

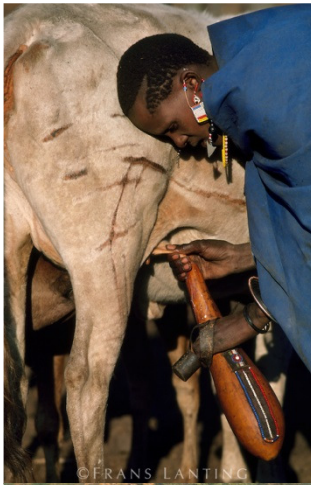
# Cultural Evolution: Pleistocene Origins, Holocene Explosion

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[www.des.ucdavis.edu/faculty/richerson/richerson.htm](http://www.des.ucdavis.edu/faculty/richerson/richerson.htm)

Moscow

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# Plan

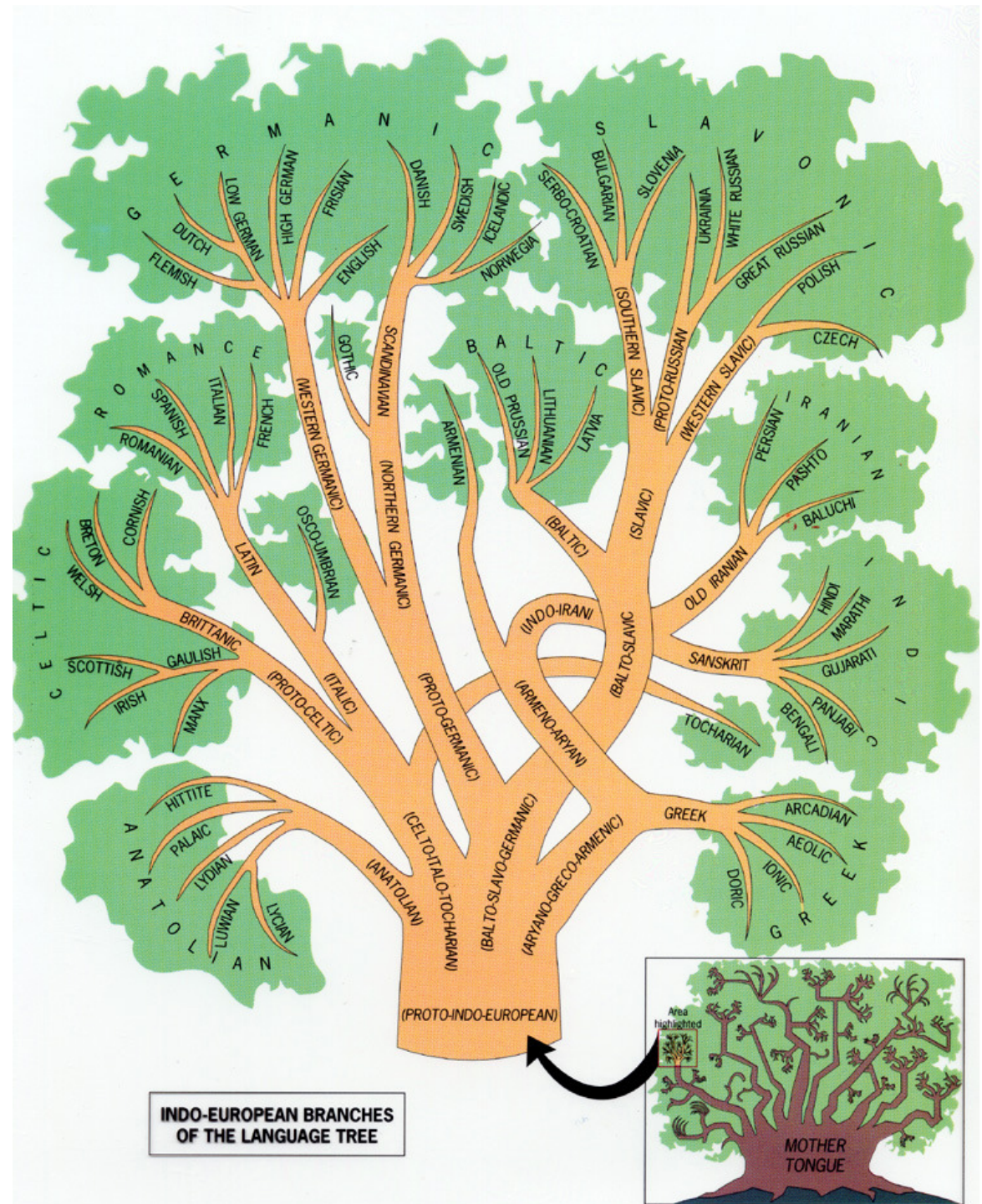
- How cultural evolution works (Boyd and Richerson 1985, Richerson and Boyd 2005)
- Why possibly our complex cumulative culture evolved in the Pleistocene
- Evolution of social and technological complexity in the Holocene

# How cultural evolution works

- Culture is a form of inheritance
  - Very different in details from genes
  - Inheritance of acquired variation
  - More than two “parents”
- Evolves in a Darwinian fashion by **descent with modification**



Language evolution looks a lot like the evolution of species, except for considerable borrowing between branches.

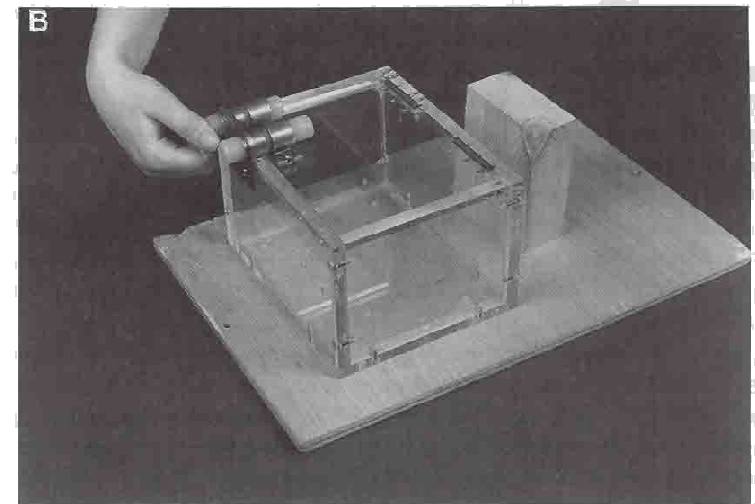
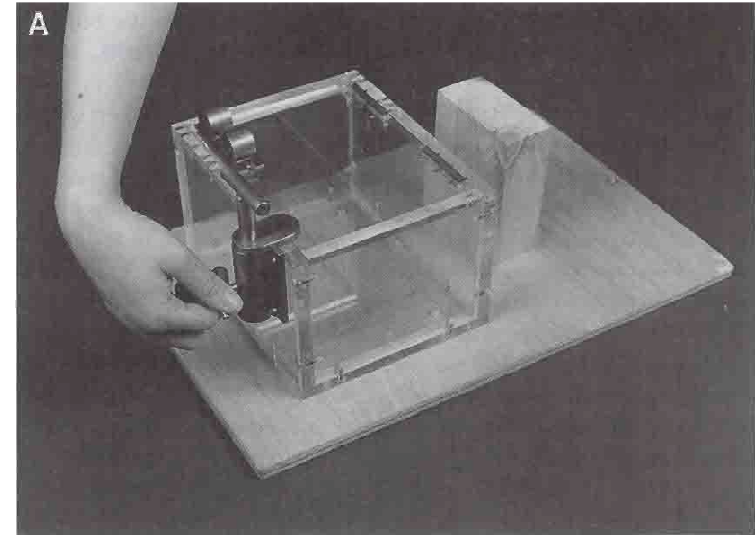


# Comparative Experiments: Social learning in chimps and children

## Kanzi and young friend



Artificial fruits with two kinds of latches  
and various methods of opening  
(Whiten and Custance 1996)



