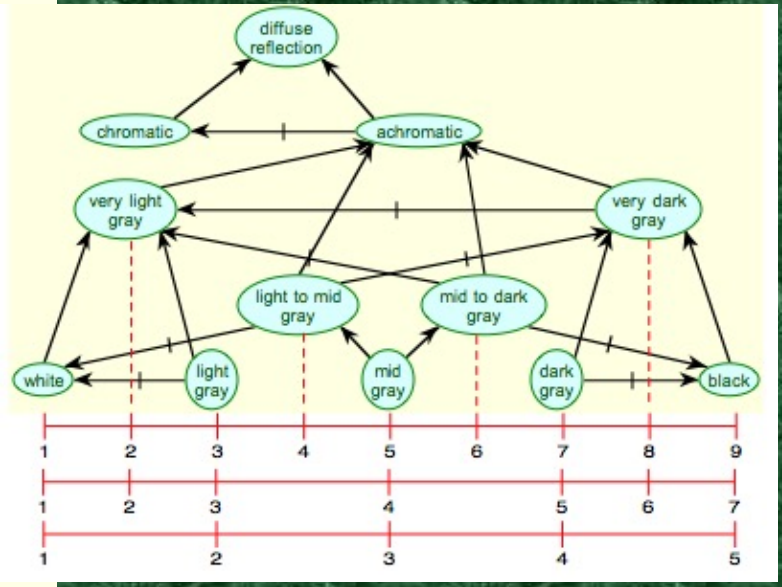


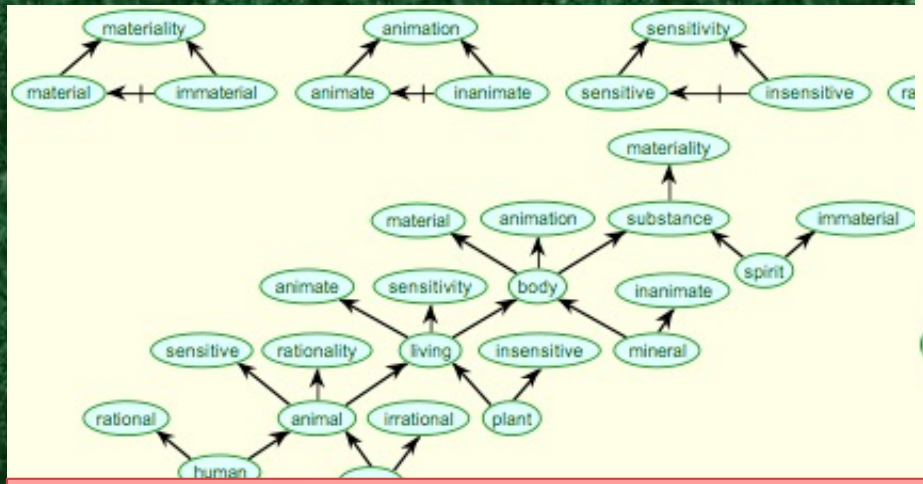


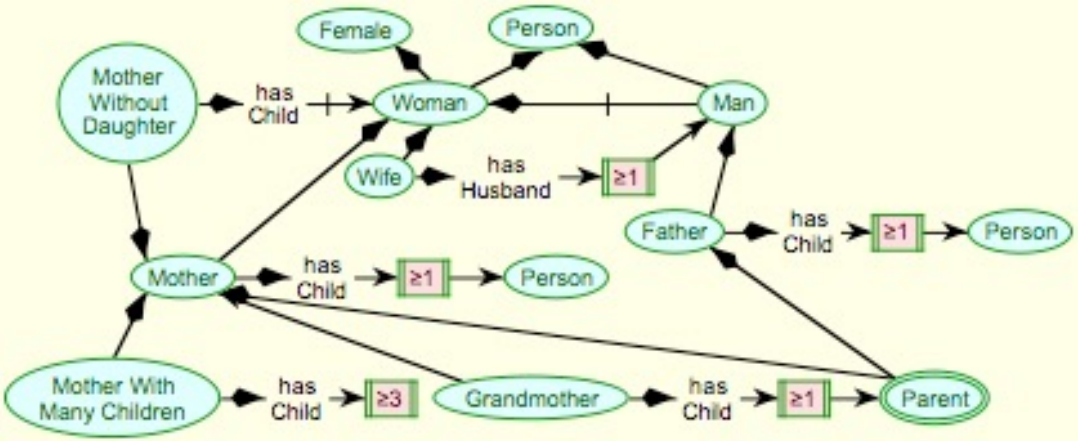


Designing Visual Languages for Description Logics, *JOLLI*, Gaines, 2008







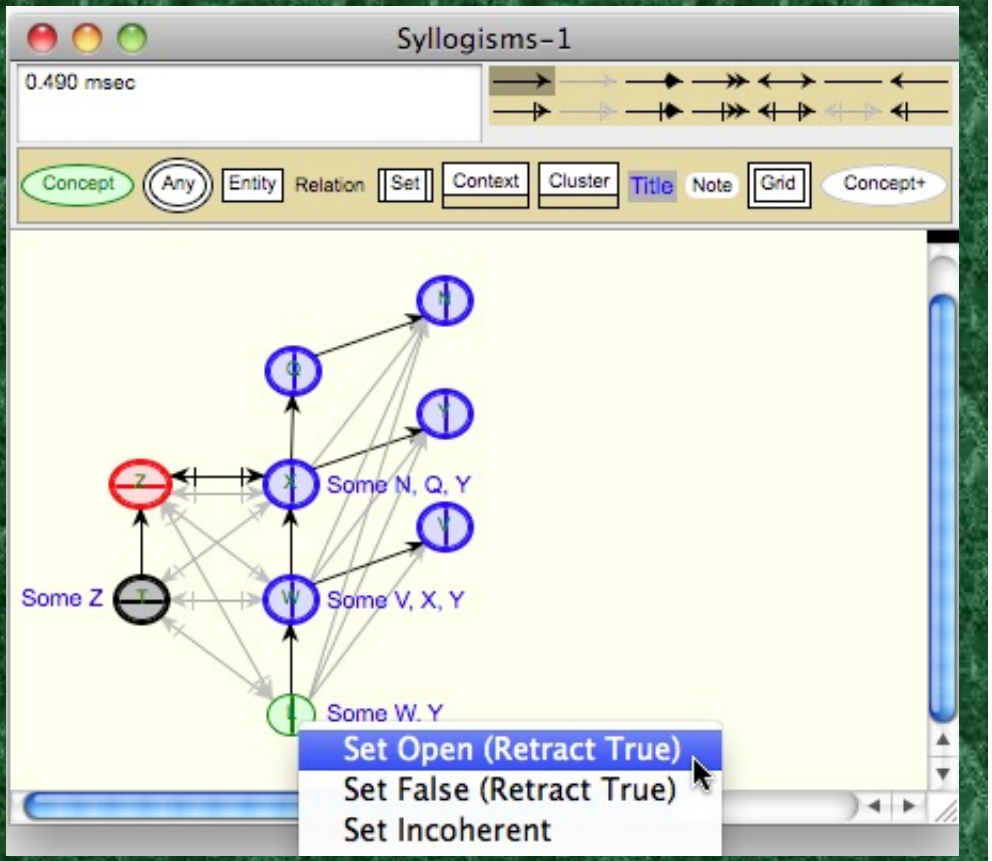


Designing Visual Languages for Description Logics, *JOLLI*, Gaines, 2008

- **Capacity for reasoning**
  - Do all human beings have the same capacity of reasoning? Does a man, a woman, a child, a Papuan, a yuppie, reason in the same way?
  - **Evolution of reasoning**
  - Does reasoning evolve? Did human beings reason in the same way two centuries ago? In the future will human beings reason in the same way? Did computers change our way to reason? Is a mathematical proof independent of time and culture?
- **Situated reasoning**
  - Do we reason in different ways depending on the situation? Do we use the same logic for everyday life, physics, economy?
- **Diversity of reasoning systems**
  - Do the different systems of logic reflect the diversity of reasonings?
- **Absolute basis of reasoning**
  - Is there any absolute true way of reasoning?

