What's new in Hominid Evolution

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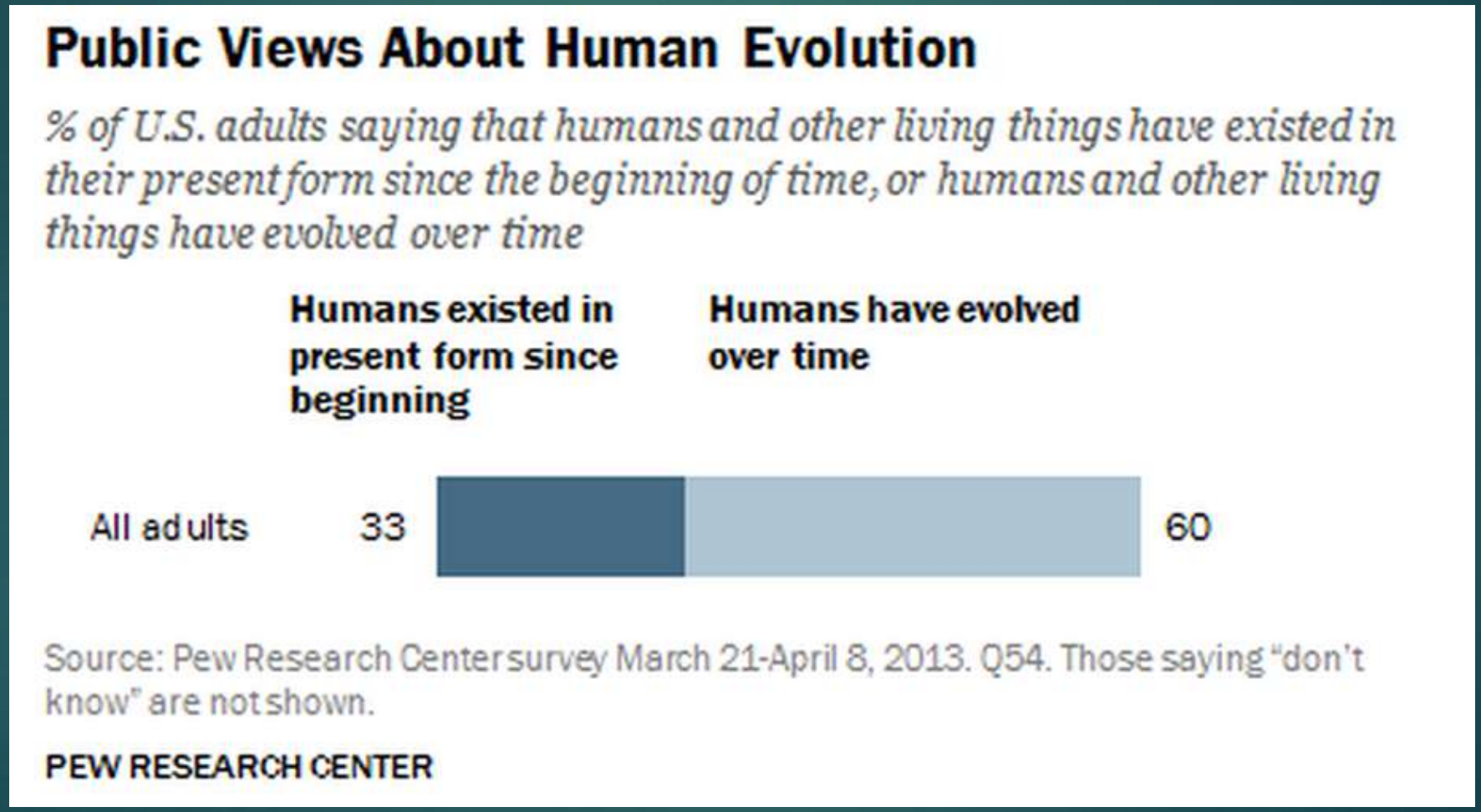
JANUARY 26, 2015

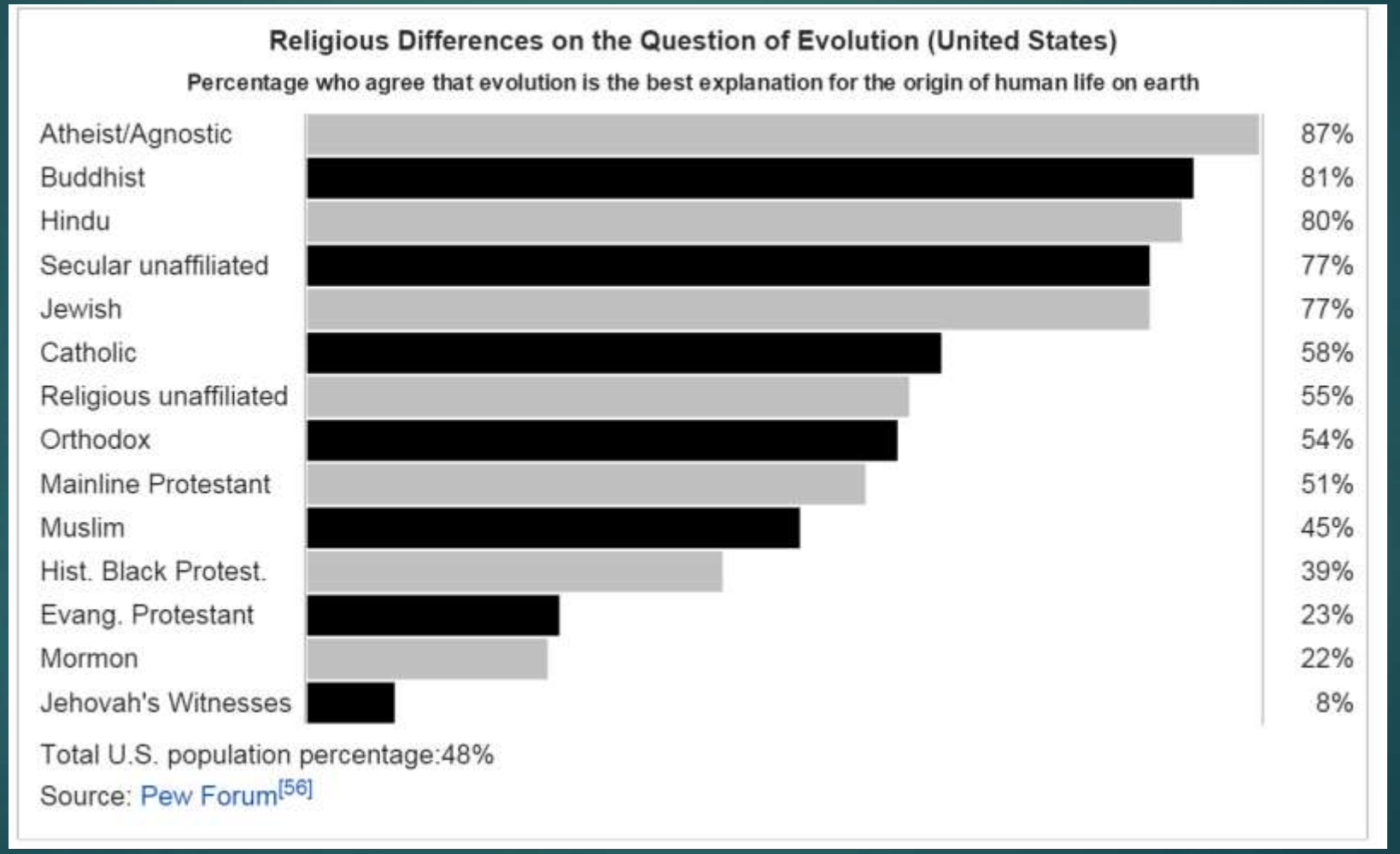
Charles Darwin

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change."