# Whiten and Custance: Results

Adult, human raised chimpanzees and children of different ages

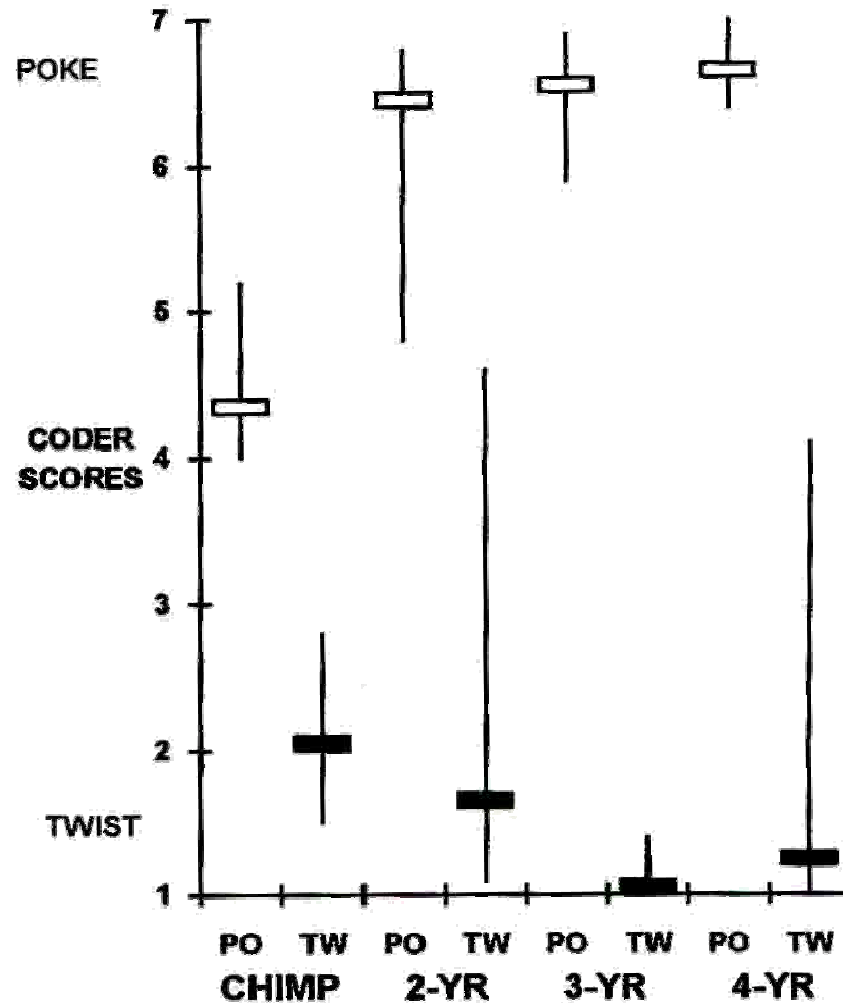
Good imitation  
of poke

↑↑


No imitation

↓↓

Good imitation of  
twist



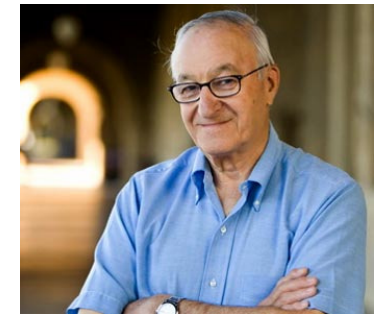
# Forces of Cultural Evolution

- Random variation
  - Idiosyncrasies of organization founders
- Guided variation
  - Learning from personal perspiration and inspiration
- Biased transmission 
  - Deciding to adopt new technology
  - A number of strategies
- Natural selection
  - Poorly run companies go bankrupt
  - Long surviving organizations school employees in successful practices

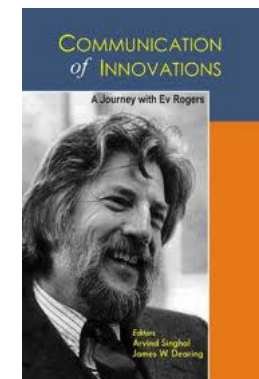
Emmy Werner 1979



Albert Bandura 1977



E.M. Rogers 1971



Boyd & Richerson 1985 v Cavalli-Sforza & Feldman 1981



# Macroevolutionary Hypotheses

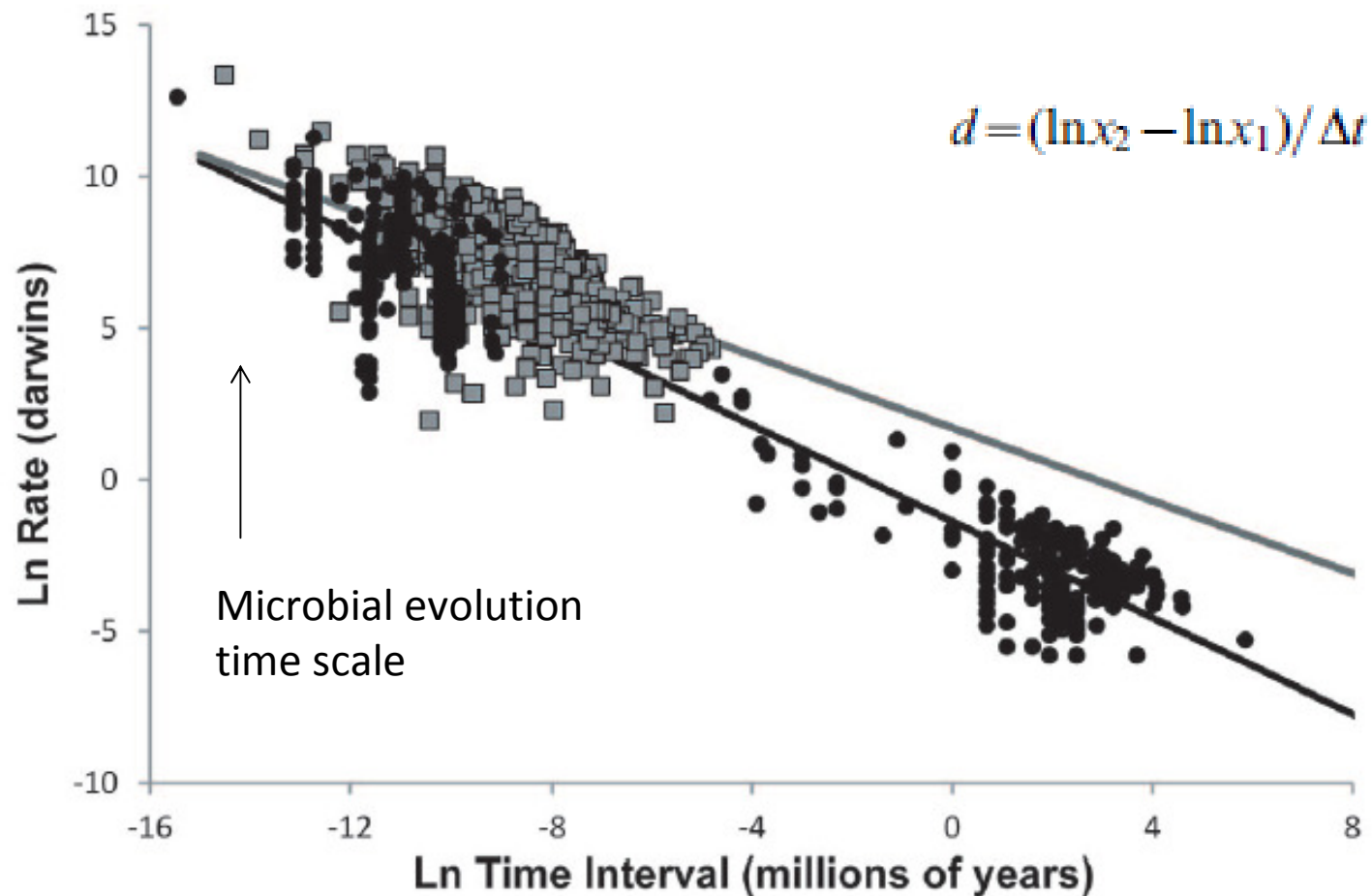
- Internalist: Long time scale events and trends (speciation, patterns of species diversity) governed by the processes of organic (and cultural) evolution. For example, the increasing complexity of organisms since the origin of life.
  - Everyone is an internalist at short enough time scales
- Externalist: The long time scale records the adaptation of organisms to changes in the earth's environment. For example, life remained simple for most of the earth's history because oxygen levels in the ocean and atmosphere were too low to support multicellular organisms
  - Everyone is an externalist at long enough time scales

# Functional Analysis

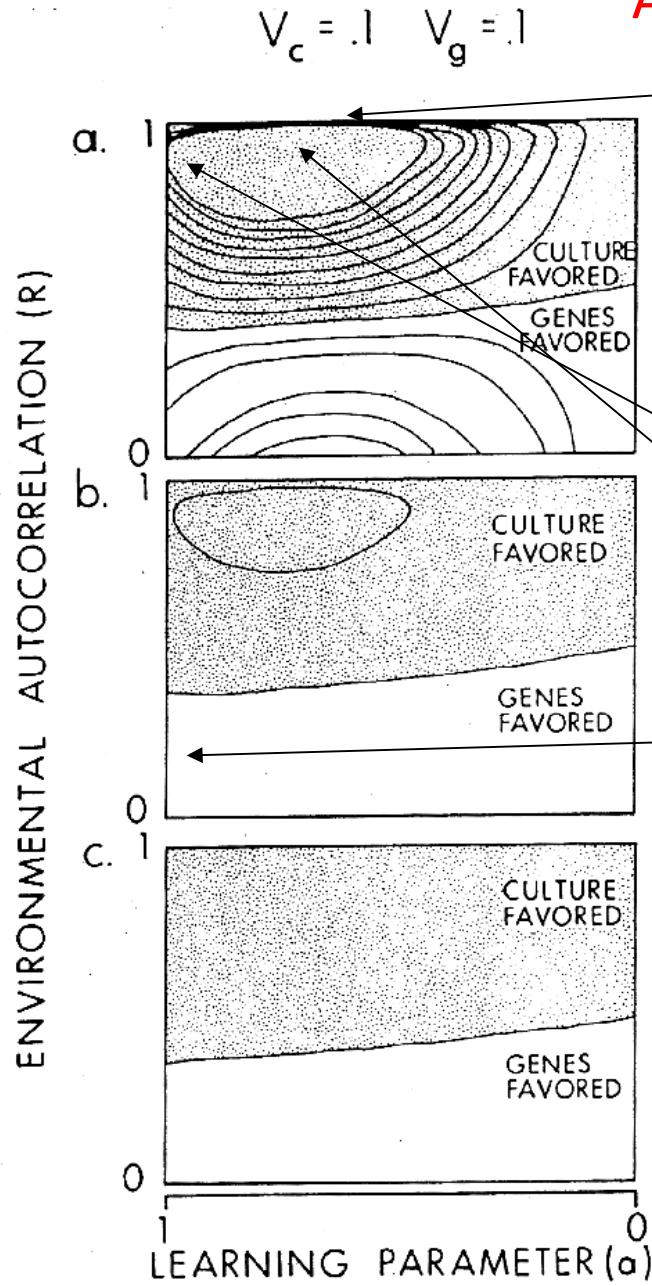
- What is culture good for?
- More rapid adaptive evolution: culture is **built for speed, not for comfort**, to cope with temporal and spatial variation
  - Technology
  - Social organization
  - Tradeoff: tolerance of maladaptations in the pursuit of speed
    - Many bias strategies are rough rules of thumb that can be exploited by selfish memes
    - Exploitation: “If you pay for it, you’re the customer, if it is free you’re the product!”

