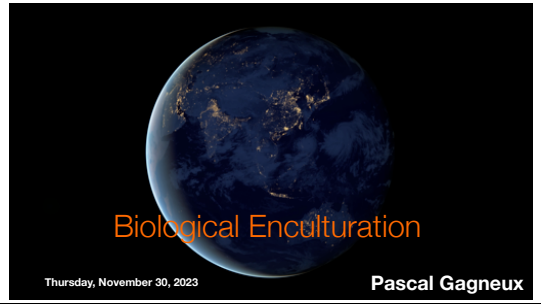
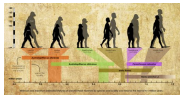
Introduction to Anthropogeny
BIOM225

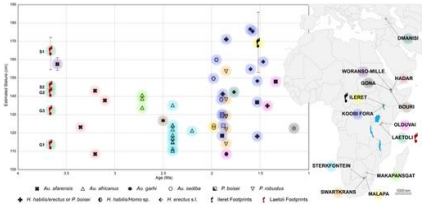


the global ape

Space: meters, our bodies

Inferred stature from fossils and footprints





Masao *et al.* 2016 ***eLife***

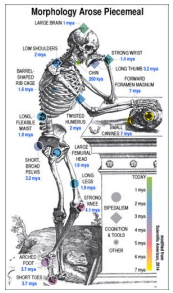
estimations of past hominid body sizes

Space: meters, our polymorphic bodies

Willie Shoemaker, jokey 4 feet, 11 inches; 100 pounds

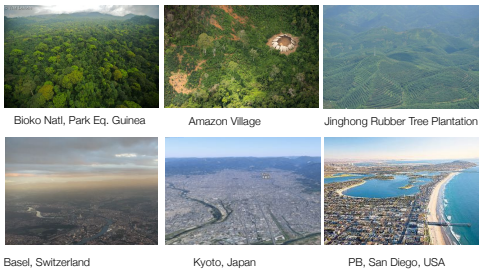
Wilt Chamberlain, NBA 7 feet, 1 inch; 275 pounds

Ekaterina Lisina , 6 feet, 9 inches



Existing variation is often ignored, but heritable variation is what natural selection operates on!

Space: kilometers, home ranges



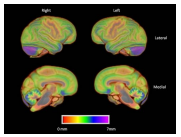
Bioko Natl, Park Eq. Guinea | Amazon Village | Jinghong Rubber Tree Plantation

Basel, Switzerland | Kyoto, Japan | PB, San Diego, USA

home ranges of wild apes, hunter-gatherer groups and modern neighborhoods

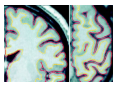
Space: millimeters, our tissues

cortical thickness in chimpanzees



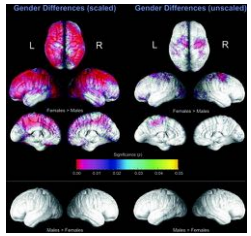
Hopkins and Avants ***J. Neurosci.***, 2013

cortical thickness in humans



Bruce Fischl, and Anders M. Dale ***PNAS*** 2000

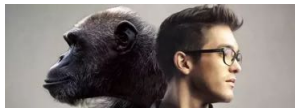
sex differences in human brain cortical thickness

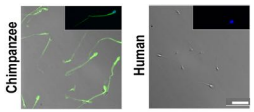


Luders *et al.* ***Hum. Brain Mapping***, 2005

Right: Mean cortical thickness of the left and right hemispheres. Color bar indicates variation in cortical thickness throughout cortex. Top, Left and right lateral view. Bottom, Left and right medial views.
Recent advances in structural magnetic resonance imaging technology and analysis now allows for accurate in vivo measurement of cortical thickness, an important aspect of cortical organization that has historically only been conducted on postmortem brains. In this study, for the first time, we examined regional and lateralized cortical thickness in a sample of 71 chimpanzees for comparison with previously reported findings in humans. We also measured gray and white matter volumes for each subject. The results indicated that chimpanzees showed significant regional variation in cortical thickness with lower values in primary motor and sensory cortex compared with association cortex. Furthermore, chimpanzees showed significant rightward asymmetries in cortical thickness for a number of regions of interest throughout the cortex and leftward asymmetries in white but not gray matter volume. We also found that total and region-specific cortical thickness was significantly negatively correlated with white matter volume. Thus, chimpanzees with greater white matter volumes had thinner cortical thickness. The collective findings are discussed within the context of previous findings in humans and theories on the evolution of cortical organization and lateralization in primates.
Left: Uncorrected statistical maps of gender differences in cortical thickness in ICBM-305 space after using 12-parameter transformations (left) and after using 6-parameter transformations (right). The color bar encodes the Pvalue associated with the t-tests of cortical thickness performed at each cortical surface point. All colored cortical regions indicate statistically significant differences. All gray-shaded regions are not significantly different between males and females.

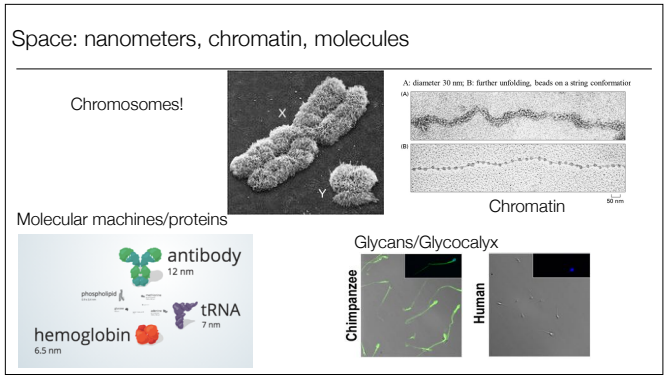
Space: micrometers, our gametes



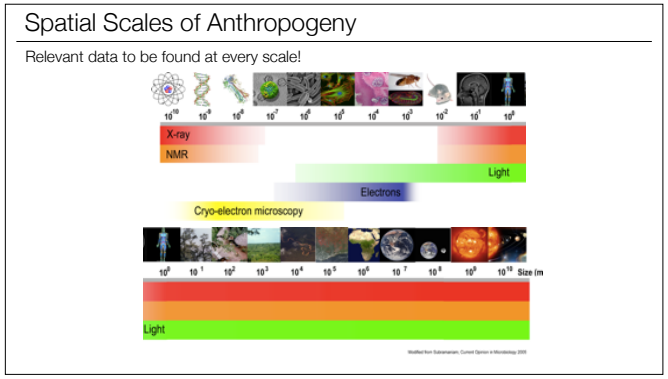


Ghaderi *et al.* 2011 ***PNAS***

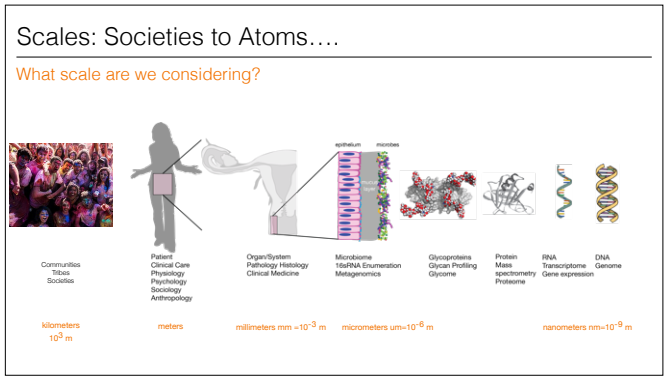
Cells including primate sperm are just a few micrometers in size.



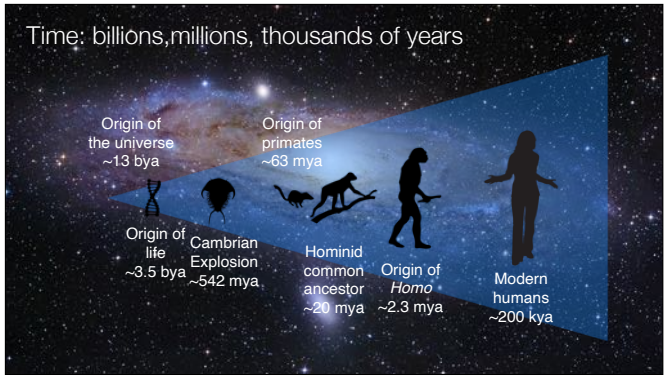
A thousand times smaller than cells: the genome, the protein machines and sugars on cell-surface and secreted glycoproteins.



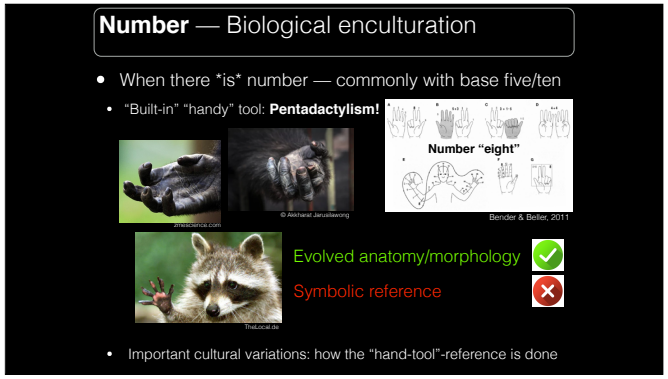
From interactions between atoms (oxygen binding capacity of Tibetan highland hemoglobin), to molecular interactions between DNA binding proteins, DNA-reading Polymerase enzymes and DNA, to cellular interactions forming tissues, organs and bodies, to somatic growth from a fertilized ovule (100 micrometers) to meter size bodies of adults, to social groups, their home ranges, the landscapes and ecosystems, the global reach of humans and the changes in climate caused by planetary interactions and solar cycles.

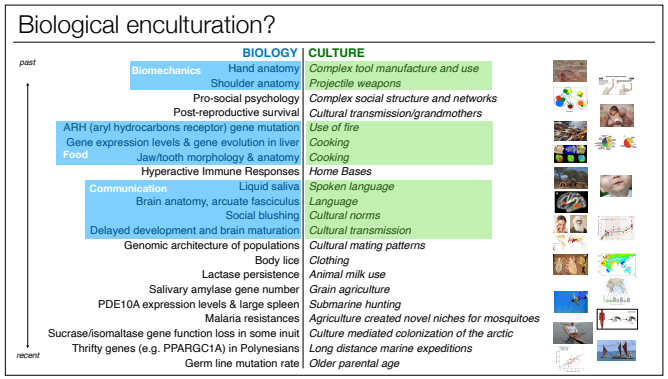


Our molecular nature ranges from societies to atoms. Genetic inheritance is mediated by molecules in the nm range: DNA.