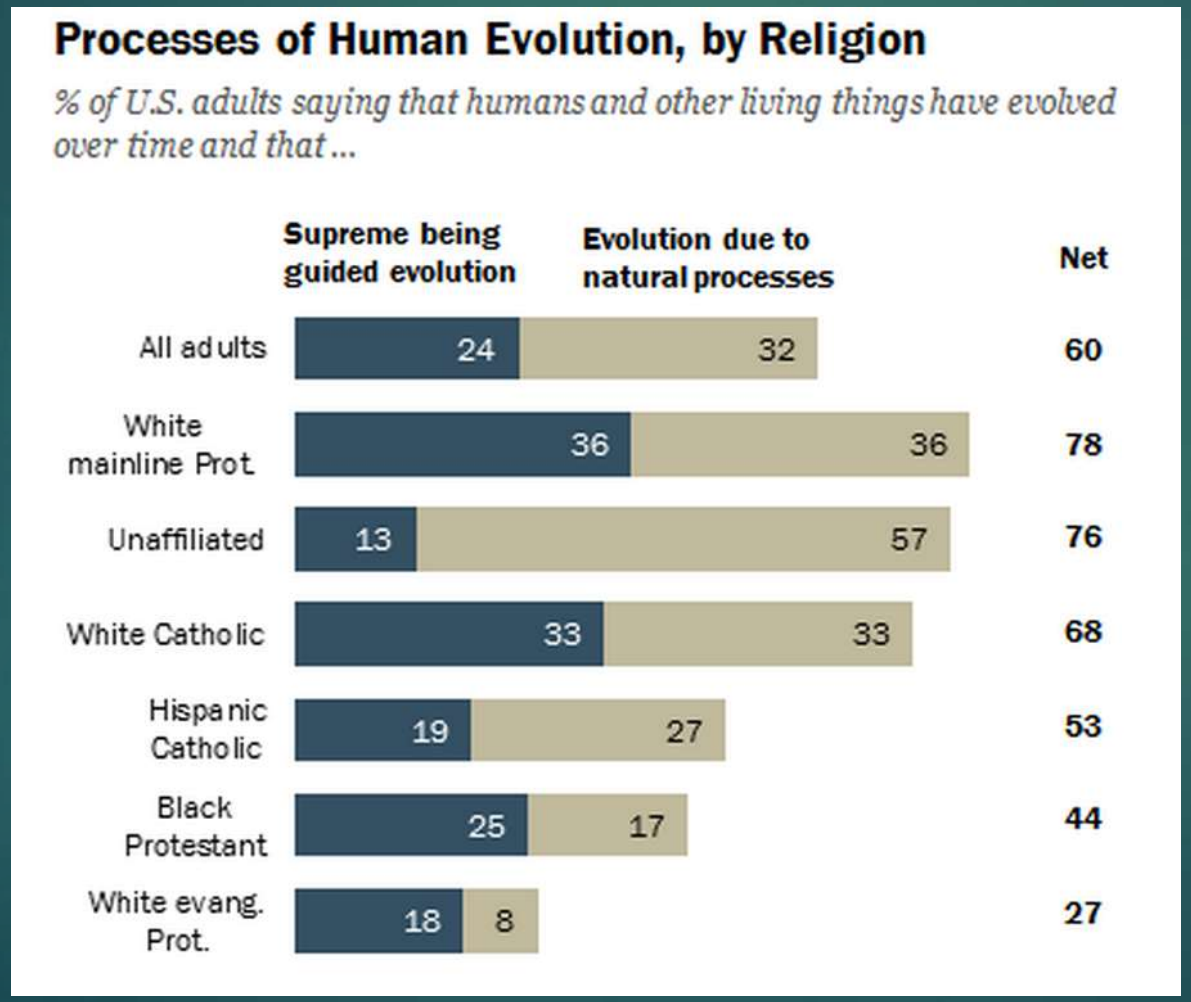
Only 60% Accept Evolution in USA



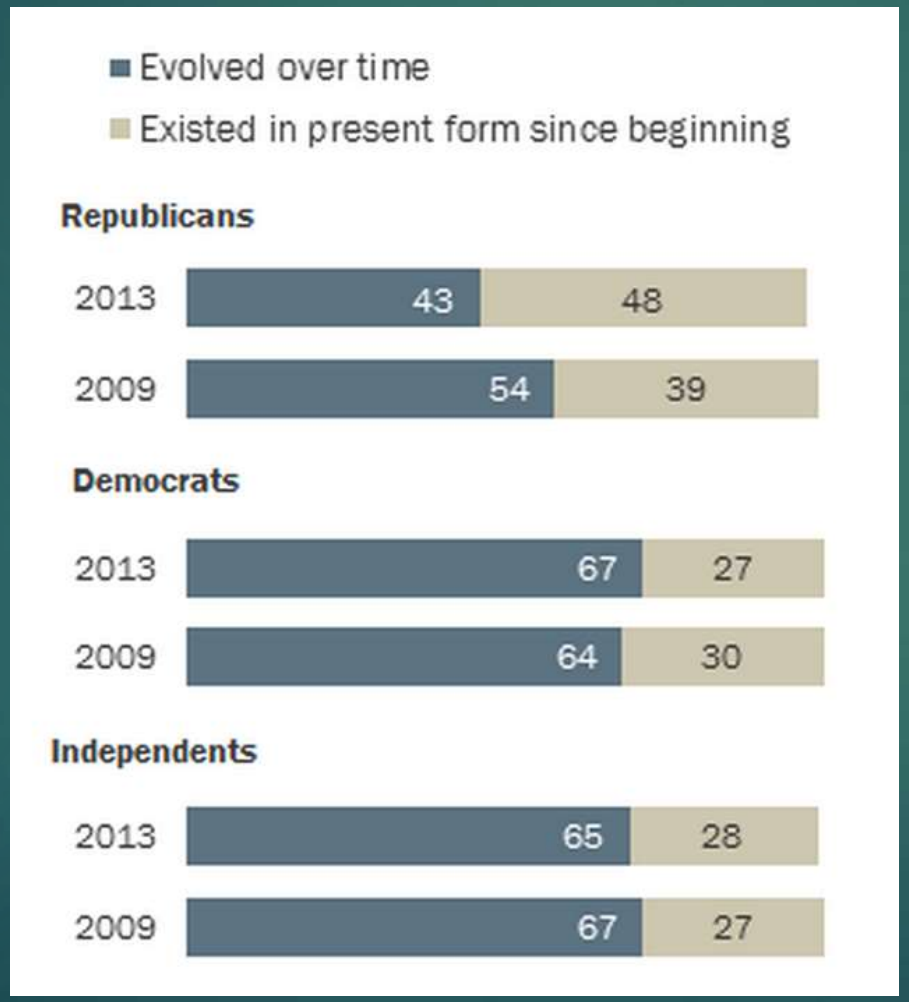
Acceptance of Evolution



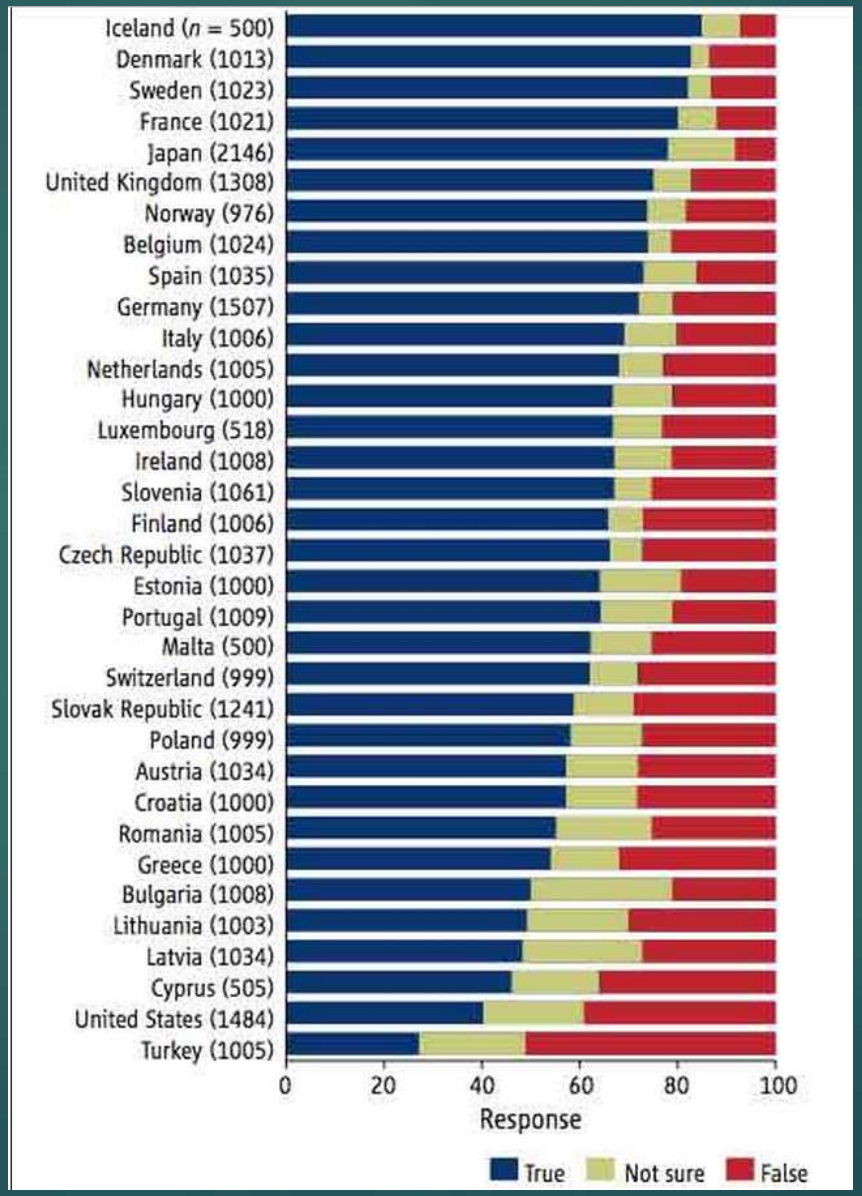
God (24%) or Nature (32%) driving evolution



By Political party:
Independents & Democrats –Yes; Republicans - No



By Country: USA is 33rd of 34 Countries



Evolution

- If you say: “It’s just a theory.”
- I hear: “I don’t have a basic understanding of science.”

Current evidence of evolution

- Misuse of pesticides on California cotton crops: most crop pests are now immune to most of our pesticides. Some feed on the pesticides. Natural selection has an amazing ability to change organisms for survival.
- Misuse of antibiotics in animals: increasing bacterial resistance to all of our antibiotics, i.e. staph (staphylococcus bacteria) resistance in hospitals
- **16 new antibiotics came to market between 1983 and 1987, but only two were developed between 2003 and 2007.**

Examples of fast Evolution

peppered moths (Biston betularia): Before the industrial revolution, a uniformly dark variant of the peppered moth made up 2% of the species. After the industrial revolution, 95% of peppered moths showed this dark coloration.

The Asian shore crab (Hemigrapsus sanguineus) is an invasive species in New England which feeds on the native blue mussels. It has recently been observed that mussels, when they detect Asian shore crabs, develop thicker shells to stop the crabs eating them.

Fast evolution 2: Olympic village effect

Cane toad in Australia is probably one of the world's most famous invasive species; highly destructive. toads at the front of the invasion wave are likely those best adapted for spreading fastest: found to be bigger, hardier, had longer legs allowing for greater speed, and were more active.