# Culture does evolve more swiftly than genes:

Generation and selection of variation by the decision-making forces swifter than mixing, creating cultural adaptive radiations



**A little theory: What is *costly* culture good for?**



If environmental change slow, genes keep up

**A contest between systems:  
Genes plus learning  
Genes plus learning plus culture**

If environmental change is large  
and  
If environmental change is not  
too fast or too slow,  
Then culture is a big advantage

If environmental change too fast, culture useless

If not much environmental variation, culture not much use

**1 = trust mom completely, 0 = trust own experience completely**

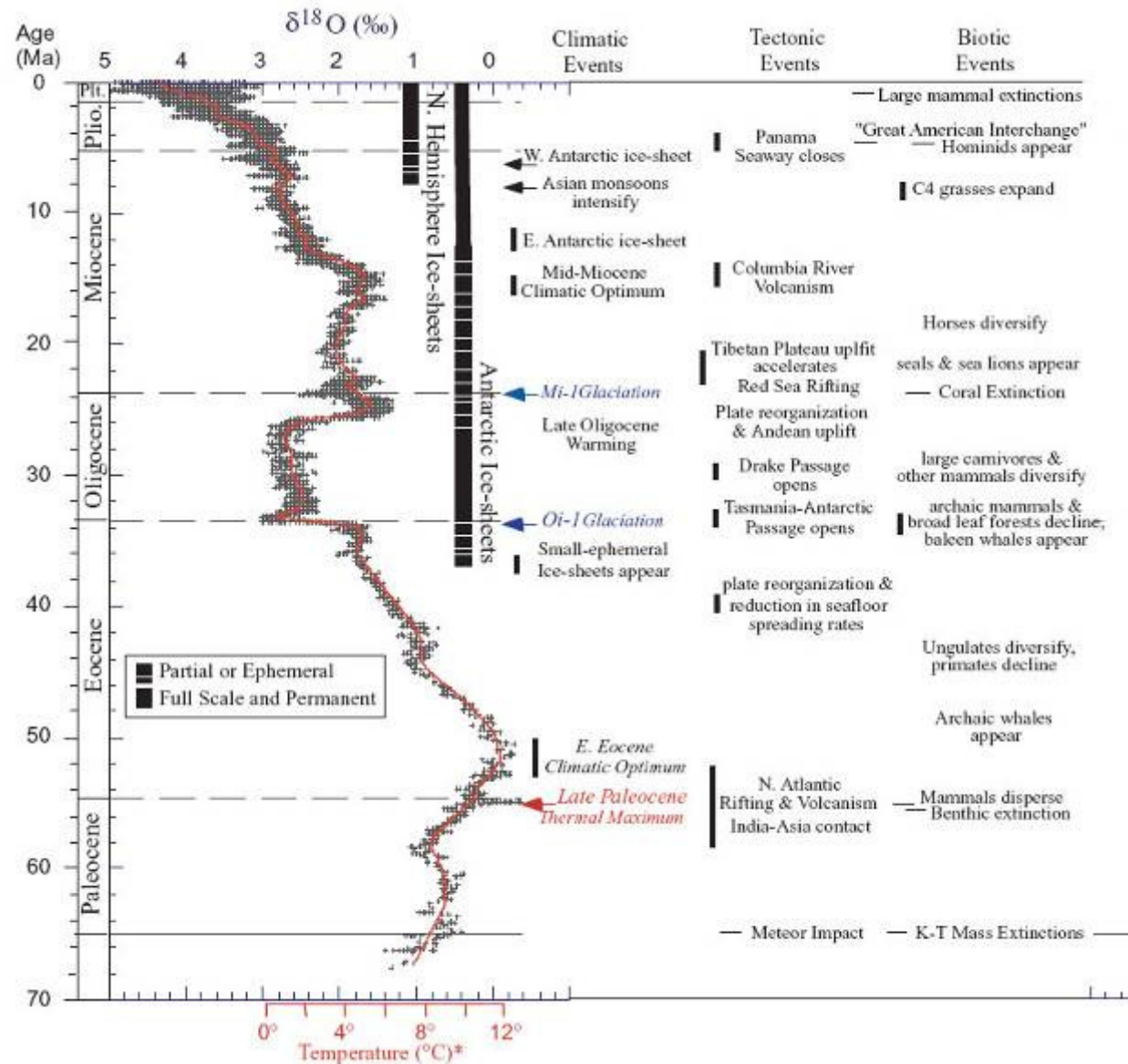
Boyd and Richerson 1985

# Why did cumulative culture evolve so recently?

## An externalist hypothesis

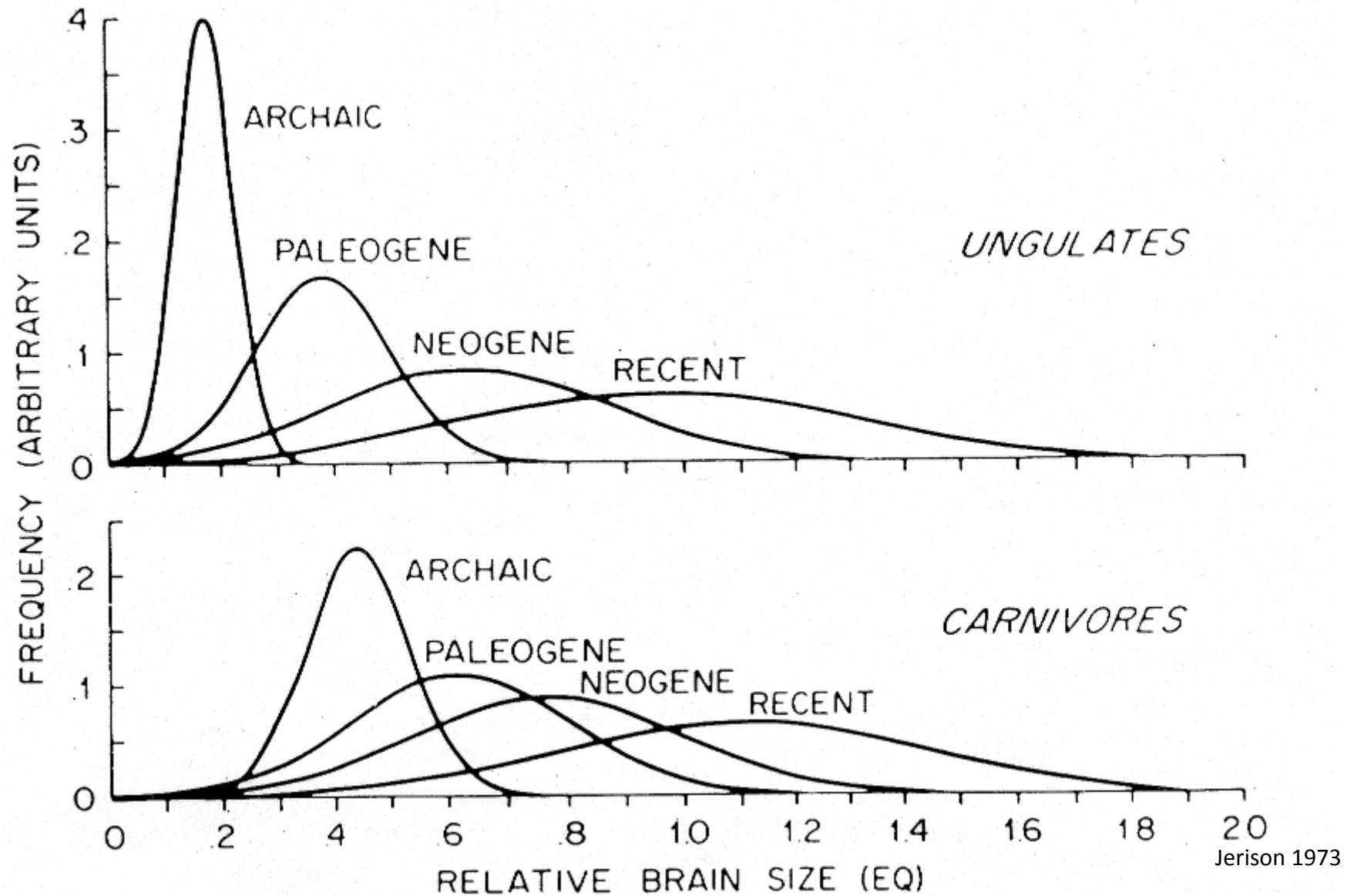
- Humans using complex cultural adaptations
  - Became very widespread in the Pleistocene
  - Became the Earth's dominant organism in the Holocene
- Simple culture widespread in other social animals
- Why didn't the human capacity for complex cumulative culture evolve long ago?
  - Amount of culture correlated with brain size (Reader and Laland 2002)
  - Big brains very expensive (Aiello and Wheeler 1995)