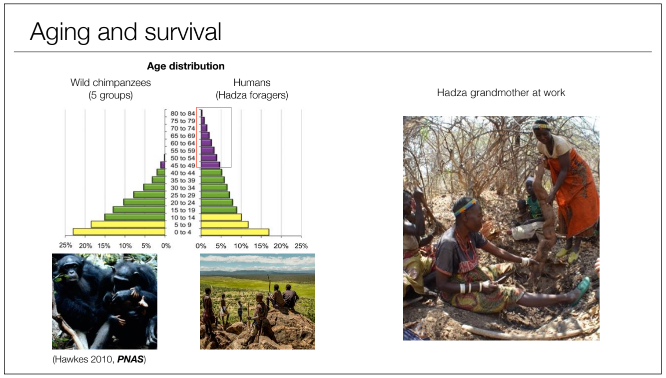


Anthropogeny is shamelessly anthropocentric as its goal is to explain: Where we came from and How we got here.

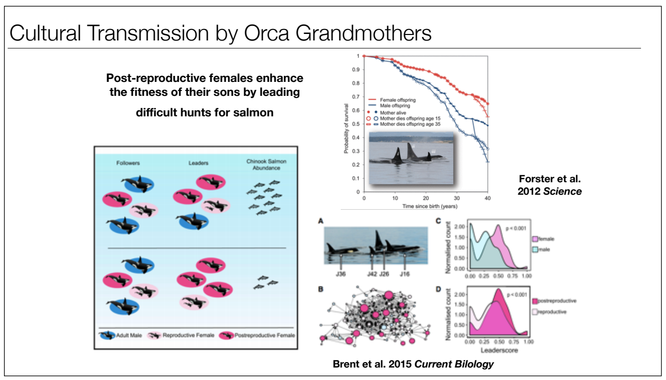




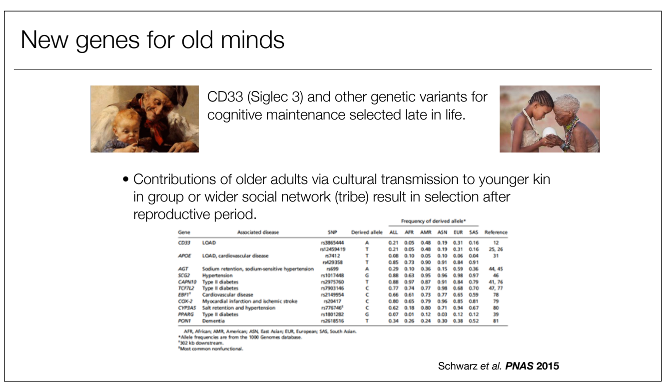
running list of evidence for biological enculturation



Humans populations have many individuals who survive long after the period of reproduction. In Most other animals, when reproduction ceases, most individuals tend to die. Due to the bias favoring female survival , many more older females survive. Up to 25% of living adults in a given social group can be post-reproductive females. The grandmother hypothesis proposes that these females benefit their younger relatives buy provisioning children with food, care and knowledge.

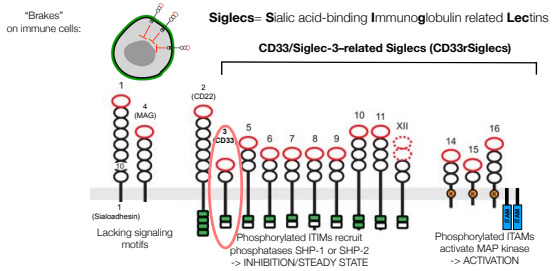


Postreproductively Aged Female Killer Whales Lead Group Movement (A) A postreproductively aged female, J16, leads her adult son and two adult daughters. (Photo
credit: Dave Ellifrit, Center for Whale Research.) (B) In this example leadership network (year 2003), arrows point toward leaders. Age increases with node size. Dark pink nodes represent postreproductively aged females, light pink nodes represent reproductively aged and juvenile females, and blue nodes represent males. (C) Distribution of "leader score" values by sex, normalized to have the same area and smoothed using kernel density estimates. Leader score values are used for visualization only and were calculated as number of times an individual led a group movement in a year/the total number of times they were seen. Statistical results are based on permutation-based binomial regression models in which the dependent variable was the number of times a whale was a leader in a given year relative to the number of times they were a follower. Adult females were significantly more likely to lead compared to adult males (N = 48 females, 24 males, 419 whale years), controlling for the impact of age on leadership. (D) Distribution of leader scores in adult females. Postreproductively aged females (35+ years of age) were significantly more likely to lead compared to reproductively aged females (12–34 years of age) (N = 23 postreproductive females, 32 reproductive females, 307 whale years).



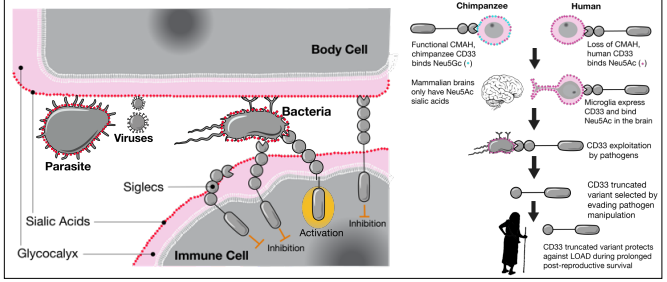
Making oneself useful while old? The benefit of older wise minds to younger related members of the tribe.

Human Siglecs: fine-tuning immune responses



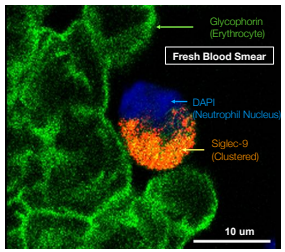
Immune cells carry "brakes" self and non-self sensing innate molecules that can tune down unnecessary inflammation.

Sialic acids, CD33 on microglia, evolutionary exploitation by pathogens, host escape, and cognitive maintenance



Scenario for important change in brain immunity and late life protection of cognition.
Humans underwent a change in cell surface sialic acids.
One of their innate receptors (Siglec 3 = CD33) adapted to binding this changed surface, including in the brain.
Human pathogens infect the brain (*Neisseria gonnorhoeae* and Group B *Streptococcus*) by binding the innate receptor.
Humans evolved a truncated variant of the receptor that cannot be bound by pathogens.
That truncated version happened to have protective effects in late life, helping the microglia (immune cells of the brain) to clean up plaque and protect from neurodegenerative disease.

"Self-Associated Molecular Patterns" (SAMPs) for Siglec-9 are widespread!

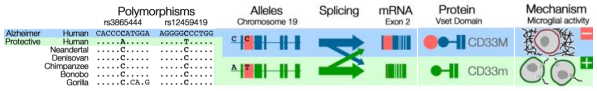


Lizcano, A. *et al.* Erythrocyte sialoglycoproteins engage Siglec-9 on neutrophils to suppress activation. ***Blood***. 2017.

Fresh blood smear of human blood with red blood cells (erythrocytes) stained for the glycoprotein glycophorin (with a green fluorescent antibody). A white blood cell (neutrophil) is stained with DAPI (blue stain for chromatin, red blood cells have no chromatin left in them) and with a yellow fluorescent antibody against the SIGLEC-9 protein, an innate silica acid sensing receptor that signals the immune cell to "relax" when it engages sialic acids on the surface off neighboring cells…..

Cognitive maintenance?

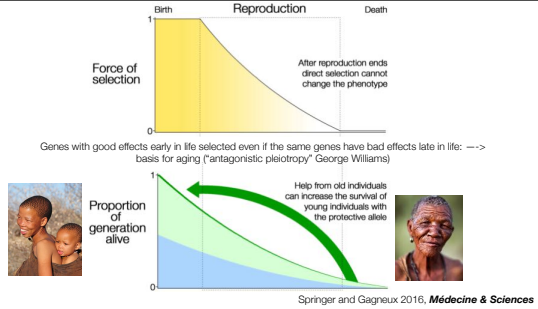
Different blend of splice variants leads to increased microglia activity, resulting in better amyloid beta clearance —> less plaque accumulation.



Schwarz et al. ***PNAS***, 2015
Springer and Gagneux ***Médecine & Sciences***, 2016

Two point mutations in DNA are associated with different mix of proteins (splice variants, one with and the other whiteout the outermost domain of Siglec-3), resulting in protection from Late onset Alzheimers disease. The splice variant lacking the sialic acid-binding outermost domain, does inhibit microglia resulting in higher microglia activity (cleaning up amyloid beta plaques).

Culture Can Change the Selective Landscape



Genes with good effects early in life selected even if the same genes have bad effects late in life: —-> basis for aging ("antagonistic pleiotropy" George Williams)

Springer and Gagneux 2016, ***Médecine & Sciences***

The altered human age pyramid allows for unexpected selection late in life, mediated by help provided by elders to younger group members.Genetic variants that protect the aging mind can be selected by their effects on younger relatives, an example of kin-selection in action.

Derived Human Growth Schedule

Delay allows increased transmission of behavior and concepts.

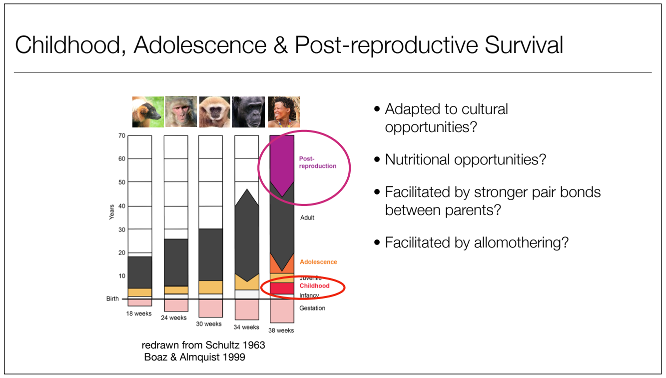
Human minds are effective copying devices and idea generators.

Language is one of the major target of imitation and idea transmission.