Darwin's Finches

Peter and Rosemary Grant: competition of two rival species. The medium ground finch was well established on the isle of Daphne, and had been studied in depth. Its beak was suited perfectly for cracking large nuts. In 1982, the large ground finch from a neighboring island arrived. These larger finches could drive away the native medium ground finches and would eat all the large nuts. The medium ground finches of Daphne island developed smaller beaks more suited to the smaller nuts, ignored by the invading larger finches.

Blue Moon Butterfly and its parasite

The Blue Moon Butterfly (Hypolimnas bolina) of the Samoan islands was being attacked by a parasite which destroyed male embryos. Males ended up making up only 1% of the butterfly population. Within ten generations (~1 year) males had returned to 40% of the population. Parasite is still present, but is no longer deadly to male embryos. This case shows how a mutation giving an advantage can rapidly spread throughout a population. Any male with the ability to survive infection would be able to mate with a great many females, due to the paucity of other males, and spread his immunity through the gene pool.

Richard Lenski and E. coli: Life evolves

Since 1988, he has grown 12 colonies of E. coli. from a single ancestor strain has been studied. Since then, over 50,000 generations (20 years) of E. coli have been and gone, and the differences between the populations and each population from the ancestor strain have been documented.
Over time the bacteria have become far more efficient at growing under the conditions used. This study has provided evidence of how evolution actually occurs. One of the populations developed the ability to utilize citrate as a nutrient, something otherwise unknown in E. coli under similar conditions

Did you know that your own bowels harbor something like a billion (1,000,000,000) E. coli at this very moment? So **remember to wash your hands** after going to the toilet, as I hope your mother taught you. Simple calculations imply that there are something like 10^20 = 100,000,000,000,000,000,000 E. coli alive on our planet at any moment. Even if they divide just once per day, and given a typical mutation rate of 10^-9 or 10^-10 per base-pair per generation, then pretty much every possible double mutation would occur every day or so. That's a lot of opportunity for evolution.

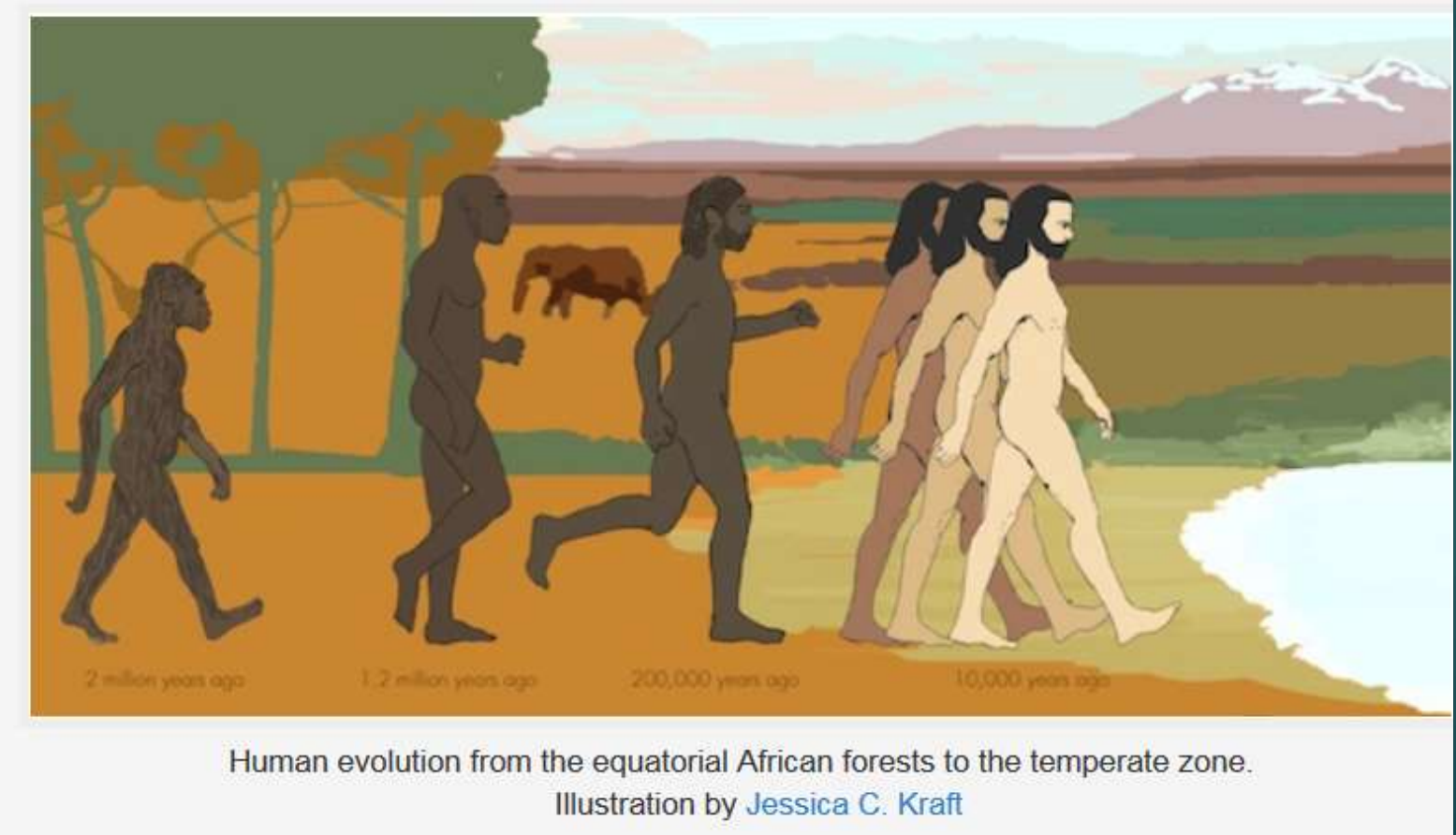
Why do modern humans have different skin colors? Evolution!!!





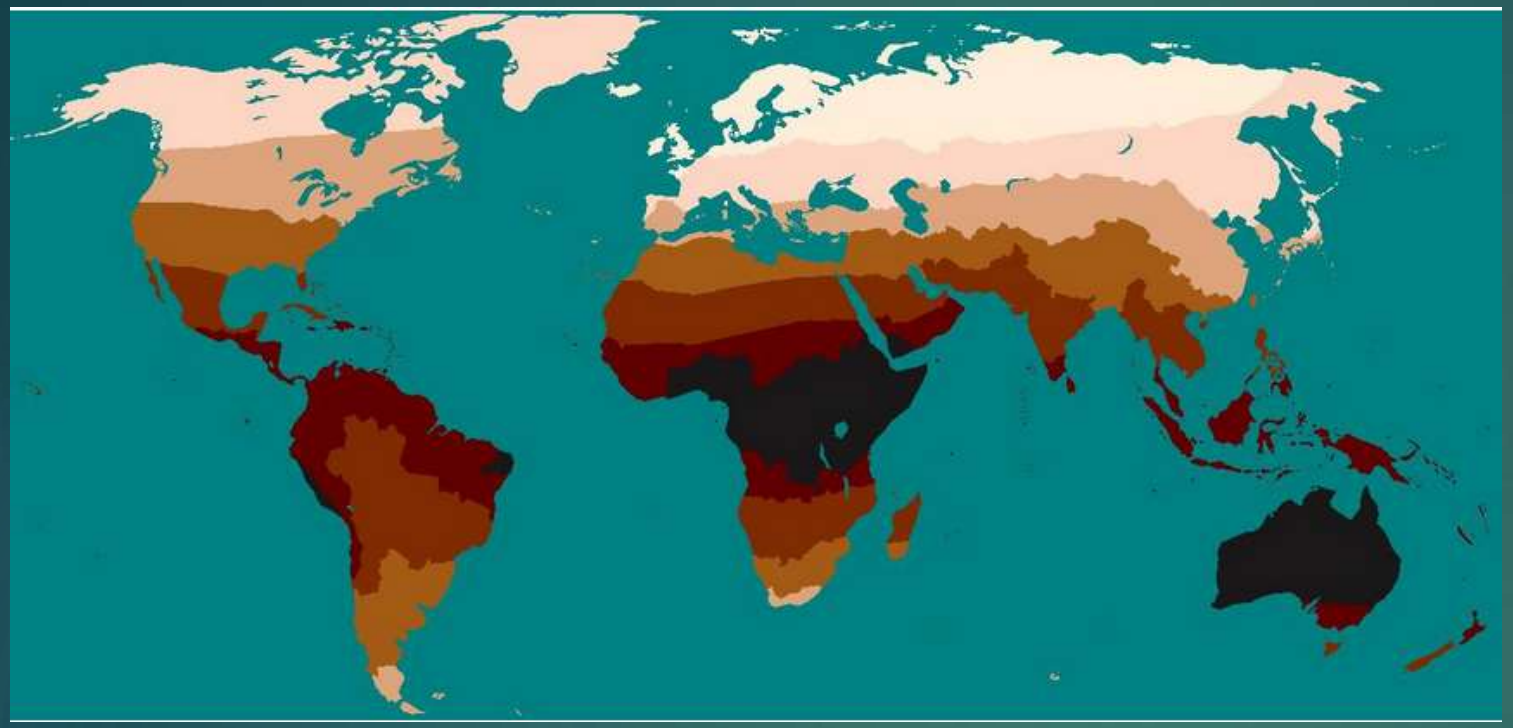



Latitude is the key to skin color evolution



Human evolution from the equatorial African forests to the temperate zone.
Illustration by Jessica C. Kraft