# Climate variation in space and time favors large brains



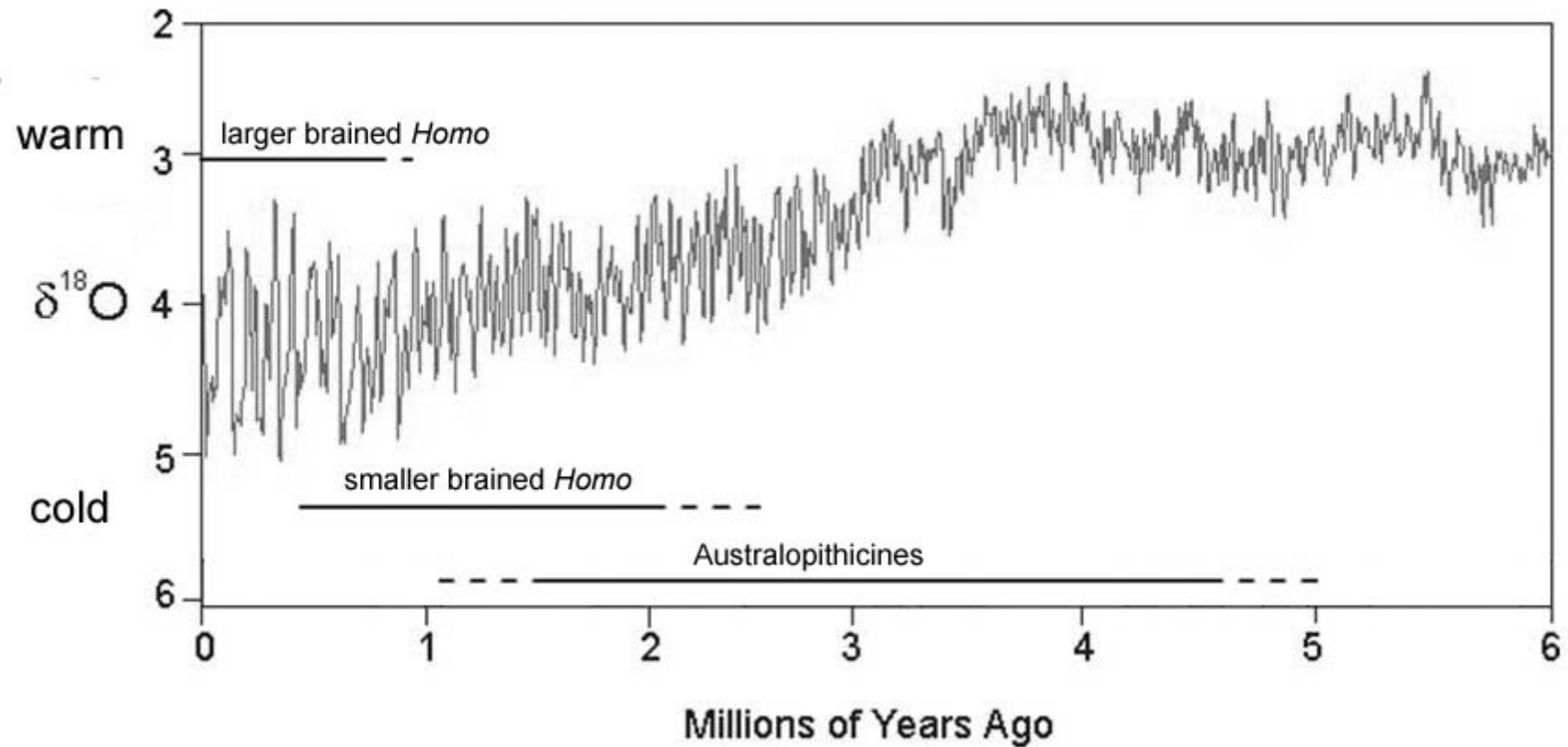
Zachos et al 2001 Science

# Bigger brains did evolve as climate got more variable



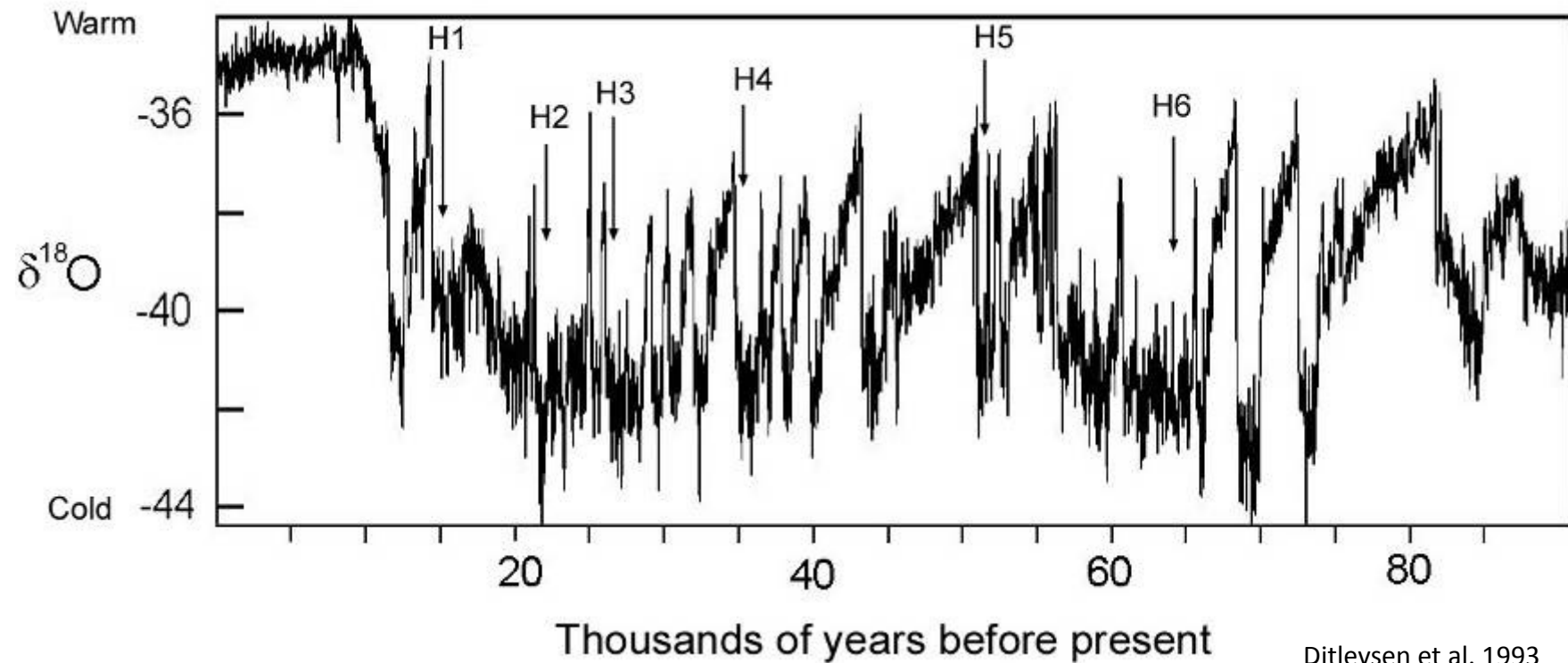
# Pleistocene Climate Deterioration

1980s story





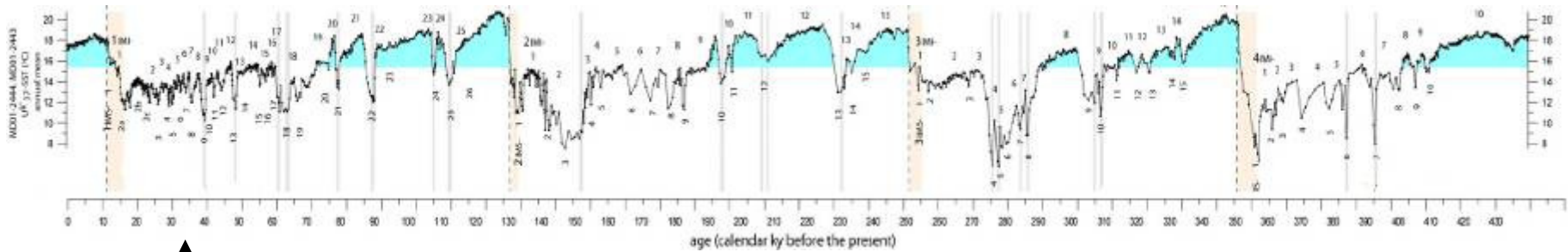
# Millennial and sub-millennial scale variation from Greenland GRIP core



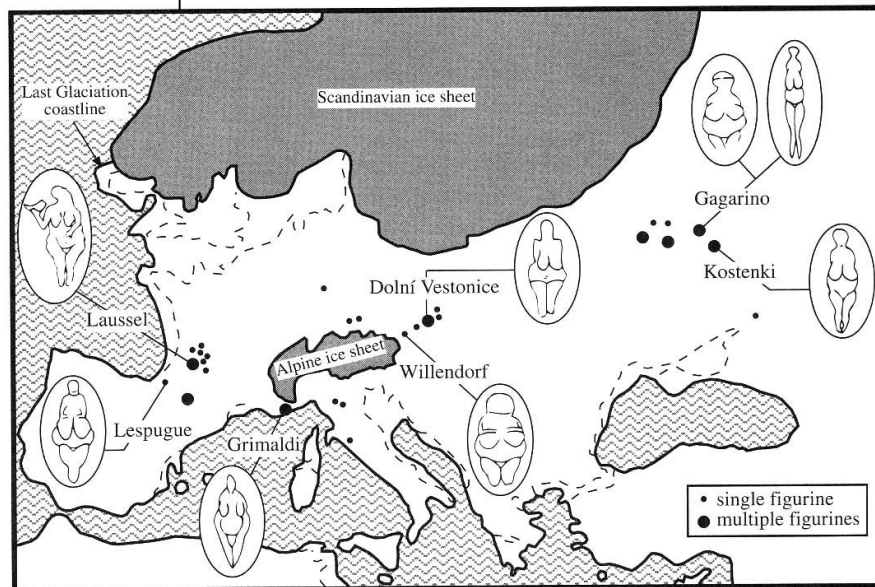
Now we're talking about the kind of variation to which culture would be an adaptation!