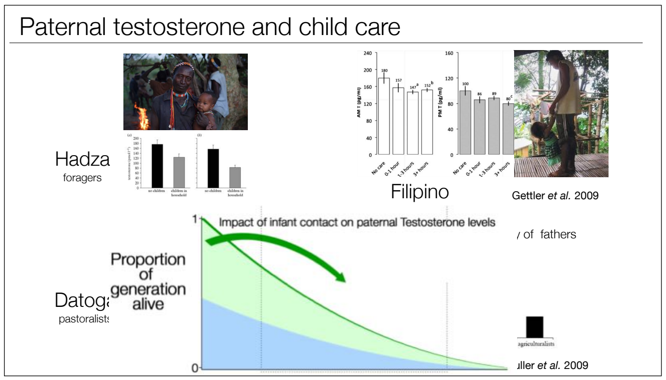
Delayed development: biological assimilation of culture?

Paradoxically shorter Inter-birth-Interval than apes.

Minds as copying machines and idea generators
Humans over-imitate, focusing as much on the way than on the goal, chimps go for the goal.
Ratcheting culture.



Humans have delayed development, But shorter inter-birth intervals! How did we pull this off?

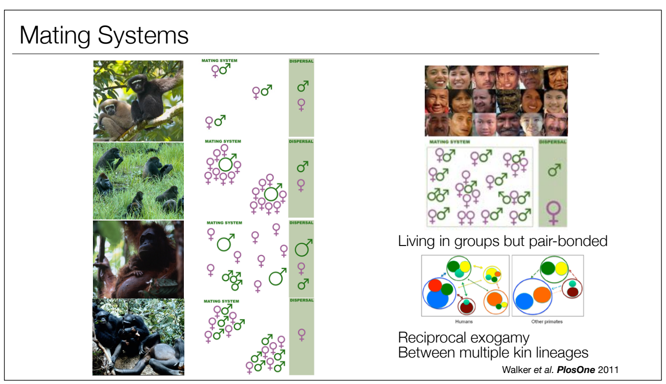


Brian Wood, Frank Marlow

Chirs Kuzawa

Exposure of males in their prime to infants reduce their testosterone level!

Less aggression and much less reason to fight (as no possession/cattle)



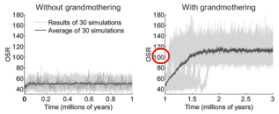
We are the only primate that lives in groups but forms strong pair bonds Combined with names and kinship terms, this allows the large social networks of tribes, even when the groups are small hunter gatherers. Cooperation by pair-bonded male and female in raising young and provisioning for “family” and group.

Decreased intra-group aggression by leveling reproductive opportunities for males? Reproductive pairs within small groups, within very large social networks! Lessening of sexual conflict?

Grandfathers: wise teachers or reproductive competitors?

Surviving older men form new competition

Operational sex ratio (OSR):
number of men capable of competing for the fertilization any given egg ovulated.



Mate guarding leading to pair bonding? (Coxworth *et al.* ***PNAS*** 2015)

Female choice for male body guard? (Smuts, ***Human Nature*** 1992)

Extending the grandmother hypothesis to mate guarding and pair-bonding. Operational sex ratio (males to female that could breed) increases dramatically with more elderly surviving adults.This could massively increase competetion for younger females and result in younger males pair-bonding to guard females against attention of older males.

Modeling effect of grandmother/grandfather survival on operational sex ratio: Time evolutions of ASRs and OSRs with and without grandmothering. (A) ASRs of 30 simulations over 1 million y without grandmothering. Each simulation is shown in light gray. The average of the 30 simulations is shown in black and ends at an ASR of 0.77. The ending point of the simulation shown in medium gray serves as the starting point for the 30 new simulations with grandmothering shown in B. (B) ASRs of 30 simulations over 2 million y with grandmothering. Each simulation is shown in gray. The average of the 30 simulations, in black, ends at an ASR of 1.56. (C) OSRs of 30 simulations over 1 million y without grandmothering. Colors as in A. The average of the 30 simulations ends at an OSR of 50. (D) OSRs of 30 simulations over 2 million y with grandmothering. Colors as in B. The average ends at an OSR of 111.

Operational sex ratio in four foraging people


!Kung
Botswana


Hiwi
Venezuela


Ache
Paraguay


Hadza
Tanzania

Table 2. Demographic parameters for human hunter-gatherers

Population	Males age 20–65 years	Females age 20–40 years	Birth interval, year	Male paternity, days/year	Female fecundable days per cycle	Cycles to conception	ASR M/F	OSR M/F
Dobe !Kung (26, 27)	0.593	0.407	4.17	365	6	4	1.46	92.40
Ache forest (28)	0.652	0.348	2.44	365	6	4	1.87	69.52
Hiwi (29)	0.618	0.382	3.70	365	6	4	1.62	91.04
Hadza (30)	0.616	0.384	3.23	365	6	4	1.60	78.80

Coxworth *et al.* ***PNAS*** 2015

Assuming stationary populations, the mortality curve mirrors the age structure. To model age structures we used probability of survival to each age in the published life tables, summing the calculated number of survivors for men and women to each of the fertile ages, then dividing the sum for each sex by their combined total to get the fraction fertile adults by sex (columns 2 and 3). We included men from 20 and 65 years based on reported age ranges of fertilities from the ethnographers and those reported by Tuljapurkar et al. Women from 20 to 40 years are included based on average ages of first and last birth.

Marriage Ceremonies

anchoring pair-bonding in social networks and conventions

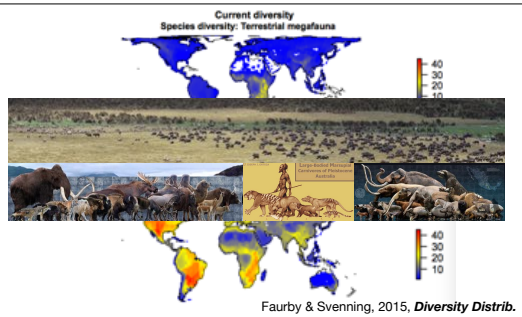
Traditional Telugu wedding in Hydrabad, India

Marriage tend to be major social affairs, highly publicized, subject to strong cultural norms, involving display of status and wealth, exchange of goods or money (dowry or bride price) and anchoring a couple in a complex mesh of social relationships, debts, gratitude etc.
Cheat and you face not just your partner, but an entire clan behind him or her…..

Merci grand-maman!

Julie Sumi, 1905-1998

Missing Megafauna (>44 kg/97 lbs)?



Faurby & Svenning, 2015, ***Diversity Distrib.***

There is strong evidence for mass extinctions of megavertebrates (animals larger than 100lbs) from all landscapes into which modern H. sapiens arrived, except for Africa.

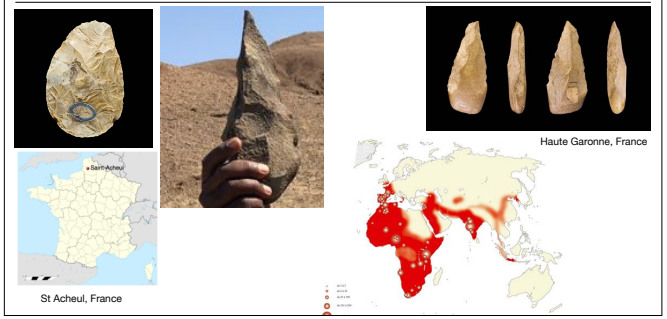
Time: 1.9 to 2.4 million of years old: Tools and their marks

Ain Boucherit , Algeria

Oldowan stone tools

Many exciting recent discoveries of fossils and artifacts, 2 million year old tools in North Africa, 50 thousand year old art in Borneo.

Lithics Acheulean hand axes



Named after a town in Northern France, but even more abundant across Africa, also found in Asia, where Homo erectus first arrived expanding from Africa.

Practice question:
Why is the name Acheulean hand axe somewhat unfortunate?
Because the oldest examples of these versatile tools appeared long before in Africa.

2 million year old hippo jaw with cut mark.

Ain boucherit- 2 my old butchery?

RESEARCH

ARCHAEOLOGY

1.9-million- and 2.4-million-year-old artifacts and stone tool–cutmarked bones from Ain Boucherit, Algeria

Mohamed Sahnouni[1,2,3]*, Josep M. Parés[1], Mathieu Duval[4,5], Isabel Cáceres[6,4], Zoheir Harichane[2,3], Jan van der Made[7], Alfredo Pérez-González[1], Saïab Abdessadok[8,2], Nadia Kandi[2,3], Abdelkader Derradji[2,3], Mohamed Medig[2], Kamel Boulaghraif[2,3,9], Nihoki Semaw[4,5]

East Africa has provided the earliest known evidence for Oldowan stone artifacts and hominin-induced stone tool cutmarks dated to ~2.6 million years (Ma) ago. The ~1.9-million-year-old stone artifacts from Ain Hanech (Algeria) were considered to represent the oldest archaeological materials in North Africa. Here we report older stone artifacts and cutmarked bones excavated from two nearby deposits at Ain Boucherit estimated to ~1.9 Ma ago, and the older to ~2.4 Ma ago. Hence, the Ain Boucherit evidence shows that ancestral hominins inhabited the Mediterranean fringe in northern Africa much earlier than previously thought. The evidence strongly argues for early dispersal of stone tool manufacture and use from East Africa or a possible multiple-origin scenario of stone technology in both East and North Africa.

Sahnouni *et al.* 2018, ***Science***

Oldowan artifacts. (A and B) Oldowan artifacts from AB-Lw [(A), images 1 to 8] and AB-Up [(B), images 9 to 17], including unifacial cores on limestone (1 and 9); bifacial core made of limestone (10) and on flint (2); polyhedral cores on limestone (11 and 12); subspherical core on limestone (3); whole flakes on flint (7, 16, and 17) and on limestone (4, 5, 6, 13, and 14); and retouched pieces on flint (8 and 15).

Evidence of hominin activity from Ain Boucherit faunal assemblages. (A and B) Slicing mark on a medium-sized bovid humerus shaft from AB-Lw (A), with scanning electron microscopy (SEM) micrograph detail (B). (C and D) Cutmarked equid calcaneum from AB-Lw (C), with SEM micrograph detail (D). (E) Hammerstone-percussed medium-sized long bone from AB-Lw. (F) Bon flake from AB-Up. (G) Equid tibia from AB-Up, showing cortical percussion notch.

Precision Grip

Tool use and the human hand: our much larger thumbs allow us to hold stone blades and slice things in a way that is almost impossible to do for an ape. Apes can do very precise tasks though, such as setting a watch.

Practice question: what part of butchery would be especially difficult to perform by an ape?
The cutting of the hide to skin the animal and the cutting of flesh using sharp edged stone flakes require strong thumbs.