Global distribution of skin color via latitude, 20K-5K



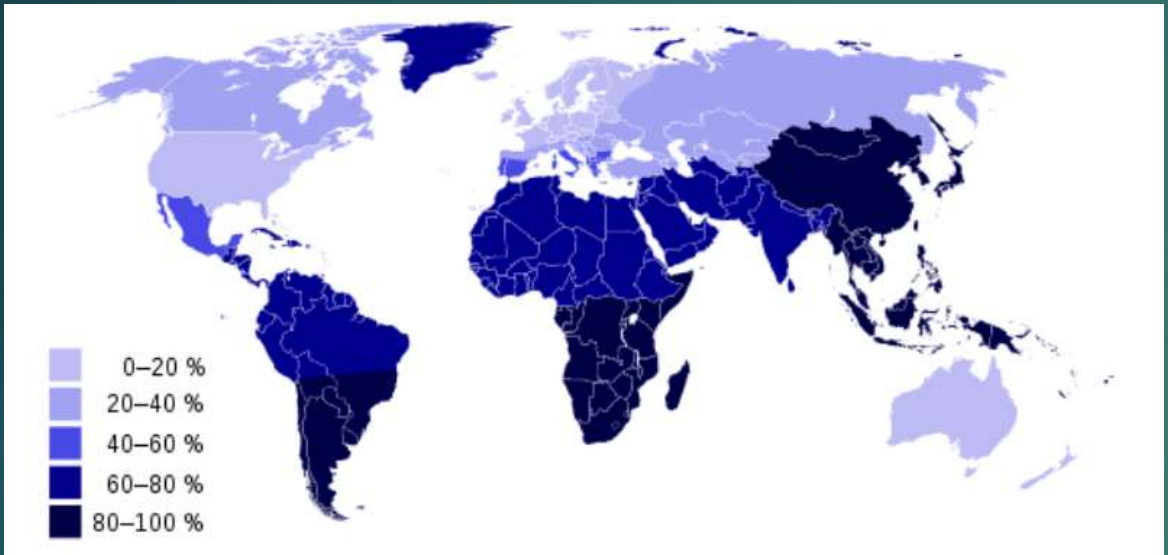
Southern darker pigmentation for UV protection;

Northern lighter = vitamin D synthesis

Skin color varies according to latitude and therefore by the intensity of incident ultraviolet light. Populations closer to the equator have darker skin; those further away, lighter skin.

It has nothing to do with “race”, a non-biological concept.

Got Milk!: Example of evolution in last 10,000 years - Evolution of lactose tolerance



75% of the global population is lactose intolerant.

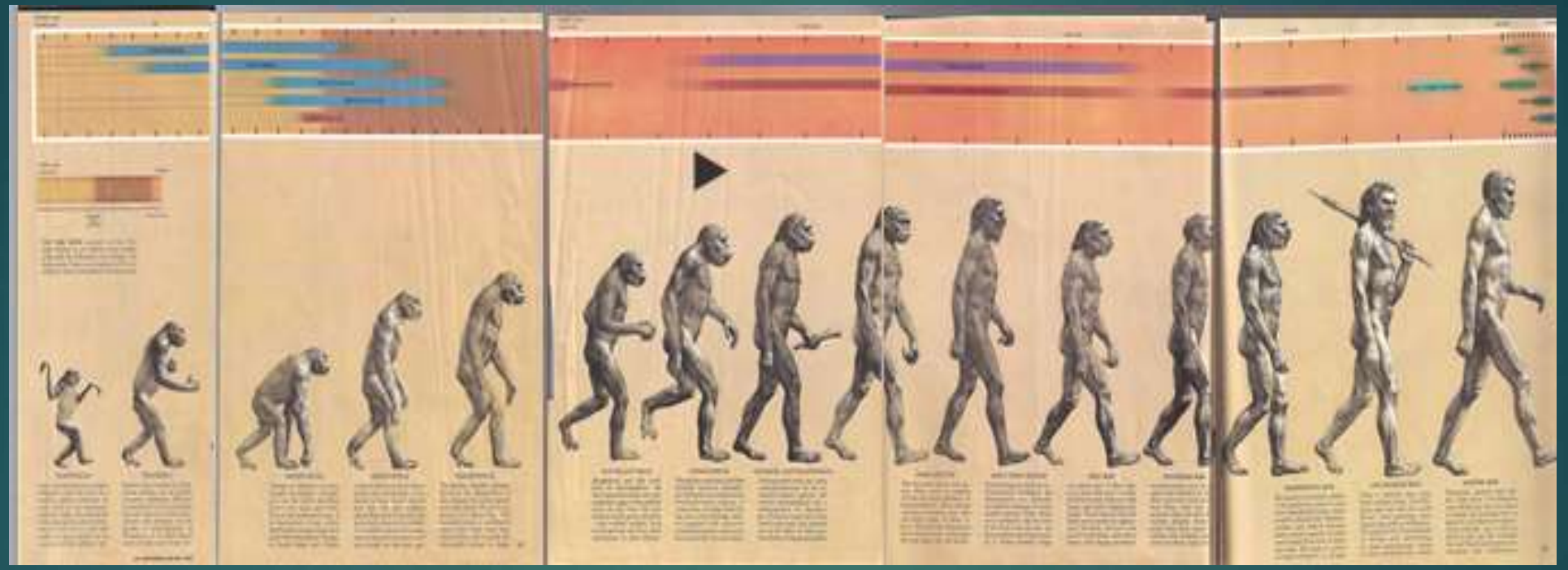
Lactase is an enzyme needed for the metabolism of the lactose sugar found in milk. Ability to drink milk as an adult is due to some individuals living around 4,000 BC in Sweden or the Middle East who acquired a particular mutation on chromosome 2. This gave an evolutionary advantage following the first domestication of cattle and rise of dairy farming since milk then became a valuable source of nutriment. Most of Western Europeans have inherited this mutation and can safely consume milk. Native Americans are 100% lactose intolerant. So was Charles Darwin.

You Share 50% of Your DNA with:

You are related to every living creature on earth

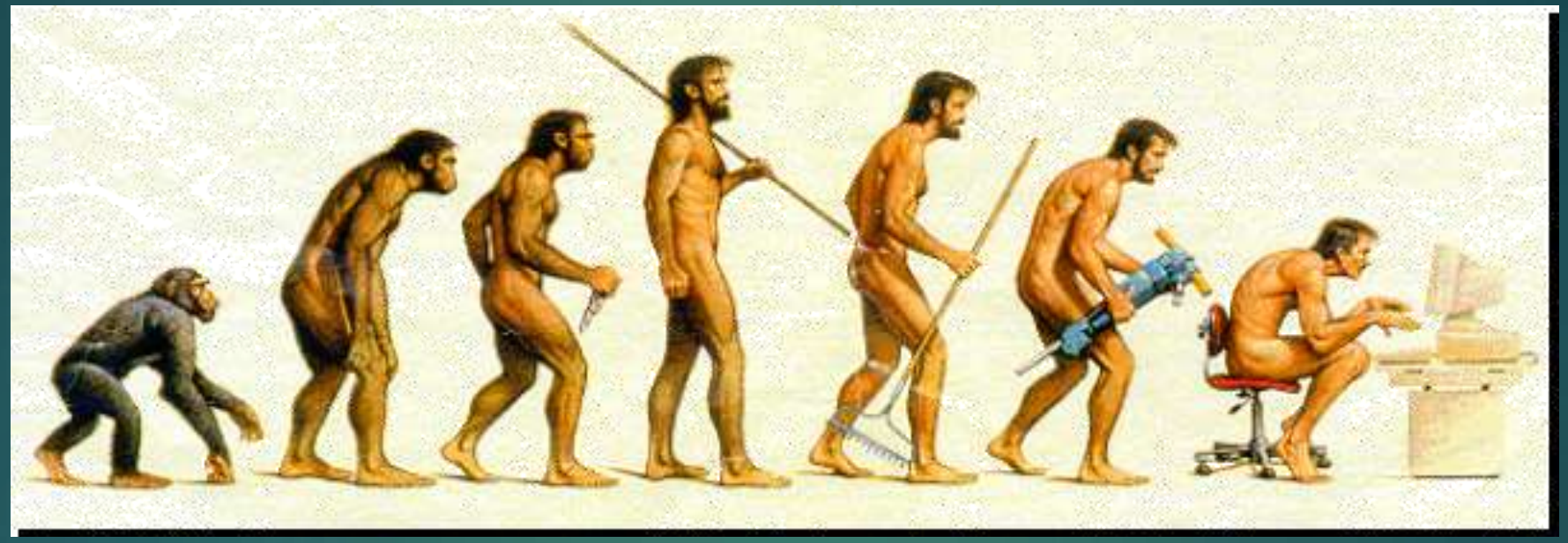
You share 98.4 % of your DNA with Chimpanzees