Human Rationality Challenges Universal Logic, *Logica Universalis*, Gaines, 2010

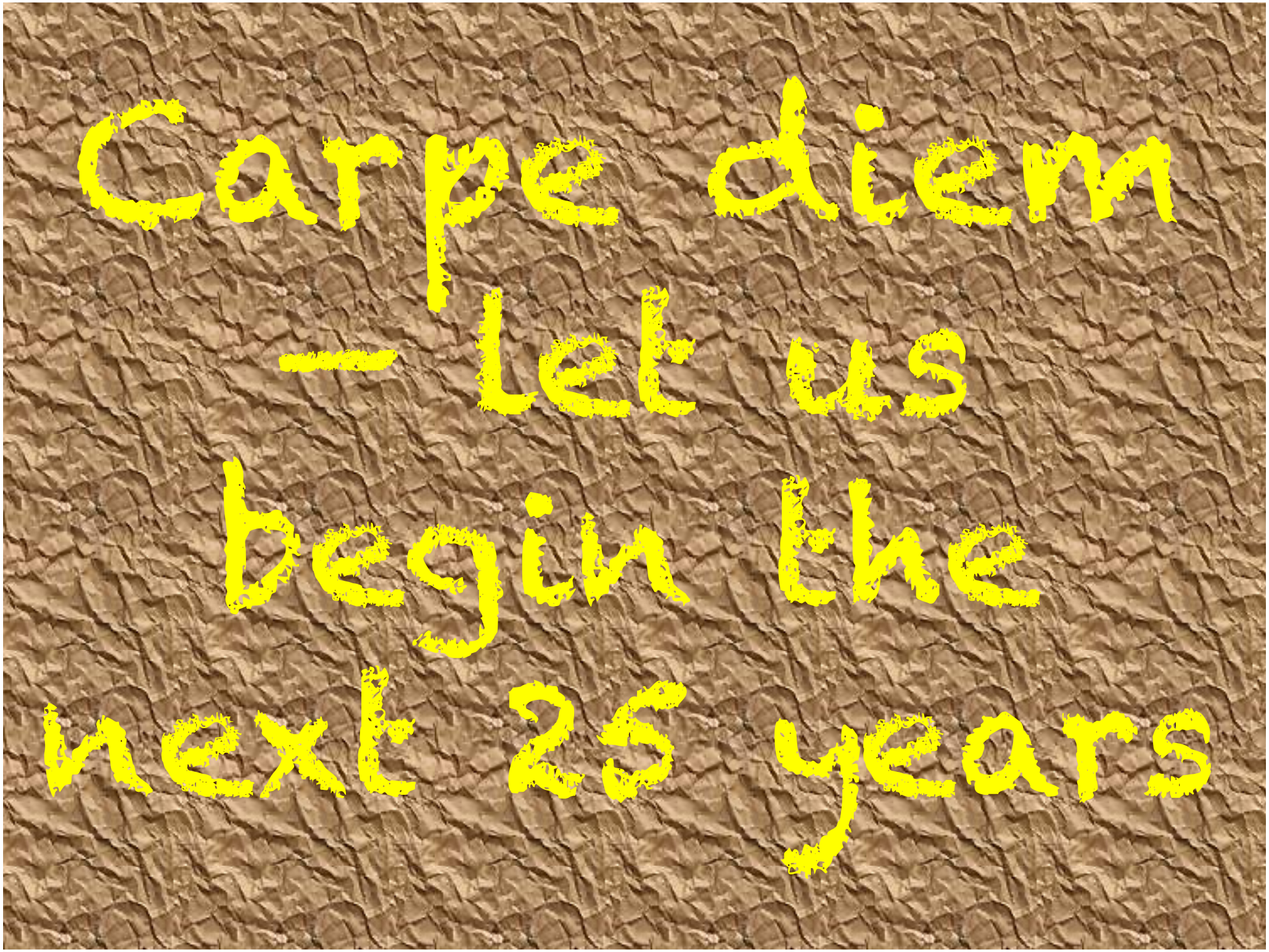
A Universal Graphical Logic, Gaines, 2011



Syllogisms in a Universal Graphical Logic, Gaines, 2011

The next challenge — ‘Muddling Through’

- Knowledge capture and transmission assumes some degree of *cognitive commonality*
  - many studies show that people use the same terms in different ways
  - ‘we must allow ordinary speech to use inexact terms’ (Sextus Empiricus, *Against the Logicians, 2200 B.P.*)
  - ‘we never understand the *same* language, only *largely similar* ones’ (Hattiangadi, *How is Language Possible?*, 1987)
- We manage to ‘muddle through’ despite lack of commonality
  - people reach a consensus and work towards common goals without noticing they are using the same terms in different ways
- Current computer knowledge representation assumes well-defined terms and commonly agreed interpretations
  - we need to develop a science of ‘muddling through’ and model the human use of open concepts to capture and transmit knowledge


Carpe diem
– let us
begin the
next 25 years