Precision Grip

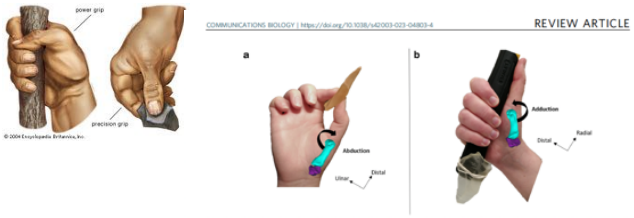


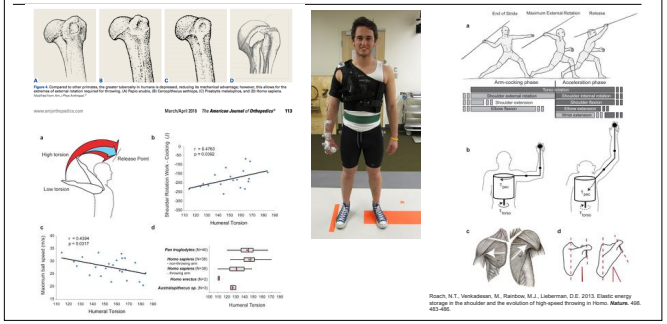
Fig. 4 Examples of the relationship between hominin fossil hand morphology and early tool use. a, b A present day human's hand demonstrating a precision grip when grasping an artifact (a) and a power "squeeze" grip when grasping a hafted artifact (b; both palmar views). Superimposed in turquoise (first metacarpal) and purple (trapezium) are the bones forming the trapeziometacarpal complex at the base of the thumb and responsible for its movements in a present day human (a) and a Neanderthal (Kebara 2; b). (Bardo312, available at https://doi.org/10.5281/zenodo.7452329).

Cutting meat, hides, scraping hides

Cutting meat, hides, scraping hides

Animal hides neat to have the fat layer removed in order to be used (otherwise they turn rancid and nasty). This can be achieved by smearing bile on the inside of the fresh skin and by later scraping the fat layer away.

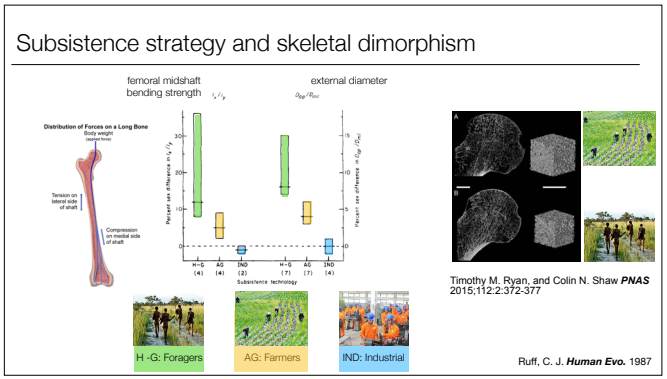
Shoulder anatomy and throwing



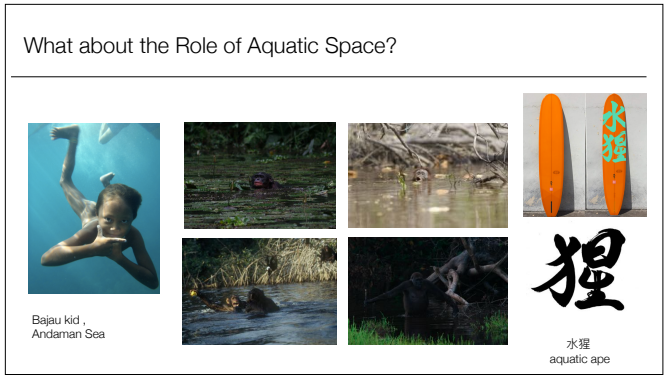
This image shows differences in the position of the shoulder between chimpanzees (left) and humans (right). These differences can be seen in both the muscular anatomy and in the bony anatomy of the scapula (shoulder blade). (Image credit: Brian Roach/Neil Roach)

Tool use and the human hand: our much larger thumbs allow us to hold stone blades and slice things in a way that is almost impossible to do for an ape. Apes can do very precise tasks though, such as setting a watch.

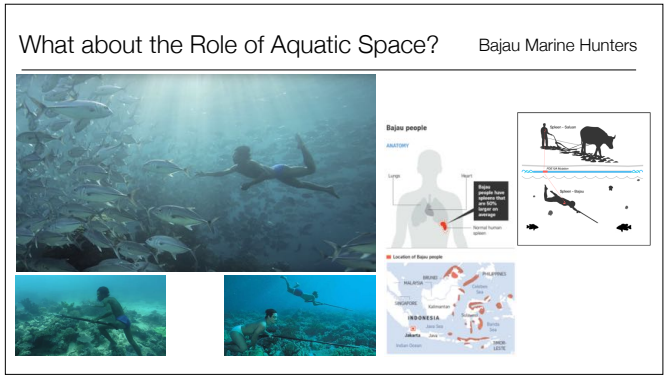
Subsistence strategy and skeletal dimorphism



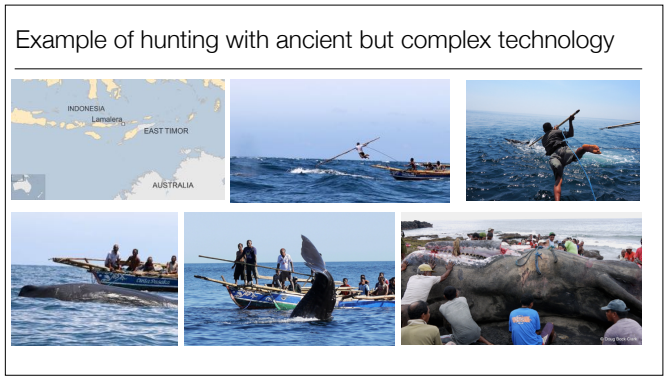
Sexual dimorphism in two measures of relative bending strength of the femoral midshaft in three broad subsistence categories.
Mode of substance can rapidly change sexual dimorphism as shown for North American Inuits, farmers and city dwellers!



The aquatic ape hypothesis tried to explain a suite of human traits by an ancient aquatic phase. Fro subcutaneous fat, to diving reflex, to swimming neonates, floating long hair, breasts in female, bipedality etc. Many of these features evolved millions of years apart……



Genetic adaptation to diving in the Bajau. Private genetic mutations in this population have been selected by conferring the ability to free dive for much longer.



The Last Whalers: Three Years with an Ancient Tribe and a Vanishing Way of Life, chronicles three years in the life of the Lamalerans, an indigenous Indonesian tribe that hunts sperm whales with bamboo harpoons and wooden boats for its living. All photos on this website are © Doug Bock Clark.

Hunting techniques: start early and practice a lot

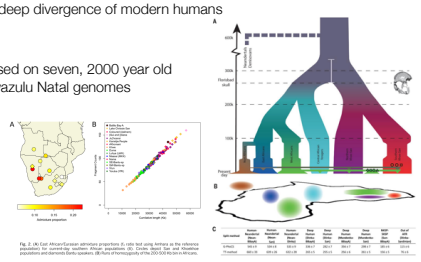
Young Hadza practicing bow and arrow making and using.
(notice the real arrows with the poison tips stashed high on pegs against a baobab tree).
Cognitive effects of aiming, predicting relative motion of target and projectile, regulating timing and projection strength etc….

Spatio temporal syntax???

Time: hundreds of thousands of years

deep divergence of modern humans

based on seven, 2000 year old Kwazulu Natal genomes

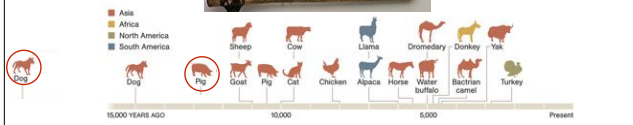


Schlebush *et al.* 2017 ***Science***

The temporal range for the existence of *Homo sapiens*.

The Neolithic: 10 thousand years of agriculture

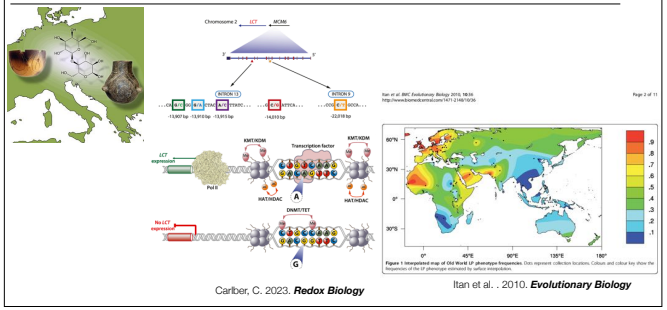
The Neolithic, the anthropocene



MacHugh *et al.* ***Annu. Rev. Anim. Biosci.*** 2017.

A mere blink of time in the past, the origin of agriculture, settlements and complex societies with all their social norms and institutions. Don't forget, *H. sapiens* has existed for over 200 thousand years without such recent innovations.

Domestication: Culture changing genes



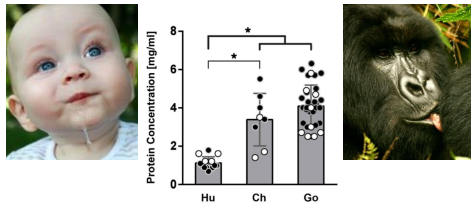
Carlber, C. 2023. ***Redox Biology***

Itan et al. . 2010. ***Evolutionary Biology***

7.5 kya process began to select for lactase persistence, the only populations with many individuals who can digest lactose as adults have histories of stealing milk from other species….
The practice was so advantageous, that lactase persistence mutations were selected at least twice (in Europe and in East Africa). A cultural practice that has changed the human genome in less than 10,000 years.
This happened at least twice independently in Europe and in East Africa respectively.

Molecular basis of lactase persistence. The genomic region of thegenes LCT and MCM6 is shown
(A). SNPs (single nucleotide polymorphism) located approximately 14 and 22 kb upstream of the TSS of the LCT gene, which are located within introns 13 and 9 of the MCM6 gene, respectively, are associated with lactase persistence. The function of regulatory SNPs is schematically depicted (B). The SNP is part of a transcription factor binding site and provides in oneallele (top) high affinity and in the otherallele (bottom) low affinity for the transcription factors. In case of rs4988235 at position −13,910 relative to the LCT genethis is POU2F1 (POU class 2 homeobox1). Moreover, epigenetic effects, such as histone acetylation and methylation as well as DNA methylation can affect the expression of the LCT gene and mediate lactase persistence.

Spit for Speech?