F. Clark Howell's famous, but misleading, march of hominid evolution (Early Man book)



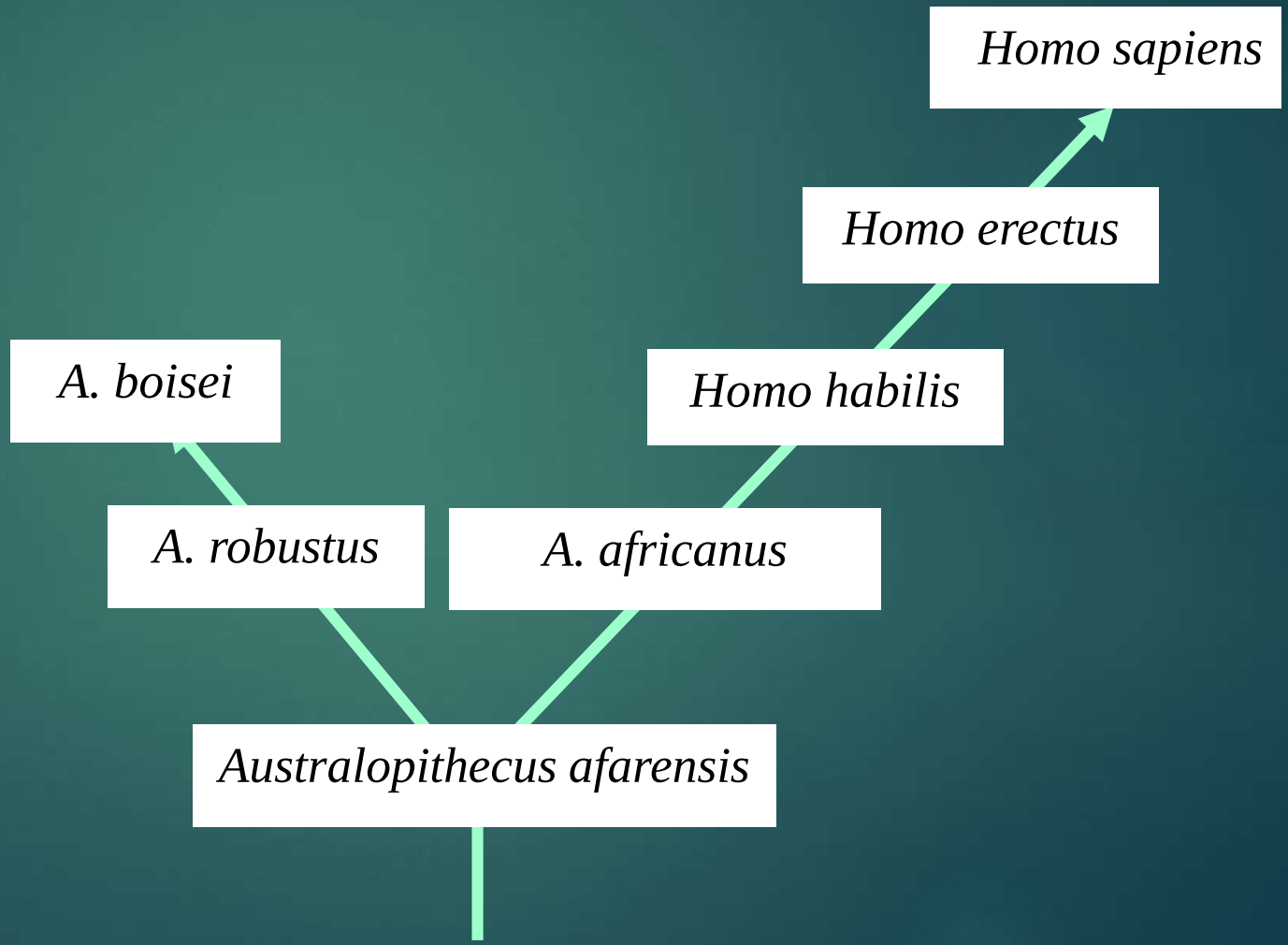
Evolution is not a unidirectional march towards perfection (*Homo sapiens)*

Classic view of Human Evolution

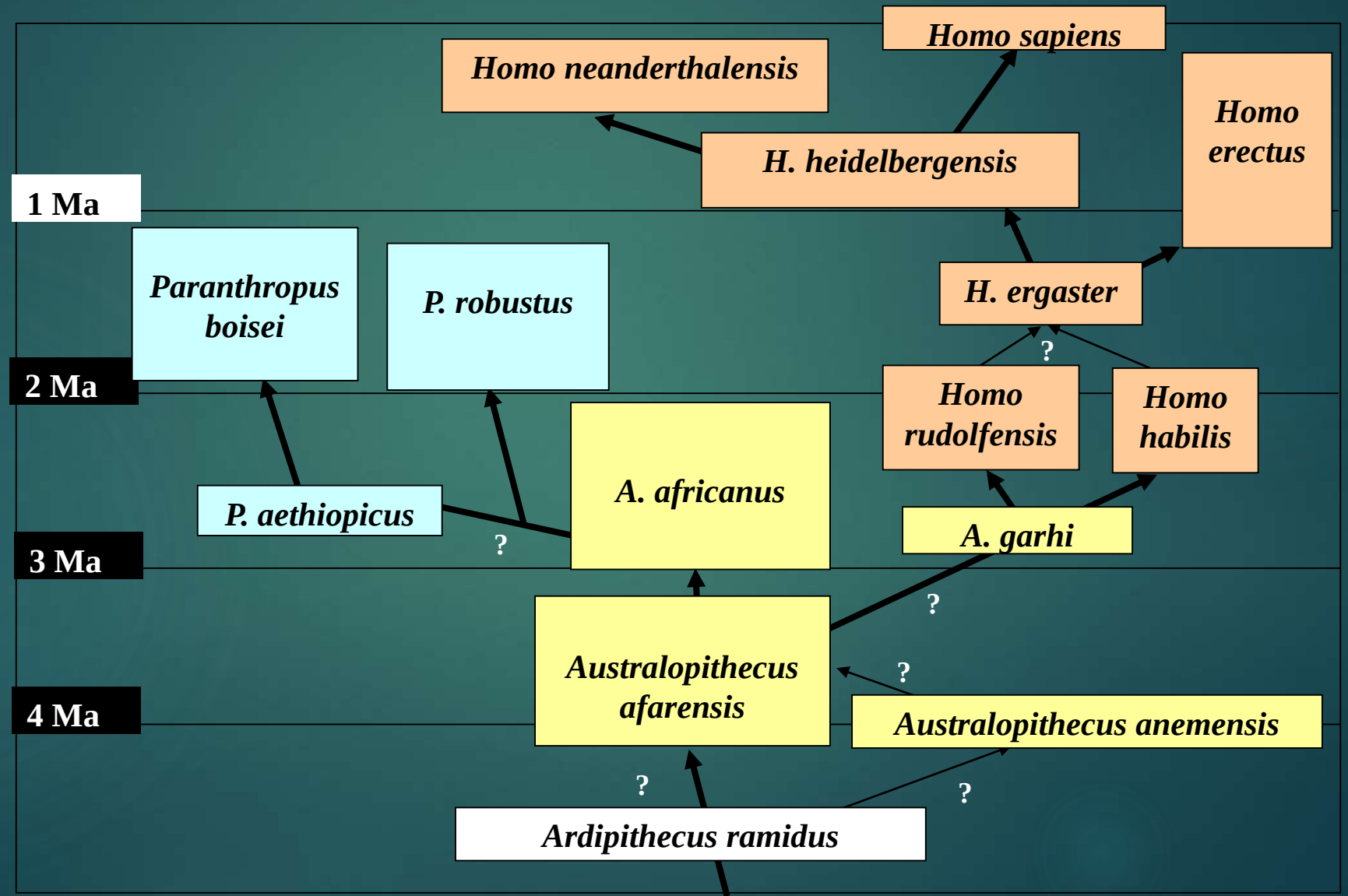


1991 Changing status

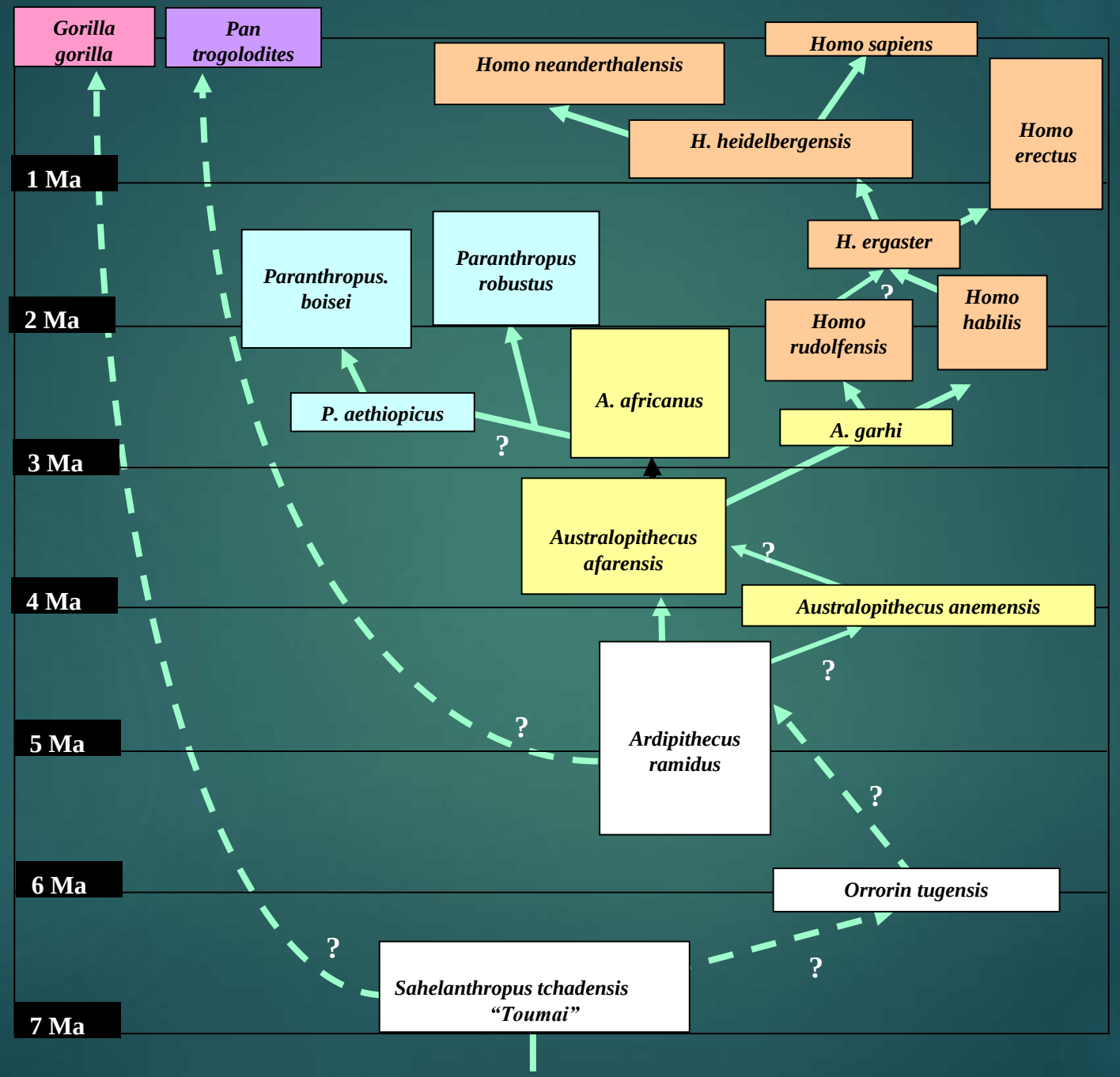
As more specimens were found a clearer idea developed of the relationships between them