# Human evolution and ongoing climate change

(Martrat et al. 2007 *Science*)



Klein 1999

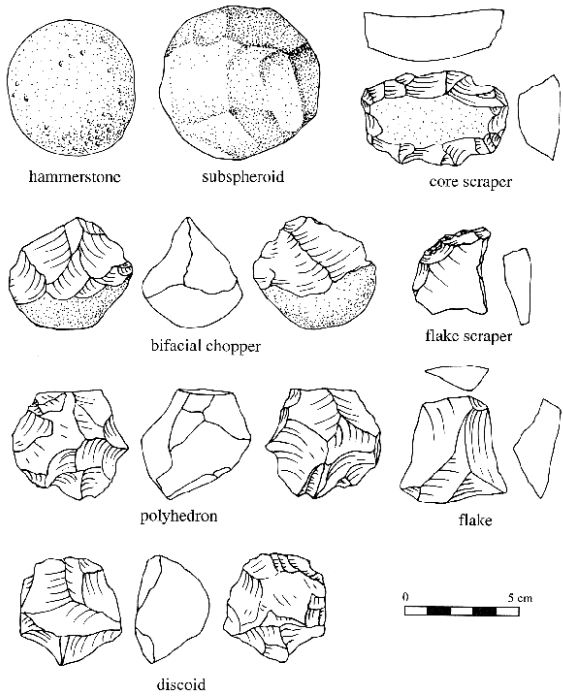


As yet, no Upper Paleolithic known outside Western and Central Eurasia!

Figure 7.20. Approximate locations of the European Upper Paleolithic sites that have provided female figurines or engravings (redrawn after 445, fig. 3.19). At most sites the figurines or engravings were certainly or probably associated with the "Gravettian" culture complex, dated to between roughly 28 and 21 ky ago.

Why did humans become more sophisticated and more successful only in the late Pleistocene?

Let's start with the evidence from the stones and bones

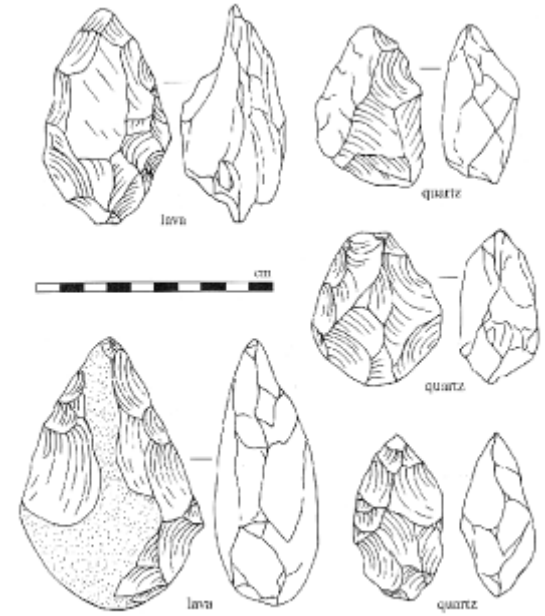


# Stone Tool Traditions

From Richard Klein, 1999

**Oldowan**  
2.5-1.7 Myr BP

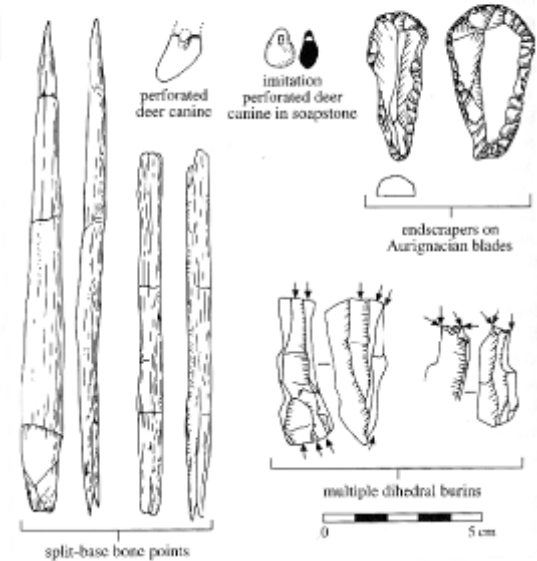
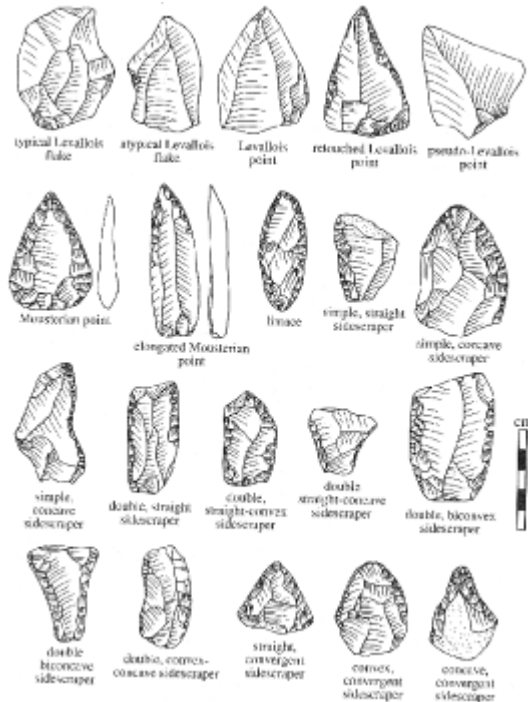
**Acheulean**  
1.65-0.250 Myr BP



Olduvai Gorge Upper Bed II



**Mousterian ~ Mode 3**  
0.250-0.044 Myr BP

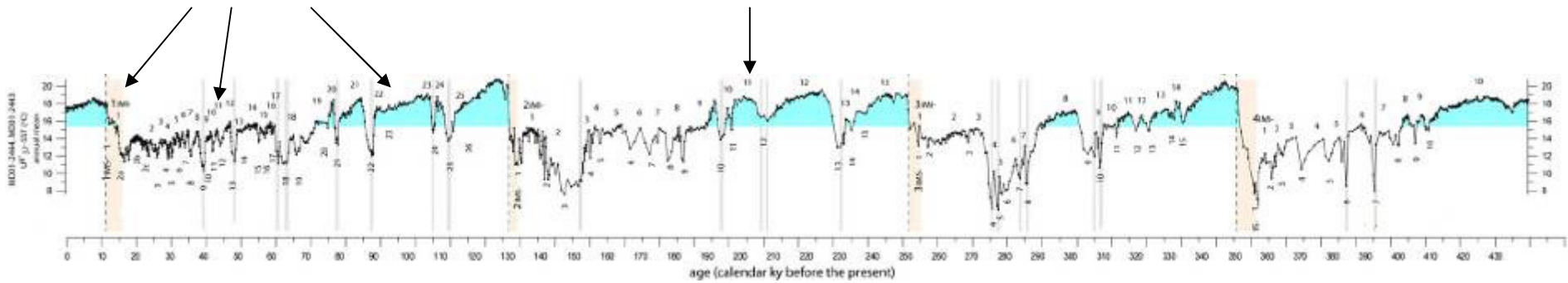


**Aurignacian ~ Mode 4**  
0.040-0.028 Myr BP

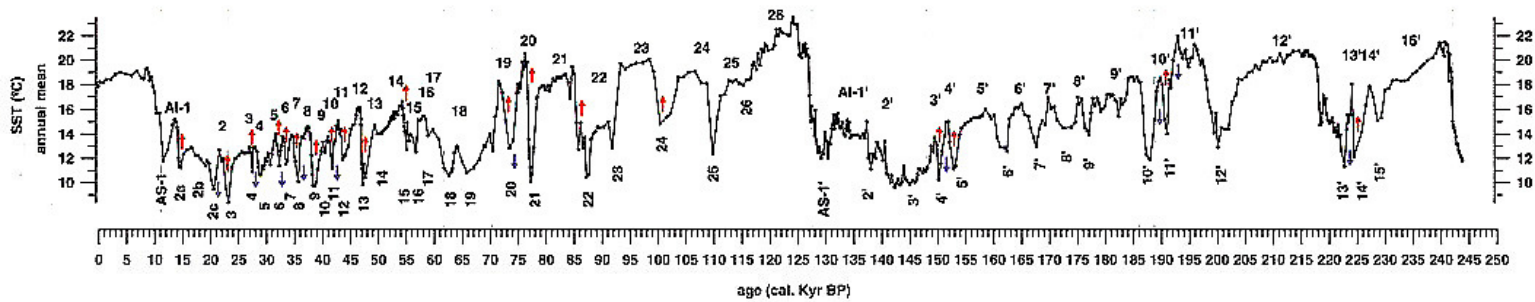
# Ongoing increases in millennial and submillennial scale variation