Humans have much more diluted saliva and lack Latherin

Stefan Ruhl et al. U Buffalo

Human spit is much less viscous than great ape spit and lacks the protein lathering, found in many other mammals including great apes.

Niche construction

The human cultural niche shapes

ecology
sociality
technology
symbols…..

each of these form environments that in turn
affect human development, survival, and differential reproduction

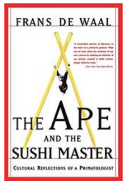
Humans have become biologically cultural!

Khoisan Toolkit

Minimal technology, cumulative culture and maximal impact!

Teaching and Cumulative Culture

Plenty of observational learning in non-humans
Teaching only in humans among primates.
Humans learn from others how to learn…

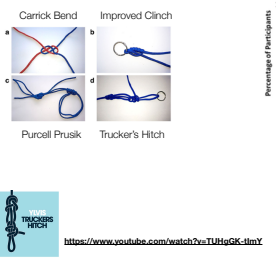


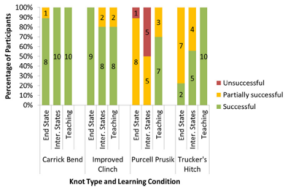
Humans can learn many skills without active instruction by teachers, but societies around the world show plenty of teaching, apes in contrast do not.

The Cultural Ape: Global Cultures

Learning but not teaching

Coevolution of Teaching and Cumulative Culture?





https://www.youtube.com/watch?v=TUHgGK-tImY

Caldwell *et al.* ***Rev.Phil. Psych.*** 2017

Verbal teaching strongly increases success rate when learning new skills.

Big open questions


Why are we bipedal?


How old is the use of fire?


Why are we so big brained?


How did we become symbolic?

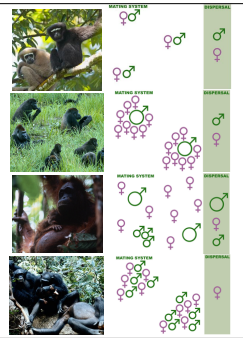

Religious Instincts?


Why only us?

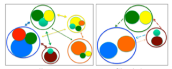

How old is language?


Compete or cooperate?

Mating Systems



Living in groups but pair-bonded



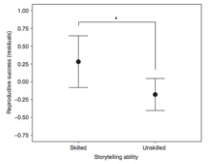
Reciprocal exogamy
Between multiple kin lineages

Walker *et al.* ***PlosOne*** 2011

We are the only primate that lives in groups but forms strong pair bonds
Combined with names and kinship terms, this allows the large social networks of tribes, even when the groups are small hunter gatherers.
Cooperation by pair-bonded male and female in raising young and provisioning for “family” and group. Decreased intra-group aggression by leveling reproductive opportunities for males? Reproductive pairs within small groups, within very large social networks!
Lessening of sexual conflict?

The Story telling Ape?

Agda tribe in N. Phillipines



Smith *et al.* 2017 ***Nat Comm.***

Ethnographic evidence for the impact of good story telling on reproductive success of individual males among the Agda.

The Allo-mothering Ape

Human infants and toddlers rely on individuals other than their mothers.

This has shaped a psychology that is exquisitely tuned to eliciting sympathy and support.

Provision of :
Protection
Food
& Stories!

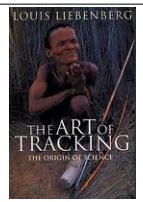
Master manipulating infants give rise to mind reading adults?

World Population

https://www.youtube.com/watch?v=PUwmA3Q0_OE

Impact of population density on social structure and cultural evolution?
We were very few, for most of the time!!

Do other species read tracks?



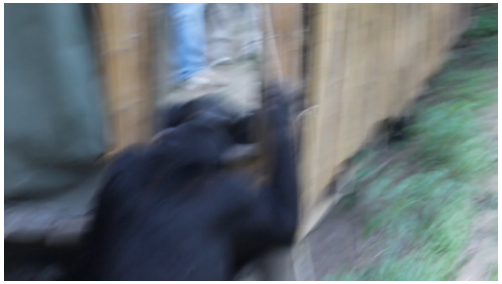
No!

Why Not?

Beginning of symbols?

Is there a connection between the use of poison arrows, tracking prey and the capacity for symbolic thinking?

reading animal tracks and reading human minds?



Matt Brown, The Nature Conservancy

male chimpanzee in Mahale National Park, Tanzania, puzzled by his reflection in a mirror

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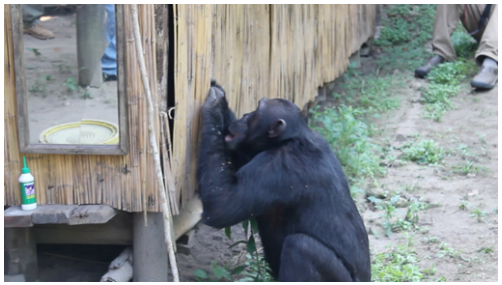
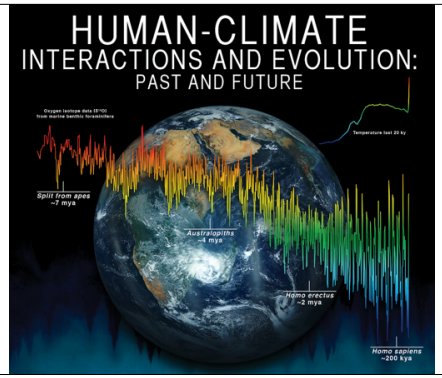


Matt Brown, The Nature Conservancy

he tries to find the other chimpanzee…



poster of past CARTA symposium on climate and its roles in human origins

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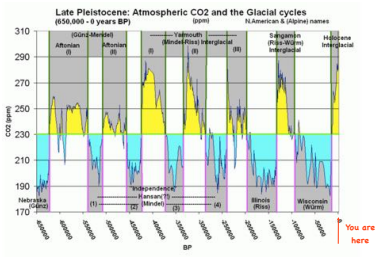
Which two species of mammals that use home bases experienced the same climatic changes as hominids?



the last interglacial period is when humans developed farming in various regions around the globe (papua New Guinea, Huang He Valley, Indus Valley, Ganges Valley, Mesopotamia, Nile Valley, Yucatan Peninsula, Central America….

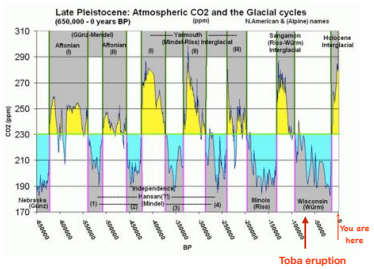
Evolved by Climate?

Brain for all seasons?

Adaptation to variable ecology, spatially (mosaic ecosystems, ecotones) and temporally (intergenerational and trans-generational shifts in climate and resulting subsistence strategies)?

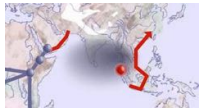
Not for spotted hyenas nor for baboons

Geological catastrophe?



One massive volcanic eruption can ruin your entire day - and shape evolution

74 kya caused a six year nuclear winter and a 1000 year glaciation



Ambrose, ***J. Hum Evol.*** 2003

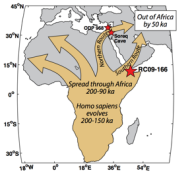
80 kya old stone tools from Dhaba

Clarkson *et al.*, ***Nature Comm.*** 2020

Punctuated natural disasters, such as the eruption of Mount Toba in South east Asia 74 ky ago, had the potential to influence the course early human history….. human life on the Indian subcontinent would likely have been wiped out…

Pushed or pulled by climate?

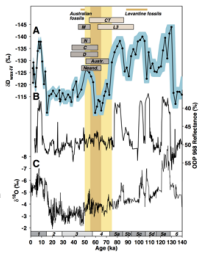
wet and warm until 80 kya, then suddenly cooler and drier



leaf wax

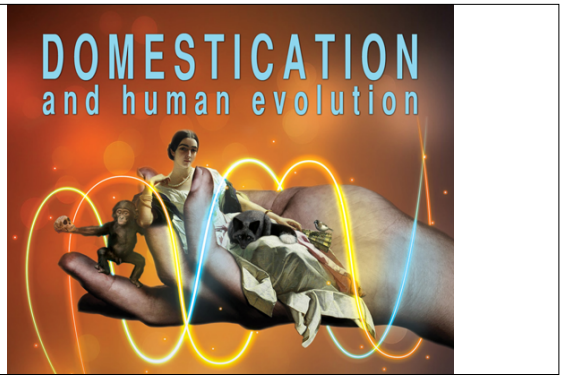
drill core reflectance

oxygen isotopes reflecting strength of monsoon



Tierney *et al.* ***Geology,*** 2017

Just prior to Mount Toba eruption, South Africa got much drier. Could such climatic changes have pushed human groups to new, less arid places and eventually out of Africa, where they met the descendants of *Homo erectus* who had left Africa more than a million years earlier and evolved into Neanderthals and Denisovans??



Poster for past CARTA Symposium on domestication and human origins.
Did we humans partial self domesticate?
Reduced aggression, neoteny (retention of juvenile traits in adults), shortened jaws, changes in pigmentation, higher levels of behavioral variation are all features of domesticated animals, BUT larger brains are not (most domesticated animals have smaller brain than their wild ancestors).

Self Domestication?

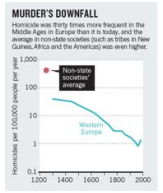
Dmitri Belyayev: 40 generations of captive foxes

- Reduced fear threshold
- Reduced aggression within groups, especially from males
- Selection for neotenous characters
- Selection for pro-sociality
- Prolongation of immature phase (childhood)
- Increased transmission of shared knowledge
- Population of minds carrying culture
- Buffering of deleterious mutations leading to possible recruitment of "impossible" genotypes?

Geneticist Dmitri Belyayev was banished to Siberia under the regime of Stalin and his pseudoscientist Lysenko (who convinced Stalin that he could shock treat wheat plants into growing well ninth Arctic Siberia..). He started a domestication experiment on fur farms with silver foxes.

Domesticated murderers?

- inter-group conflict as intra-group glue?
- How old is war?
- Old enough to have shaped modern human cognition/behavior?
- Evidence for paleolithic organized homicide?