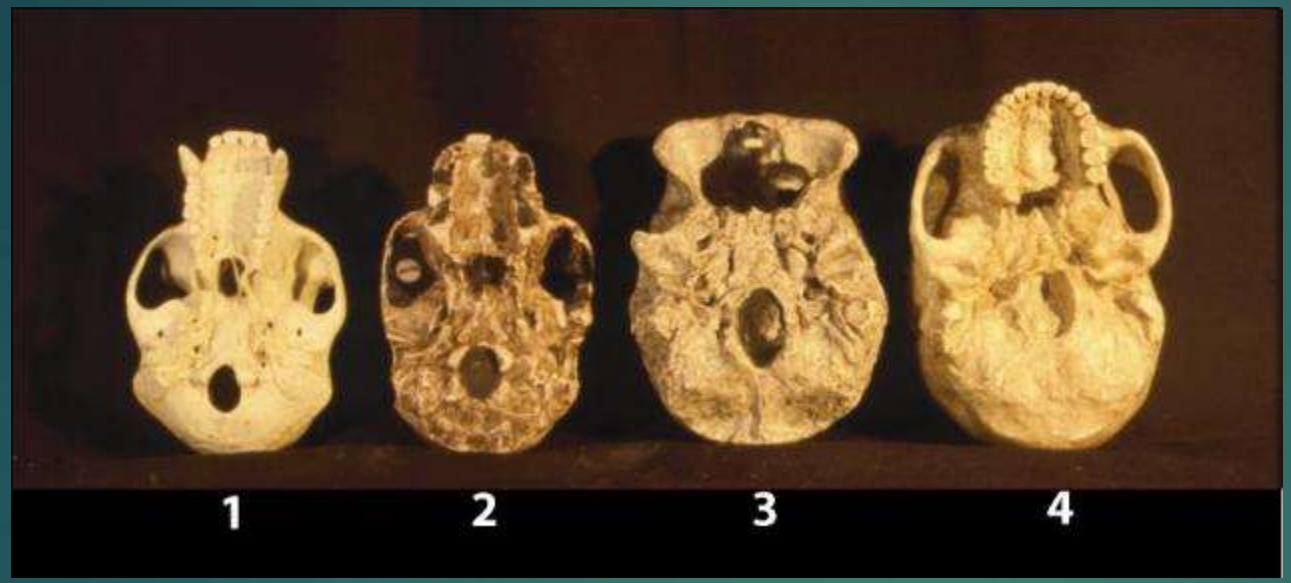
2001 From a tree to a bush



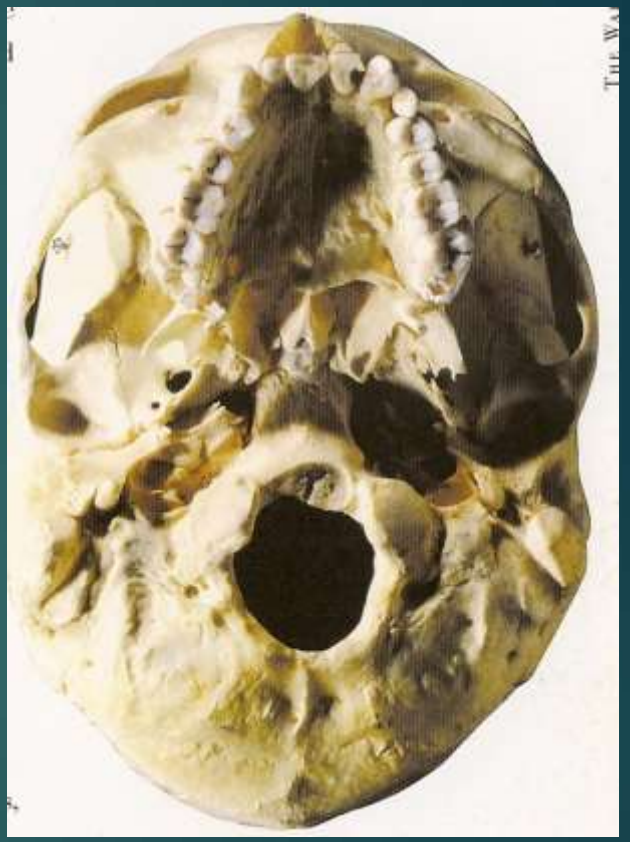
2003 DEEPER ROOTS



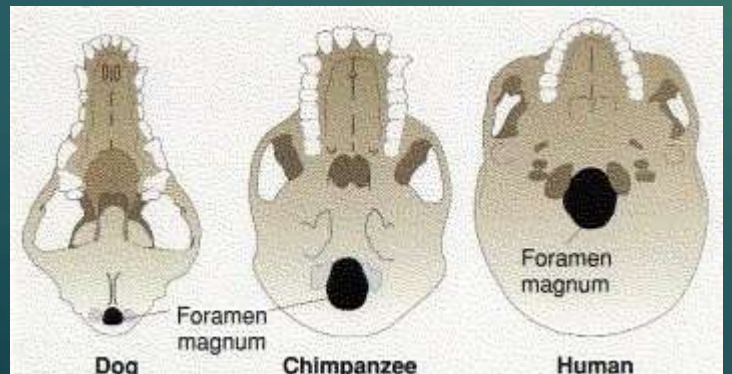
Foramen magnum: Ape vs. Hominid



1. Chimpanzee 2. *Australopithecus africanus* 3. *Pithecanthropus erectus* 4. *Homo sapiens*



In the back



More forward

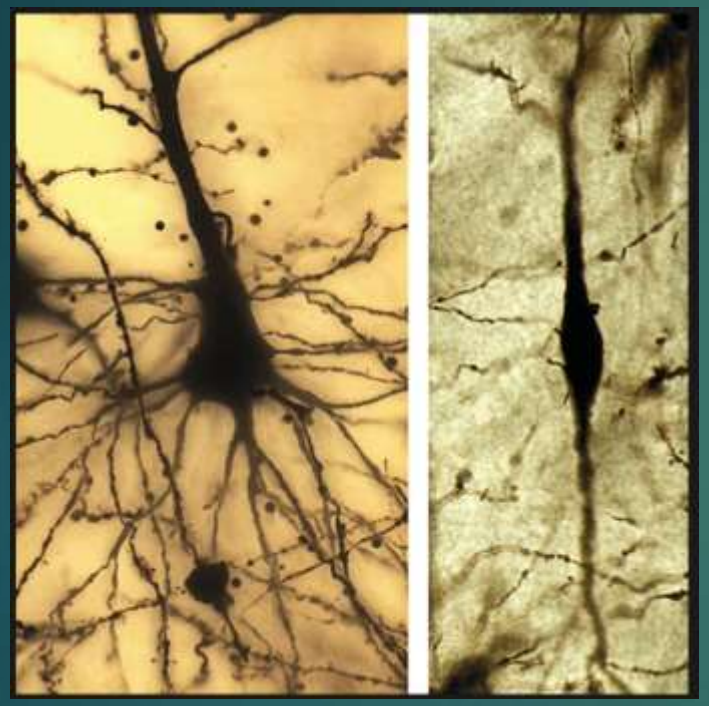
Modern human

Robin Ian MacDonald Dunbar (1947-): Social Brain Hypothesis

- 1998: study proposing the Social Brain Hypothesis, which states brain size increases with social group size and complexity

What is the neuron in all social animals with large brains?

Von Economo Neuron: Brain Cells for Socializing?



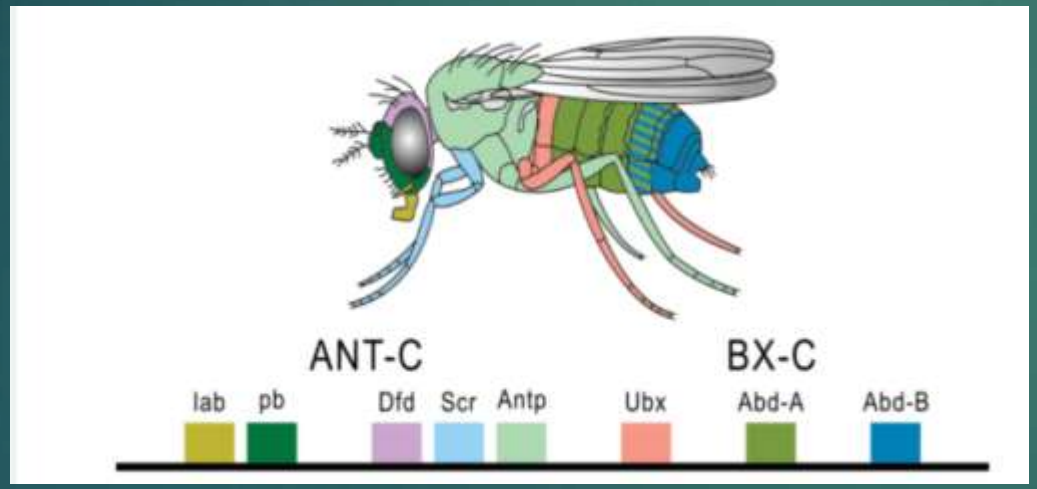
A focal concentration of VENs in ACC and FI distinguishes large-brained, highly social mammals from other mammalian species.