Mode 4 or 4ish stone tools

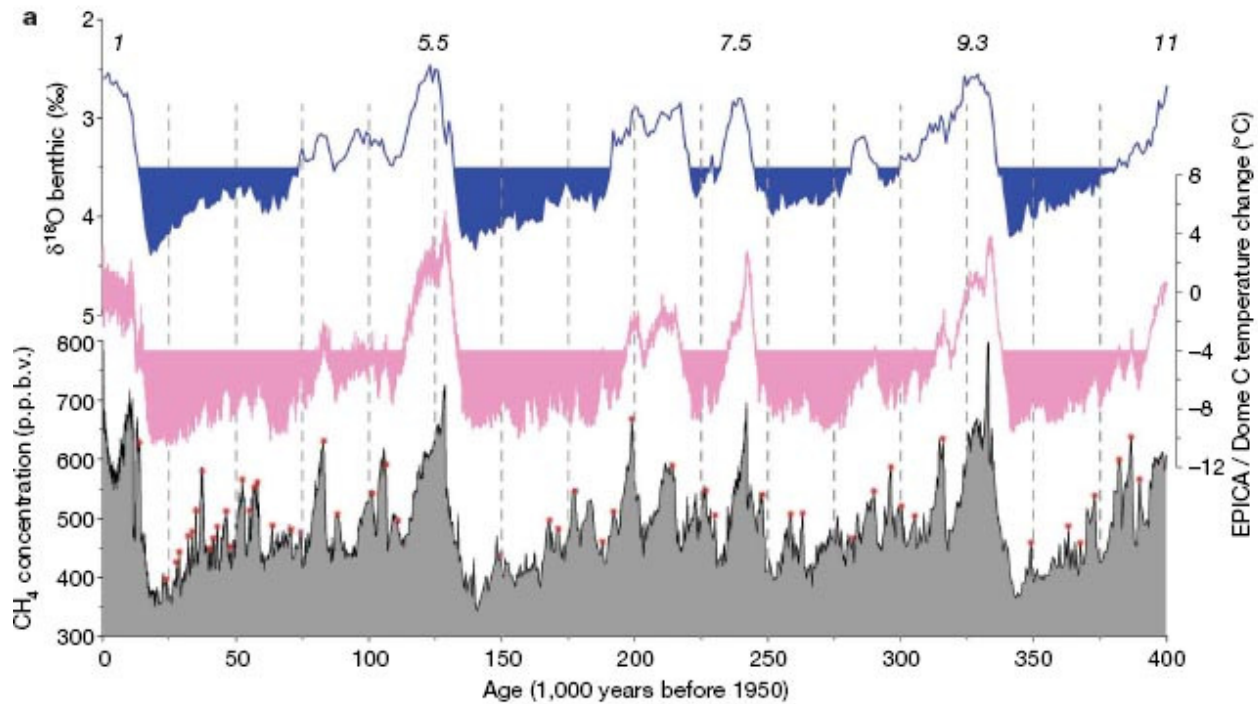
Big brained hominids



Martrat et al. Science 2007

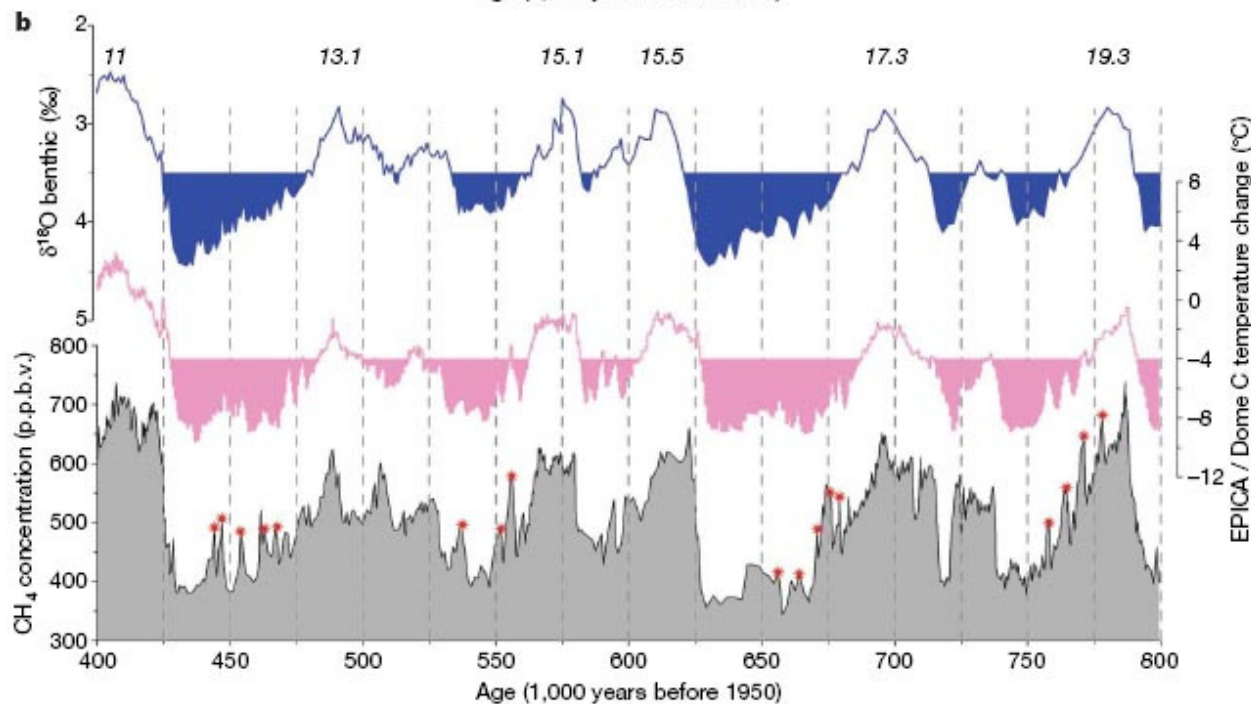


Martrat et al. 2004



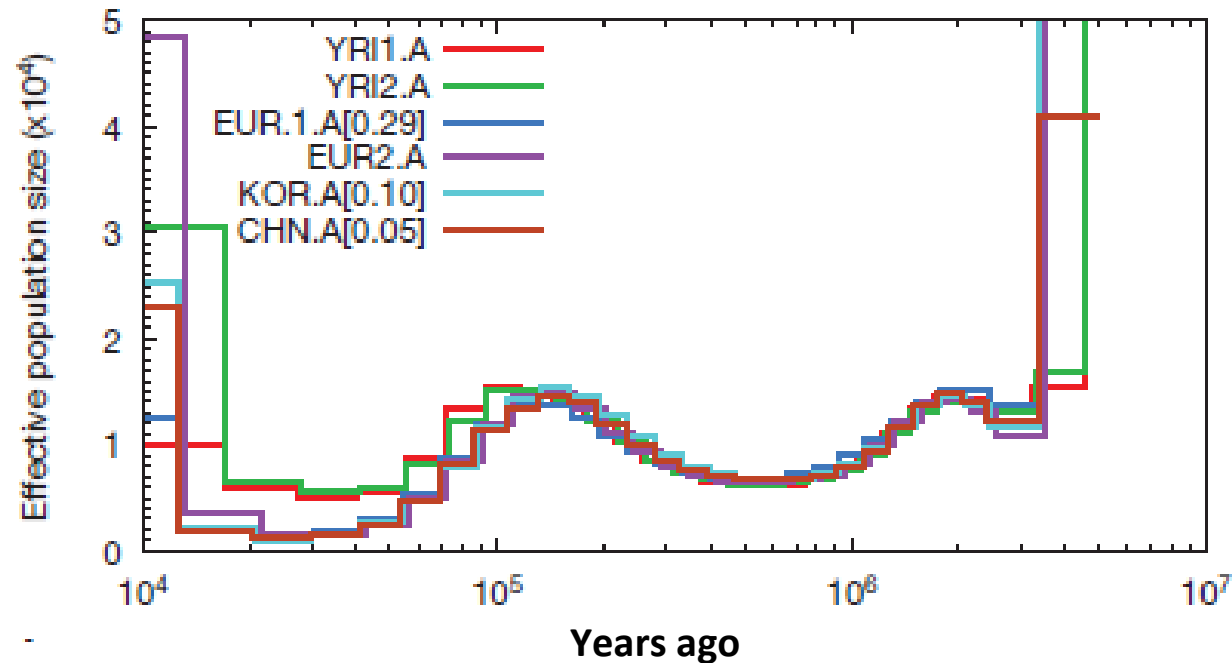
Antarctic ice core

Increasing millennial scale variation over last 8 glacial cycles



Loulergue et al. 2008 Nature 453: 383

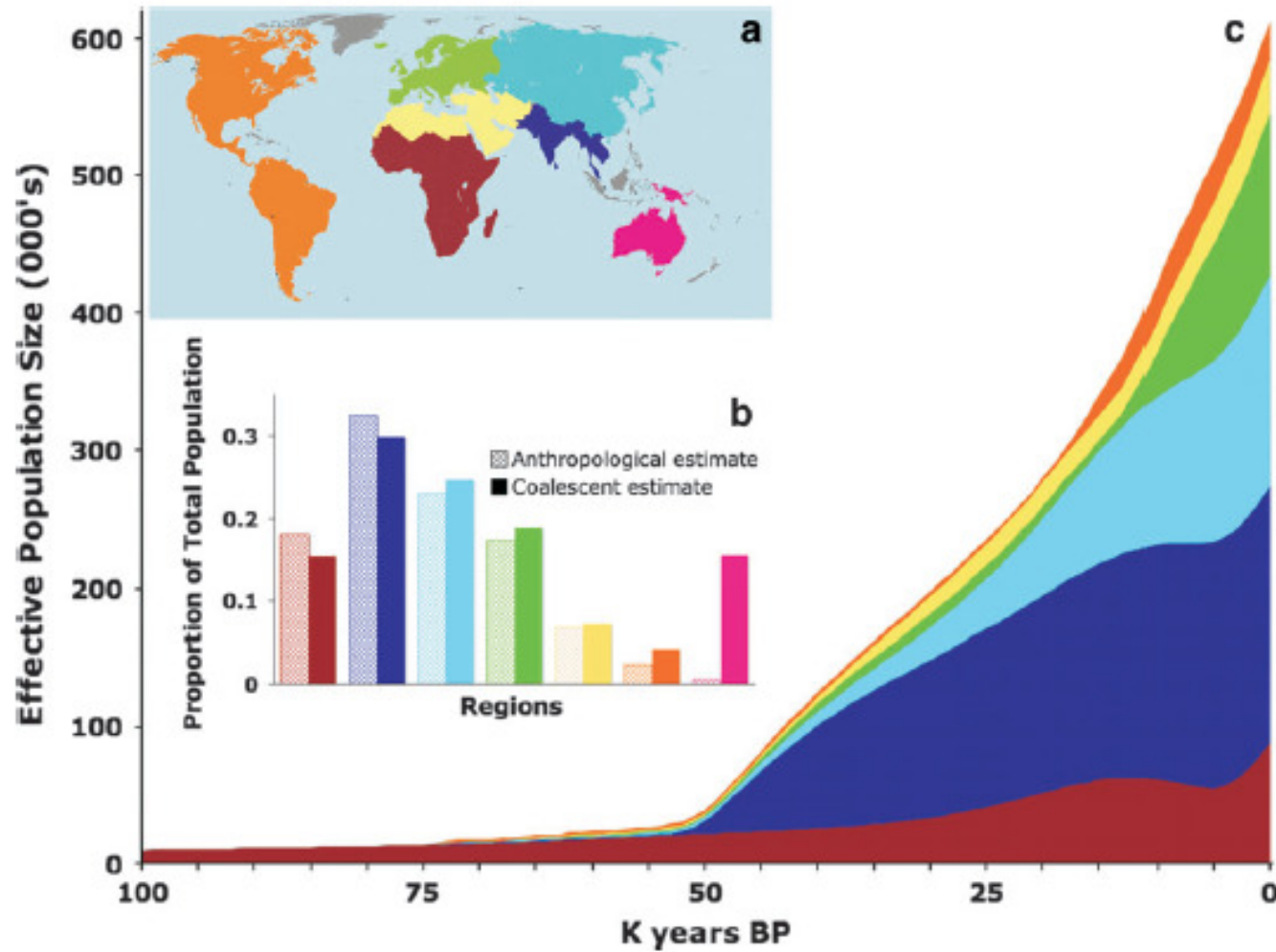