Pinker, ***Nature*** 2011

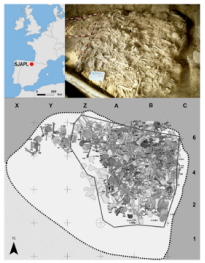
Steven Pinker has proposed that human societies have recently evolved to be much less violent (despite, or because of state sponsored violence..) a controversial claim, as there is little evidence for warfare among hunter gatherers, and it is difficult to precisely measure the rate of homicide in non-state societies.
Richard Wrangham has proposed that hunter gatherer societies night have exerted a strong selection against violent bullies by murdering these across generations, essentially selecting against human (male aggression). The last ten thousand years have seen a reversal, where bullies can now become heads of states….

Warfare 5000 years ago?

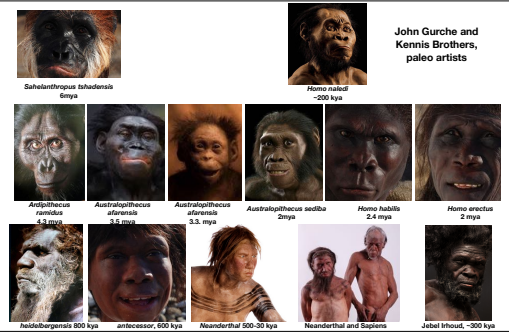
Large-scale violence in Late Neolithic Western Europe based on expanded skeletal evidence from San Juan ante Portam Latinam

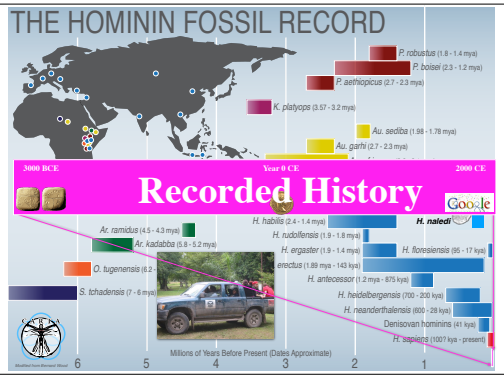
Teresa Fernández-Crespo[1,2,3✉], Javier Ordoño[4], Francisco Etxeberria[5,6], Lourdes Herrasti[6], Ángel Armendariz[7], José I. Vegas[8] & Rick J. Schulting[2]

This paper explores the nature and extent of conflict in Late Neolithic Europe based on expanded skeletal evidence for violence from the San Juan ante Portam Latinam rockshelter in present-day Spain (ca. 3380–3000 cal. BC). The systematic osteological re-examination has identified 65 unhealed and 89 healed traumas—of which 77 were previously undocumented—consistent with aggression. They affect 23.1% of the 338 individuals represented. Adolescent and adult males are particularly affected (44.9% of the 107 identified), comprising 97.6% of unhealed trauma and 81.7% of healed trauma recorded in individuals whose sex could be estimated and showing higher frequencies of injuries per individual than other demographic subgroups. Results suggest that many individuals, essentially men, were exposed to violence and eventually killed in battle and raids, since warriorship is mainly restricted to this demographic in many societies. The proportion of casualties is likely to have been far greater than indicated by the 10.1% individuals exhibiting unhealed trauma, given the presence of isolated cases of unhealed postcranial trauma and of arrowheads potentially having impacted into soft tissues. This, together with skeletal indicators of poor health and the possible socioeconomic outcomes evidenced in the region, suggest wider social impacts, which may relate to a more sophisticated and formalized way of warfare than previously appreciated in the European Neolithic record.

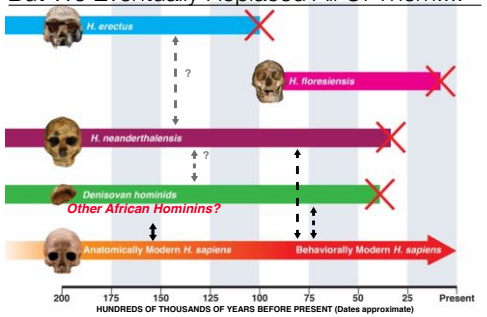


Meet the ancestors and extinct relatives



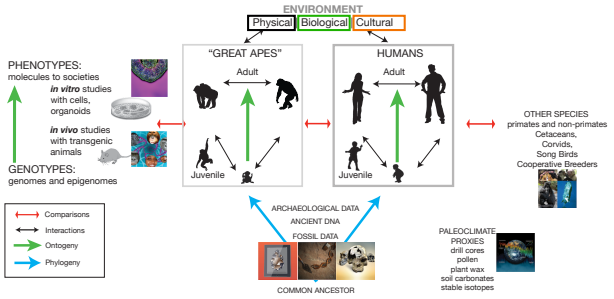


Limited Interbreeding With Other Hominins But We Eventually Replaced All Of Them....



How did we come to be the “last hominin standing”?

Anthropogeny: A Transdisciplinary Approach



modified from: A Systematic Approach to Anthropogeny. Updated by P. Gagneux from Varki, A., Nelson, D., 2007. Genomic Differences between humans and chimpanzees. *Annual Review of Anthropology* 36, 191-209

Where are we?

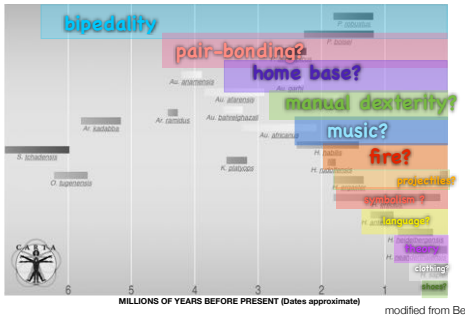
Half full

- a truck load of fossils
- 60 ka old engraved ostrich shells & artifacts from around the world
- avalanche of genome data including extinct genomes
- comparative data on brain anatomy and development
- functional brain imaging
- *in vitro* models for cell differentiation
- vast body of ethnographic data
- new data on paleoclimate
- new data on human and great ape child psychology
- comparative approach and new methodologies
- natural human experiments

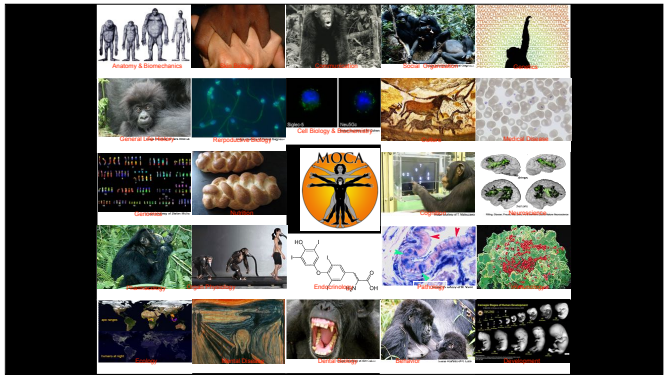
Half empty

- a truck load of fossils
- very few artifacts from 100 ky ago
- no way to translate genomes into phenotypes
- very limited opportunities for comparative brain studies
- limitations of brain imaging
- in vivo experiments not possible in great apes
- rapid loss of traditional cultures
- ethnographic data are biased
- rapidly vanishing great ape populations
- singularity of human phenomenon

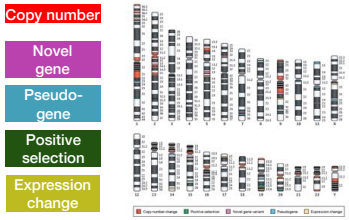
Time Line of Human specific Innovations



modified from Bernard Wood



Human-Lineage-Specific Changes are Scattered throughout the Genome



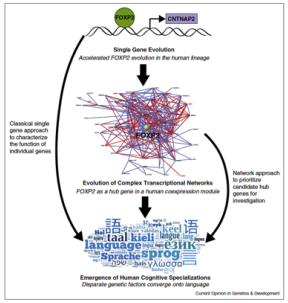
A vast landscape of functional elements still being discovered…

O'Blenness *et al.* ***Nat Rev Genet. 2012***

Ape genomes are about three meters long. 33 billion basepairs on 23 or 24 different chromosomes. Each of us is a unique mosaic of reshuffled parental chromosomes. Human changes are scattered throughout this vast landscape. 5% of our DNA differs from that of the chimpanzee genome if deletions and duplications are included. The search is one identifying key genetic changes.

Genome positions of human-lineage-specific gene changes. Human-lineage-specific (HLS) gene changes discussed in this paper are displayed in their corresponding genomic position across the human karyotype. The changes are divided into five categories that correspond to those listed in TABLE 1, and each type is color coded. It should be noted that many genes have undergone multiple types of HLS changes, and in this case only one type is shown. For visualization purposes, the size of the colored bands is not drawn to scale.

Single Gene vs Gene Networks

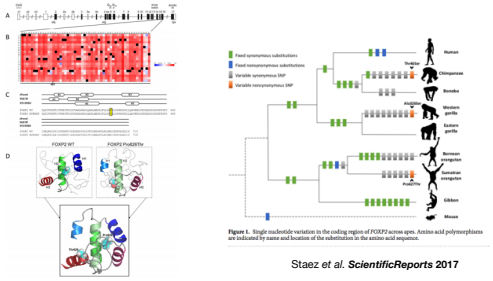


Fontenot and Konopka 2014 ***Curr. Opinion Genet. Devel.***

Genes can have powerful effects by themselves (e.g. sickle cell mutation in hemoglobin), but most genes are part of vast gene co-expression networks. slight alterations of gene expression and/or nature of transcritpion factor (proteins) can have large impacts on resulting networks.

Pleiotropic effects

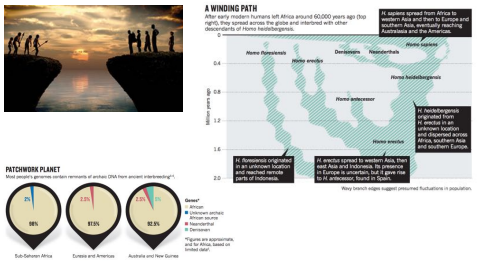
FOXP2 variation in great ape populations offers insight into the evolution of communication skills



Staez *et al.* ***ScientificReports*** **2017**

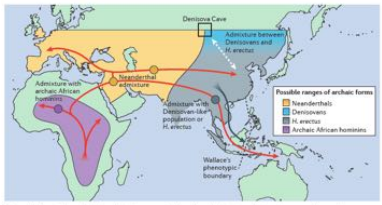
Many genes have more than one function!
pleiotropic: having multiple effects. e.g. the one encoding the protein FOXP2, a transcription factor (a protein that regulates the expression of hundreds of other genes by forming complexes with other proteins around gene regulatory region of the genome….)

The hybrid hominin: “Archaic admixture made us”



Solid evidence for “hybridization” or introgression of archaic genomes into modern human genomes.