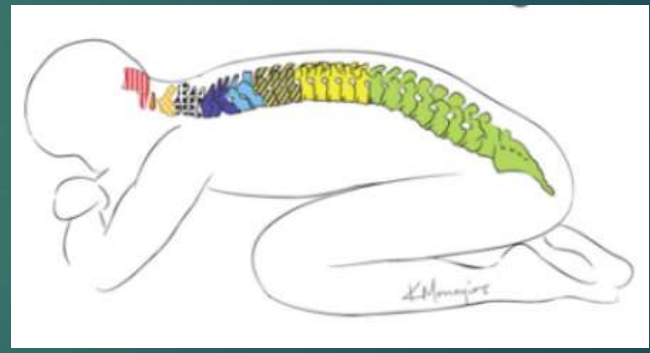
Frontal Dementia wipes out these VENs = Loss of social abilities

(Allman et al., 2010; Hakeem et al., 2009; Hof and Van der Gucht 2007; Nimchinsky et al., 1999; Rose 1928)

Evo-Devo: Same genetic body plan for 600M

- HOX gene: **All animals have *Hox genes***, and nearly all animals use their *Hox* genes to determine which body parts go where; 600M years old





Sahelanthropus tchadensis: Miocene ape or hominid

- 7 Million ya,
- Single Skull; no skeleton
- Cranial size: 350 cc

- Foramen magnum shape and position indicate bipedalism

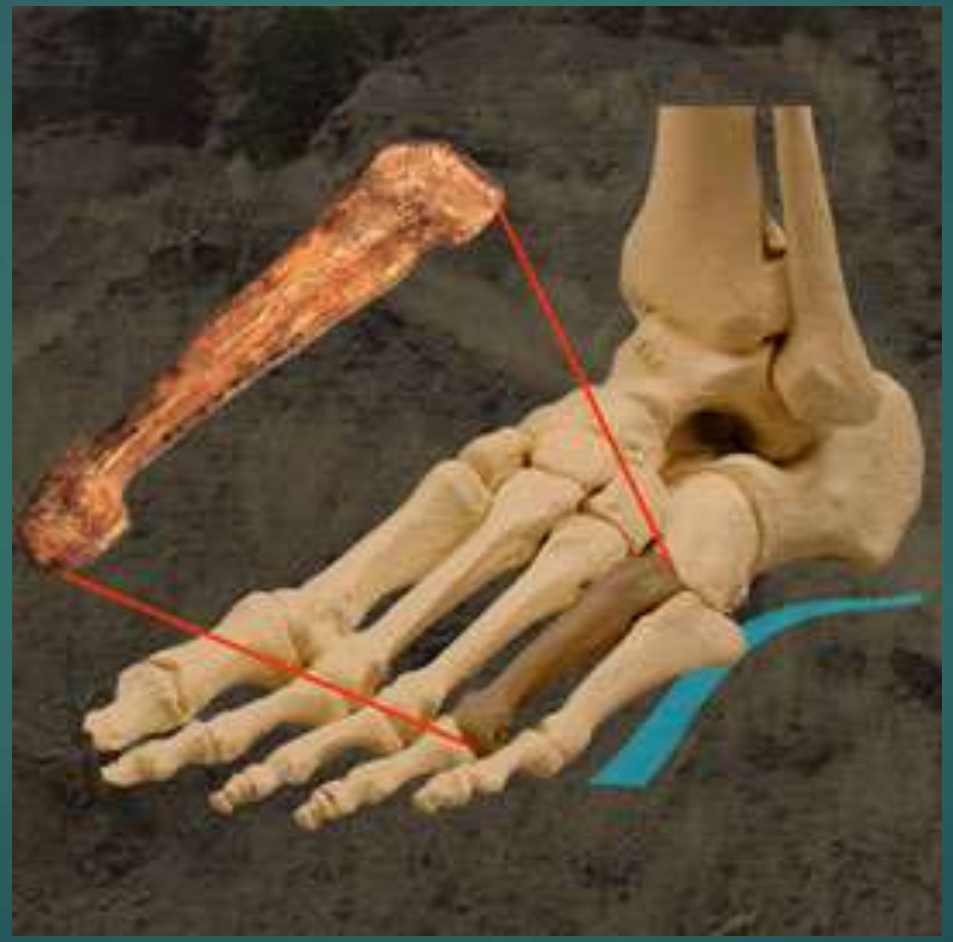
- Larger supraorbital torus than any other hominid or living ape

Posteriorly projecting occipital lobes, a tilted brainstem, and a laterally expanded prefrontal cortex, among other hominin brain characteristics.

Latest Lucy reconstruction

A. afarensis, Lucy, 1974
Science reconstruction, 2013

Lucy's foot: arched



New research: metacarpal bone indicates arched foot (bipedal sign)

1978: Laetoli Footprints: *A. afarensis* male and female, 3.6 M

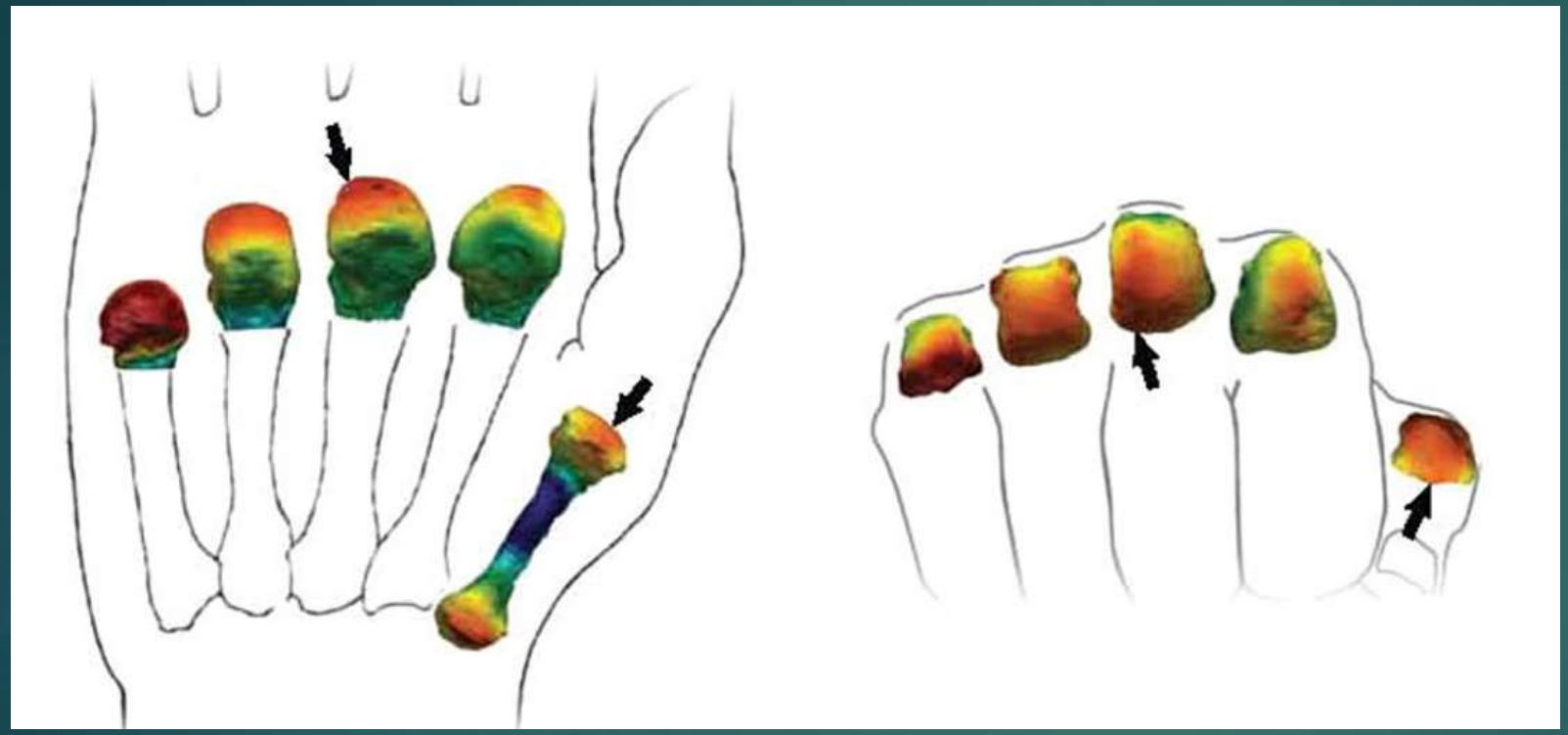
88 feet long, 70 footprints; left foot of female deepest; discovered while playing football with elephant dung

Australopithecus afarensis: Bipedal

Left: Trail of footprints of *A. afarensis* made in volcanic ash, discovered by Mary Leakey at Laetoli.