# Humans a fugitive species for most of our history?



Li and Durbin 2011

Big costly brains for fancy culture almost didn't pan out!

# Modern humans expand rapidly after 50 kya

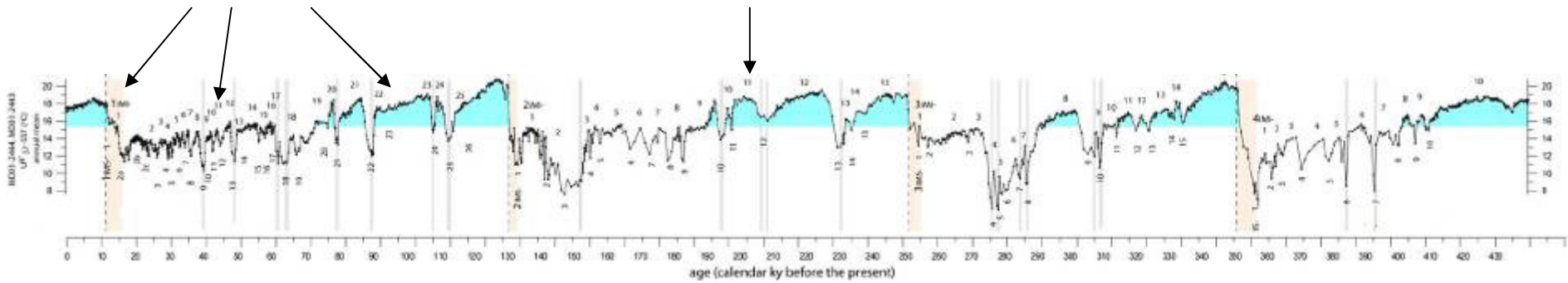




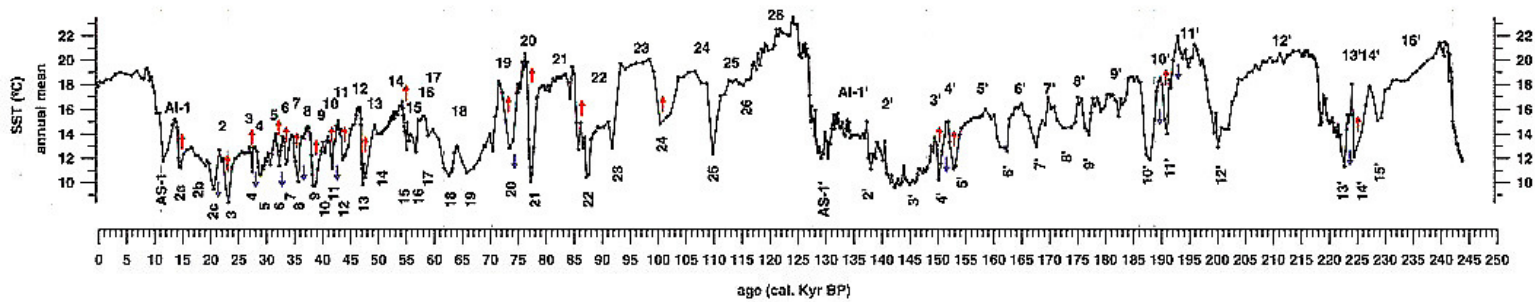
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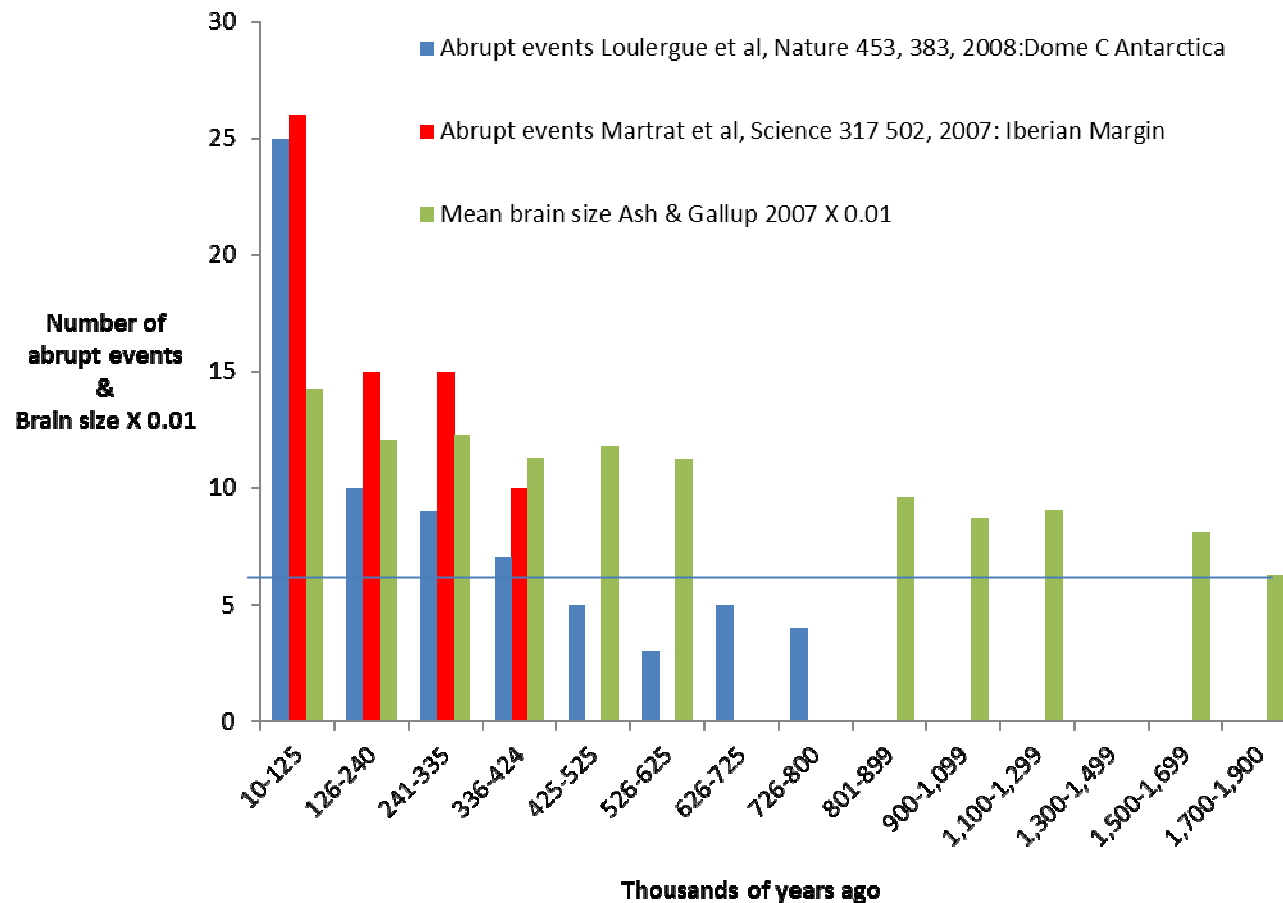