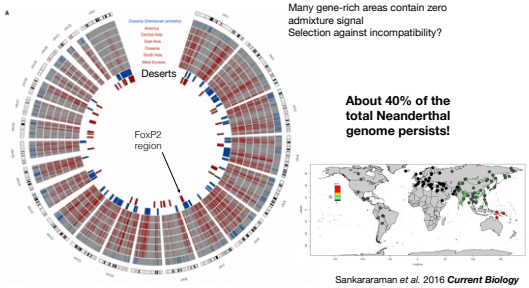
Hybridization happened



Veeramah & Hammer, ***NATURE Reviews Genetics***, 2014

A possible model of archaic introgression based on the latest analysis using second-generation sequencing. Red arrows indicate initial colonization events across the Old World after the origination of anatomically modern humans (AMHs) in Africa, including two movements into Asia. Approximate positions of introgression events are represented by coloured circles and are not intended to be accurate. This model portrays the hypothesis that portions of the Denisovan genome entered the human gene pool through hybridization with more widespread populations of archaic hominins (such as Homo erectus), which also interbred with the Denisovan population. The black arrow shows a more recent expansion of Asian farming populations (that is, <10,000 years ago) that did not carry introgressed Denisovan alleles and that replaced much of the indigenous resident population up to Wallace’s phenotypic boundary (shown by the dashed line), which lies just east of Wallace’s biogeographical line. This hypothesis may explain the lack of evidence for Denisovan introgression outside islands in Southeast Asia and Oceania.

Did not generate modern humans: “Deserts” of Archaic admixture



Sankararaman *et al.* 2016 ***Current Biology***

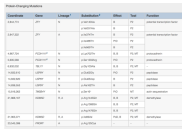
Distribution of Denisovan and Neanderthal DNA across the human chromosomes: The remaining archaic hominin DNA are concentrated in “gene deserts” areas with relatively few protein coding sequences and away from other know functional elements in the genome. This would indicate that there could have bee selection to purge such introgressed DNA. After .5 million years of independent evolution, one can safely expect that some of the Neanderthal/Denisovan genes, might have evolved too much to still “harmoniously” function with modern human genes.

more evidence for New genome liabilities: Y-chromosome, mt DNA?

Protein-coding differences between Neandertal and modern human Y chromosomes, including potentially damaging changes to PCDH11Y, TMSB4Y, USP9Y, and KDM5D. Three of these changes are missense mutations in genes that produce male-specific minor histocompatibility (H-Y) antigens. Antigens derived from KDM5D, for example, are thought to elicit a maternal immune response during gestation. It is possible that incompatibilities at one or more of these genes played a role in the reproductive isolation of the two groups.

Mendez *et al.* 2016 ***AJHG***

Many gene-rich areas contain zero admixture signal
Selection against incompatibility?



Mito-nuclear incompatibilities?

Sharbrough *et al.* 2017
Genome Biol. Evo

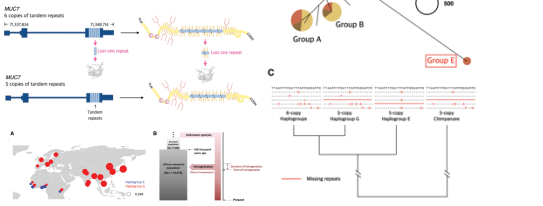
Both, the neanderthal Y-chromosome and the mitochondrial genome seem to have contained elements that gave rise to conflicts with the modern human genome.

Adaptive gifts from archaic hominids:

EPAS1 high altitude in Tibetans
BNC2 pigmentation in Europeans
POU2F3 keratinicyte proliferation in Europeans
HLA-C 15:05 allele disease resistance in Asia&Europe
TLR1/6/10 (Toll like receptors) innate immunity Asia & Europe
SLC16A11: Lipid metabolism (protection from starvation)Asia

There are however, several genes that have been actively retained in the genomes of modern humans, some just in relatively few local populations: EPAS1 in Tibetans and Sherpas in the Himalayan plateau appears to be a Denisovan variant that is highly adaptive for high altitude. Several disease -resistance genes have also been co-opted after hybridization.Genetic variants that protected against starvation are now genetic risks fro type 2 diabetes, an example of genomic mismatch between archaic genes and modern human lifestyle….

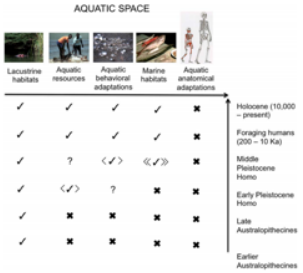
Saliva and African Archaic Admixture



Xu *et al.* 2017 ***Mol. Biol. Evo.***

MUC7 is one of over a dozen genes encoding mucins (glycoproteins in saliva and other secretions of our mucosal tissues). An African variant of MUC7 is extremely distant from all others found in humans, indicating that it may have introgressed into African human populations from another hominid species on that content only.

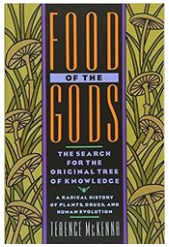
Aquatic Space



Foley and Lahr, 2014 ***Evol. Anthropol.***

Foley and Lahr have recently argued that there is value in retaining several ideas about the importance of human exploitation of aquatic and coastal niches and its rich resources.

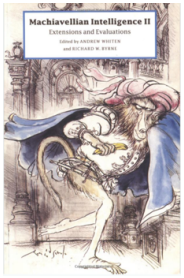
The Stoned Ape



Halucinogenic drugs from plants fungi and animals can contain “entheogens”

Their effects on the hominid mind contributed to self awareness and the uniquely human mind.

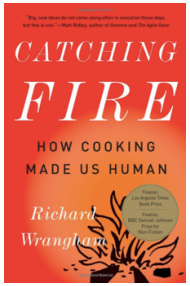
Machiavellian Intelligence



Social complexity of large primate societies selected for the capacity to manipulate others, i.e. use them as “social tools”

This selected for sophisticated cognition and larger brains.

Fire and cooking



Treating food with heat massively broadens feeding opportunities and improves caloric intake.

Cooked food represent clumped resources that can be stolen and need to be defended.

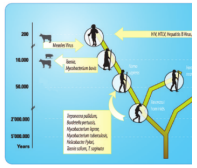
Creativity

Primate creativity, mostly in the context of simple tools use and social situations..

allowed the type of massively cooperative creativity that characterizes humans.

Evolved by Infection?

Parasites also utilize niche construction….. they can change their hosts



Molecular parasites (transposable elements), pathogens and parasites can shape the development, immune systems and behaviors of their hosts.

Trueba & Dunthorn, 2012 ***Plos Infect, Dis.***

The Mind as a key “adaptive landscape”

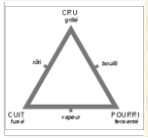
Denial: Self-Deception, False Beliefs, and the Origins of the Human Mind

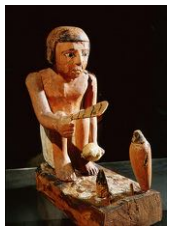
Ajit Varki and Danny Brower *Twelve* 384 pp. $27 (2013)

Do you skydive? Deep-fry? Chain-smoke? Denial of mortality is a strange trait that is also key to human nature, argues medic Ajit Varki. His argument stems from the ideas of late geneticist Danny Brower, who asked why species such as chimpanzees have not evolved to be aware of both self and the minds of others. Varki speculates that such intersubjectivity could only arise in tandem with 'death blindness', as fear would otherwise hamstring a species' fitness. A thoughtful foray into "mind over reality".

We need dialogues between disciplines to uncover our blind spots.

Cooking, no biological effects?





Claude Lévi-Strauss, one of the most influential Anthropologists of all times published on cooking, but strongly doubted that cooking would have a biological effect!
Sociocultural anthropology can be as blind to biology as biology is to human culture……

Genetic adaptation to cooking?

Mice fed raw or cooked food, differ in their gene expression:

Controlled feeding experiments in mice combined with with comparative primate genomics: show that consumption of a cooked diet influences gene expression and that affected genes bear signals of positive selection in the human lineage.

Genes affected by cooking were highly correlated with genes known to be differentially expressed in liver between humans and other primates, and more genes in this overlap set show signals of positive selection in humans than would be expected by chance.

Carmody *et al.* ***Genome Biol. Evol.*** 2016

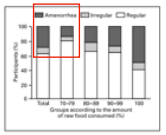


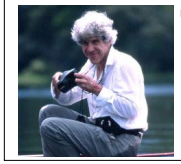
Fig. 4. Classification of menstruation occurrence in groups according to the amount of raw food consumed (n = 145).

Koebnick *et al.* ***Nutrition and Metabolism.*** 1999

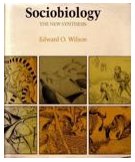
Lab mice prefer cooked meat and tubers. Fed such a diet, the genes changing expression in the mice's livers, when examined in primates, appear to have been under natural selection in humans compared toothier primates. One study of raw foods in Germany reported that 30% of adult women on raw food diet stopped ovulating. One of the strongest evidence that humans have become biologically dependent on cooking.

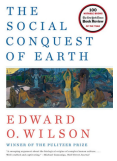
Language, no effects on prosocial behavior?

Edward O. Wilson



Bill Hamilton





Explaining human prosocial behavior by kin selection and reciprocal altruism.

Humans exhibit many prosocial tendency and engage in costly third party punishment for enforcing social norms.

Sociobiology has been very blind to human culture……
Wilson now argues that humans through their cultures are subject to group selection, a very contented notion among biologists.

Genes for behavior?

Bottom-up determinism.

Complex interplay between biology and culture!

Cultural inheritance

- Estimates for the heritability of "intelligence" dropped from above 80% to single digits. Feldman and Ramachandran, ***Philos Trans R Soc Lond B Biol Sci.*** 2018
- Cultural transmission from parent to offspring can mimic genetic heritability. Cavalli-Sforza and Feldman, ***Am J. Hum. Genet.*** 1973.
- Extreme polygenicity: "typical human behavioral trait associated with very many genetic variants, each of which accounts for a very small percentage of behavioral variability"—> **omnigenicity**. Boyle *et al.* ***Cell*** 2017.

A new type of ecological niche: ratcheting/cumulative cultures, both technical and social!

Human spirit freed from biology?

Modern humans are free to shape their destiny.

Cultural impact on biology and biological impacts on culture!

Parasites can manipulate your personality

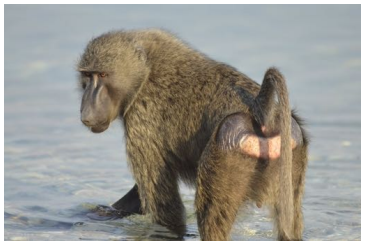
- *Toxoplasma gondii* infection causes changes in risk-taking behavior. Flegr ***Schizophr Bull***. 2007
- Not looking at distant views outdoors (reading books or tablets) causes myopia. Xiong *et al.* ***Acta Ophthalmol.*** 2017
- Life in cities affects the composition of your microbiome and several health parameters. Gupta *et al.* ***Front Microbiol. 2017***

A new type of ecological niche: ratcheting/cumulative cultures, both technical and social!

Comparative Primatology moment

"*Nyani haoni kundule – huliona la mwenziwe*"
The baboon does not see its behind – bit regularly sees those of others.

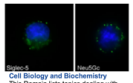
Swahili Proverb



Matrix of Comparative Anthropogeny MOCA

Anatomy and Biomechanics
This Domain lists topics relating to bodily structure as discovered by dissection, including skeletal and soft tissues, as well as topics relating to the movements of the organism.

Behavior
This Domain lists topics related to Behavior, i.e., manner of conducting oneself in the external relations of life; demeanor, deportment, bearing, manners or the expression of an effort to adapt or adjust to different internal and external conditions.



Cell Biology and Biochemistry
This Domain lists topics dealing with composition and function of animal cells, with the substances present in living organisms and their relation to each other and to the life of the organism.

Cognition
This Domain lists topics related to the set of abilities dealing with knowledge taken in its widest sense, including phenomena such as perception, attention, memory, learning, symbolization, conception, and communication.

Communication
This Domain lists topics dealing with the imparting, conveying, or exchanging of ideas, knowledge, information, etc. whether by vocalization, body movements, speech, or signs.

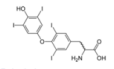
Culture
This Domain lists topics dealing with the distinctive ideas, customs, social behaviors, products, or way of life of societies, peoples, or periods, and their transmission across generations.

Matrix of Comparative Anthropogeny MOCA cont'd

Dental Biology and Disease
This Domain lists topics dealing with the teeth.

Development
This Domain lists topics dealing with growth and unfolding of organs and organisms.

Ecology
This Domain lists topics dealing with relationships between living organisms and their environment.

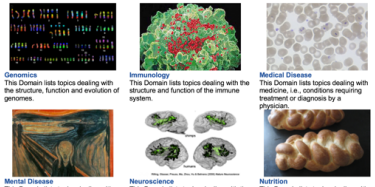


Endocrinology
This Domain lists topics dealing with the physiology or study of the endocrine glands, having an internal secretion, which is poured into blood or lymph and acts at distance.

General Life History
This Domain lists topics dealing with key maturational and reproductive characteristics defining the life course. The history of changes undergone by an organism from conception to death.

Genetics
This Domain lists topics dealing with inherited variation in living organisms, and some of the genetic processes responsible for this.

Matrix of Comparative Anthropogeny MOCA cont'd



Genomics
This Domain lists topics dealing with the structure, function and evolution of genomes.

Immunology
This Domain lists topics dealing with the structure and function of the immune system.

Medical Disease
This Domain lists topics dealing with medicine, i.e., conditions requiring treatment or diagnosis by a physician.

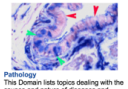
Mental Disease
This Domain lists topics dealing with temporary or permanent impairment of the mind due to inherited defect, injury, illness, or environment, usually needing special care or rehabilitation.

Neuroscience
This Domain lists topics dealing with the structure or function of the nervous system.

Nutrition
This Domain lists topics dealing with the action or process of supplying, or of receiving, nourishment or food.

Matrix of Comparative Anthropogeny MOCA cont'd

Organ Physiology
This Domain lists topics dealing with the normal functioning of living organisms and their systems and organs.



Pathology
This Domain lists topics dealing with the causes and nature of diseases and abnormal anatomical and physiological conditions.

Pharmacology
This Domain lists topics dealing with drugs and their uses, as well as the physiological response of an organ or its function to drugs or other pharmacologically active substances.

Reproductive Biology and Disease
This Domain lists topics dealing with biological traits related to reproductive organs and systems, their function and diseases.

Skin Biology and Disease
This Domain lists topics dealing with biological traits related to the integument (skin).

Social Organization
This Domain lists topics dealing with social groups, their sizes, composition, spatial distribution and relative stability.

Matrix of Comparative Anthropogeny MOCA Graphic Tools

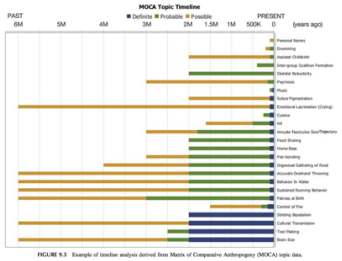


FIGURE 9.3 Example of timeline analysis derived from Matrix of Comparative Anthropogeny (MOCA) topic data.

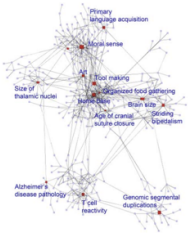
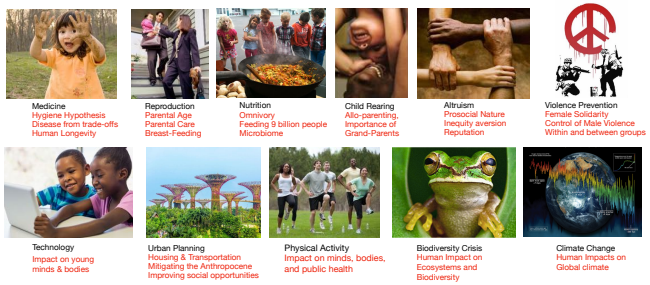


FIGURE 9.4 Example of a relational Matrix of Comparative Anthropogeny (MOCA) topics.

Varki and Gagneux 2017 in On Human Nature

Examples of graphic tools on the CARTA MOCA webpage. time lines and interconnections between distinctly human traits may one day "tell the story"…

Utilitarian Arguments for Anthropogeny



Better understanding of our origin will inform many aspects of what we do: EVOLUTIONARY MEDICINE: Hygiene hypothesis, NUTRITION: an omnivorous ape that became top predator and then settled and tamed plants and animals; ALTRUISM:ho to promote pro social behavior and curtail harmful selfish behavior; REPRODUCTION: reproductive timing, importance of young parents; CHILD REARING: cooperative breeding; VIOLENCE PREVENTION: limiting situations that foster violence; EDUCATION: role of trust, emotion and impact of technology; HEALTH: role of physical activity on minds and bodies.BIODIVERSITY CRISIS and CLIMATE CHANGE, both linked to human activities form giant challenges that require novel insights into human nature and huge behavioral changes at a global level..

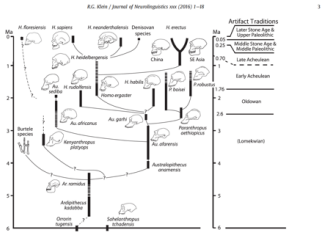
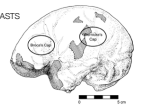


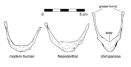
Fig. 1. Left: A hypothetical phylogeny of the hominins. Right: Paleolithic technological stages. Modified after (Klein, 2009, Fig. 4.49), which provides supporting references.

Hard Evidence for language?

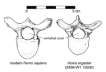
ENDOCASTS



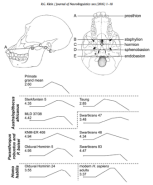
HYOID (TONGUE) BONE



THORACIC VERTEBRAL CANAL

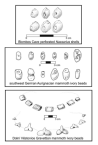


BASICRANIAL FLEXION



2 million to 50 ky?

BEADS (SYMBOLISM)



ABSTRACT AND FIGURATIVE ART

Klein, 2016 ***J. Neurolinguistics***

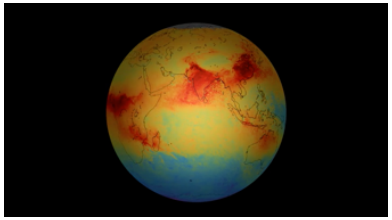
A selection of cultural packages

- Mbuti pygmies: fire, huts, dogs, projectile weapons, hunting nets, music, drugs, rituals, taboos, patrilineal and sister exchange common, mostly monogamous
- Khoisan: fire, huts, carrying slings, projectile weapons, arrow poison, containers, rituals taboos
- Penan: fire, huts, blow gun, arrow poison, music, hunting traps, rituals, taboos
- Polynesians: fire, huts, outrigger canoes, crops, domestic animals (chicken, pig, rat and dog), navigation, rituals, taboos (and tattoos)
- Inuit: fire (oil fire), snow huts, clothing, eye protection, projectile weapons for marine hunting, kayaks, dogs, sleds, rituals, taboos.





Space: Thousands of kilometers: Global CO



Visualizing the Anthropocene!

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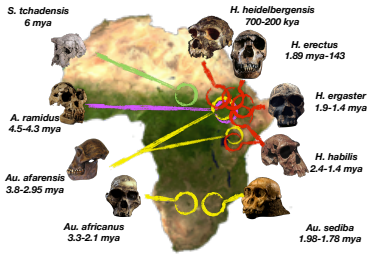
https://www.nzz.ch/panorama/der-umweltsatellit-sentinel-5p-zeigt-luftverschmutzung-auf-der-erde-ld.1334755

1 December 2017， Launched on 13 October, the Sentinel-5P satellite has delivered its first images of air pollution. Even though the satellite is still being prepared for service, these first results have been hailed as exceptional and show how this latest Copernicus satellite is set to take the task of monitoring air quality into a new era. This new mission promises to image air pollutants in more detail than ever before. And, while these first results demonstrate the sophistication of the satellite's instrument, they certainly bring the issue of air pollution sharply into focus. One of these first images shows nitrogen dioxide over Europe. Caused largely by traffic and the combustion of fossil fuel in industrial processes, the high concentrations of this air pollutant can be seen over parts of the Netherlands, the Ruhr area in western Germany, the Po Valley in Italy and over parts of Spain.
Global carbon monoxide measured by Sentinel-5P。 Access the video： Some of the first data have been used to create a global map of carbon monoxide. The animation shows high levels of this air pollutant over parts of Asia, Africa and South America.

Time: millions of years, hominin fossils

Hominin Fossils older than 2 million years: only in Africa



Without exception, all really old fossils of upright walking hominins are only found in Africa.