Martrat et al. Science 2007



Martrat et al. 2004

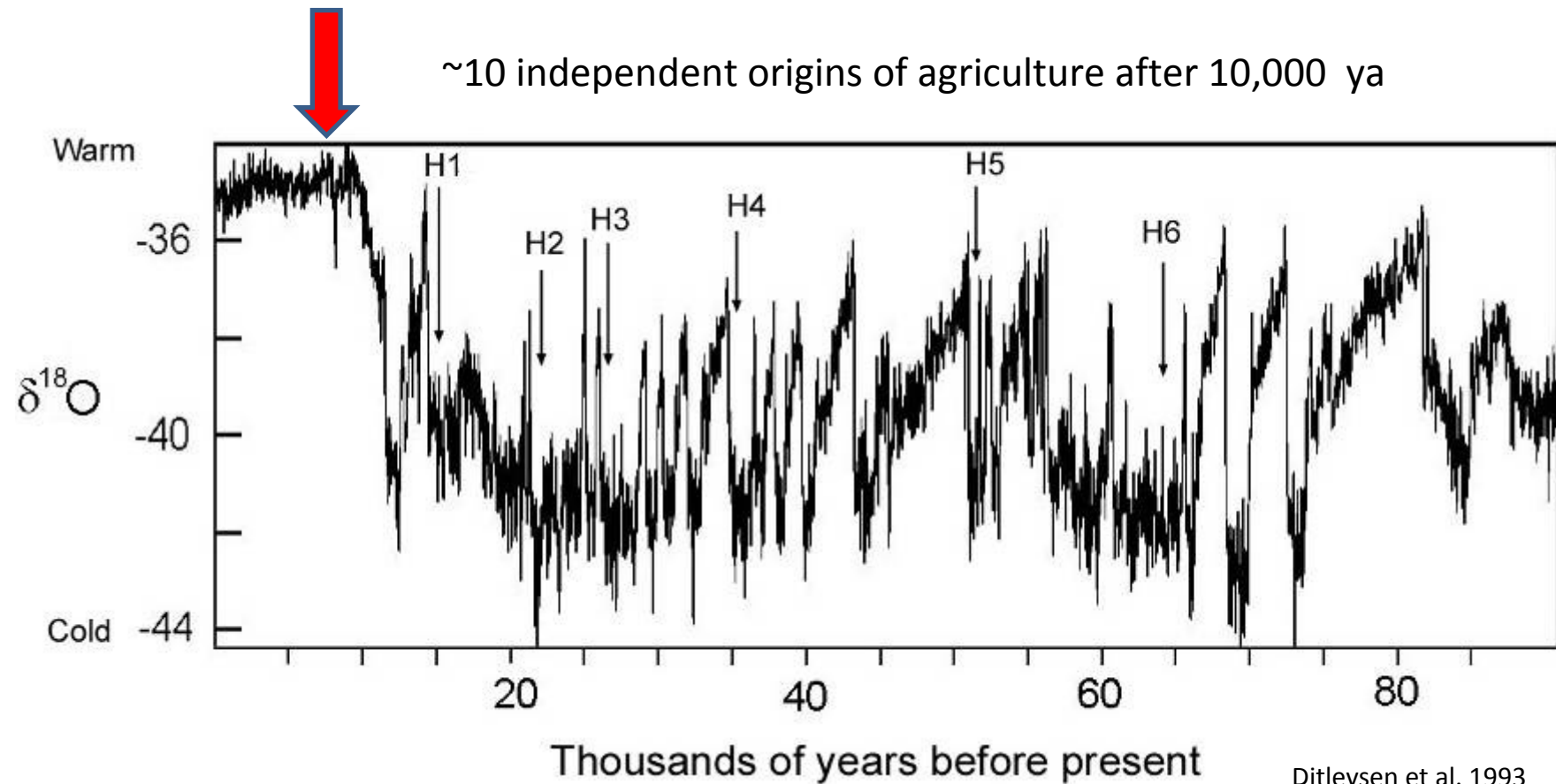
# Human brain size increases with increasing climate variation



The Holocene increase in human population and  
cultural sophistication

An internalist hypothesis

# Abrupt Pleistocene-Holocene transition creates natural experiment



# Agriculture's (r)evolutionary demographic impact

- Today supports ca 6 billion people
- On the demographic time scale, this could have been achieved in less than a millennium
- What has regulated the tempo of cultural evolution in the Holocene?

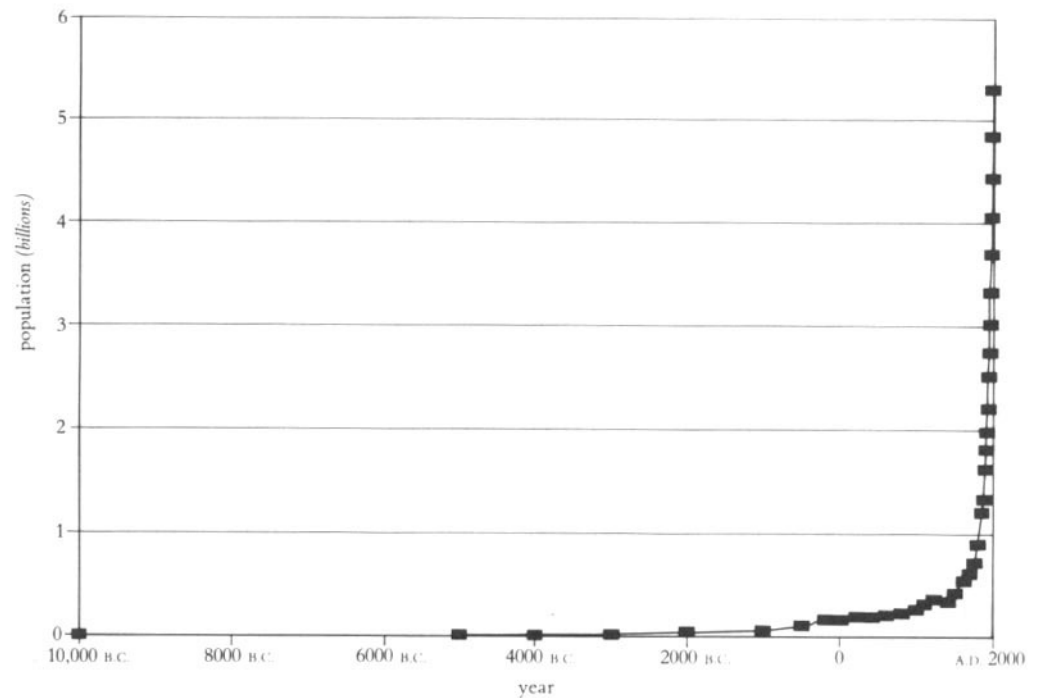


FIGURE 5.2 Estimated human population from the last ice age to the present.  
SOURCE OF DATA: Appendix 2

# A Competitive Ratchet

- Competition between societies favors
- More populous societies
- More technologically advanced societies
- Better organized societies
- Individual societies may slip backwards (the collapse of the Western Roman Empire) but advanced techniques and ideas have seldom been totally lost

# Possible rate limiting processes

- Geography
  - Jared Diamond's explanation for the Eurasian advantage
- Small role for climate change
  - Perhaps large impact of anthropogenic climate change in the future
- Coevolutionary processes play a big role
  - Agriculture requires pre-adapted plants and animals
    - SW Asia particularly rich
    - California particularly poor

# Rate limiting processes, continued

- Humans have to adapt genetically to agricultural diets
  - Amylase copy number
  - Adult lactase persistence
  - Pale skin in low UV environments
- Diseases limit population expansions hence competition
  - Malaria other diseases inhibit conquest, trade



# Rate limiting processes, continued

- Cultural evolutionary processes often slow
  - Technology a complex design problem
    - Evolving balanced diets based on plants
    - Dinner forks and paper clips (Henry Petroski 1992)
  - Social institutions evolve especially slowly
    - Marx famously argued that that factory production technology in the 19<sup>th</sup> Century was managed by archaic social systems
    - Cultural group selection has millennial time scale (Soltis et al. 1995)
    - Social institutions diffuse with difficulty
      - Not observable or “trialible”

# Conclusion

- A Darwinian framework for studying cultural evolution
- Leads to mathematical models that can be coupled to models of organic evolution
- Can model microevolutionary events like the evolution of adult lactase persistence
- Leads to hypotheses about macroevolutionary phenomena

END

Thanks for your attention!