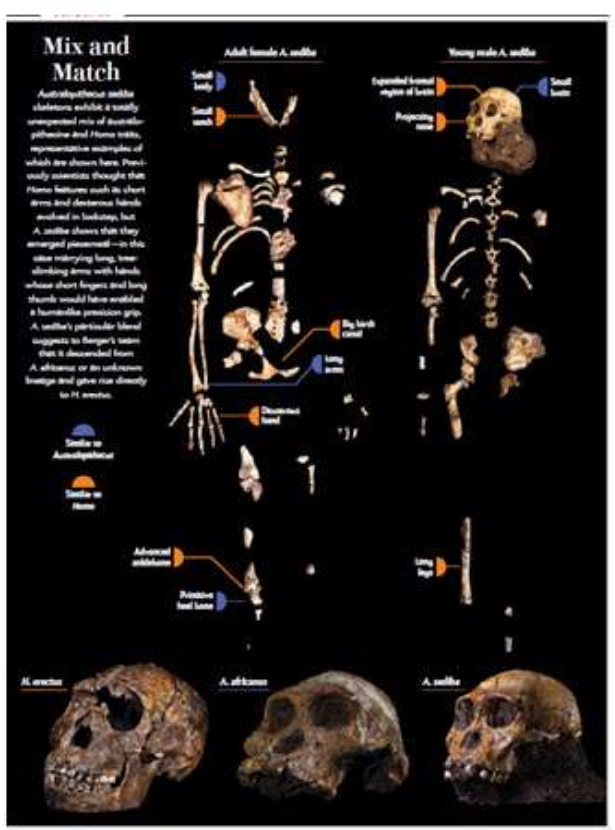
Right: Close-up of footprint at Laetoli

Fossil hand bones of *A. africanus* indicate stone tool capability at 2.8 MYA



Advance Hand High concentrations of spongy inner bone in an ancient hominid's knuckles and thumb base (indicated by arrows, red indicates more spongy bone) suggest humanlike hands evolved nearly 3 million years ago.
M.M. Skinner et al/*Science* Vol. 347, issue 6220 (2015)

A. Sediba discovery by 9 year old boy, 2008



A. sediba, 1.9M, Malapa, South Africa, 2008

Matthew Berger, 9 Y old

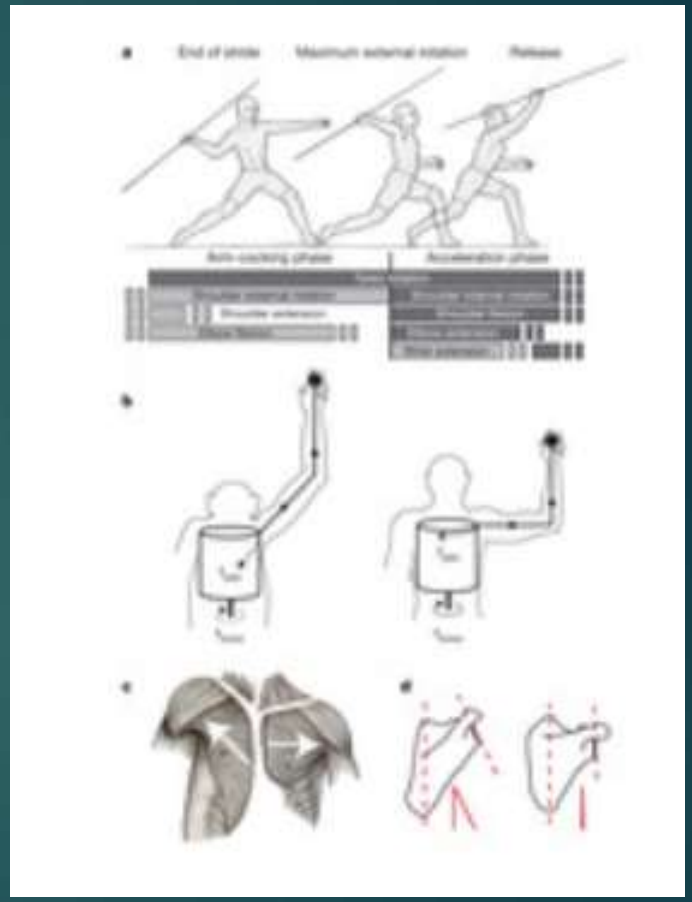
2008: *Australopithecus sediba,* 1.8M, not ancestor

Brett Eloff, via Lee Berger and the University of the Witwatersrand

Australopithecus sediba
(LH1, type, cranium)
Discoverer: Matthew Berger
Locality: Malapa Cave, South Africa
Date: 2008
Age: 1.98 M

Homo erectus: Original Starting Pitcher

- Our ability to throw projectiles with speed and accuracy originated around two million years ago in *Homo erectus* thanks to key shoulder adaptation.
- This new throwing arm helped make our ancestors deadly predators.



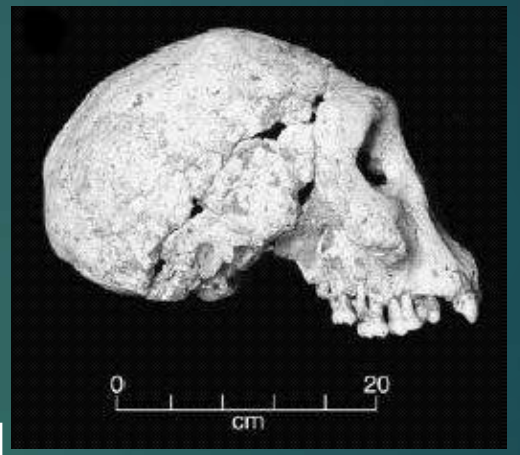
Neil T. Roach, et al., **Elastic energy storage in the shoulder and the evolution of high-speed throwing in *Homo*,** Nature, 2013

Dmanisi, Georgia

Dmanisi, Georgia
Earliest known hominid site outside of Africa, 1.8M

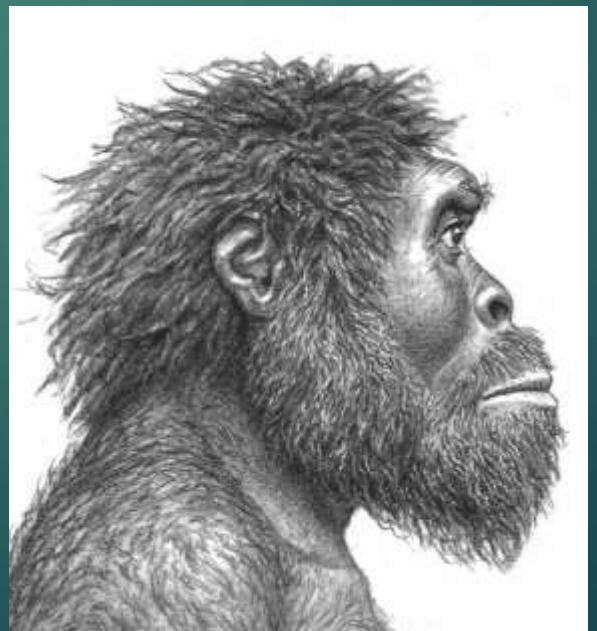
Homo georgicus (Homo erectus)
1st Hominid to Leave Africa

- Dmanisi, Georgia (Caucasus Mtns)
- 1.7 - 1.8 m.y.a.
- Early *H. erectus*
- Brain size: 600-750 cc
- Stature: 1.5 m: the smallest of any adult hominid found outside Africa
- Oldowan tool technology
- No fire use evidence



Dmanisi 5: All Homo erectus

- Skull 5 on right



Homo erectus at Dmanisi

Most complete skull ever found

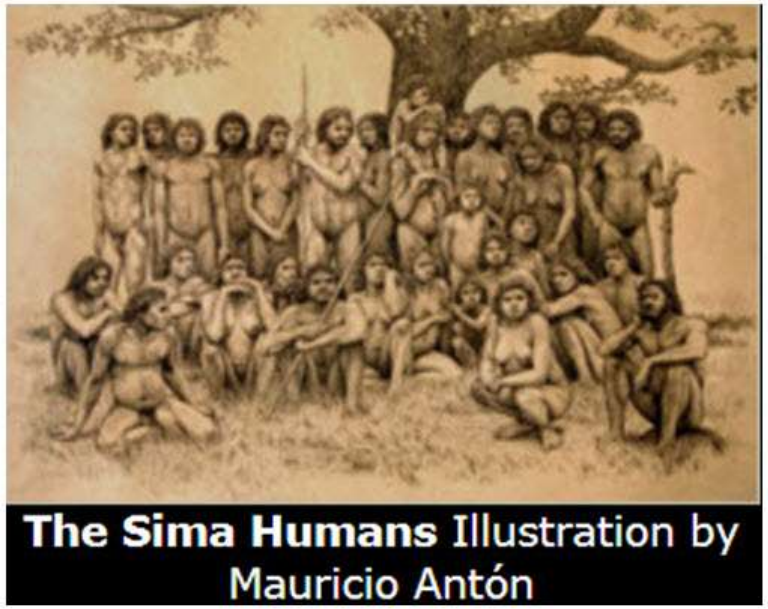
Old Man of Dmanisi:
Empathy evidence at 1.8M

Homo erectus art?:
Scratch Marks on mussel shell, 500K, Trinil, Java

SHELL GAME A geometric design carved into this shell may indicate that human ancestors took up at least one form of "modern human behavior" long before *Homo sapiens* came along.

1992: Sima de los Huesos

Sima de los Huesos, Atapuerca, Spain



The Sima Humans Illustration by Mauricio Antón

Sima de los Huesos
Homo heidelbergensis hominins, 400K

Human fossils, Sima de los Huesos
E436/0172 Rights Managed

Excavated La Sima de los Huesos; remains of 28 bodies have been dug up, the world's greatest single haul of ancient *Homo* fossils; dated 400K, Homo heidelbergensis?

Homo Neanderthalensis

Neandertal Man
250K-39K

Many hypotheses for the demise of Neandertals

1. AMH had "complex symbolic communication systems" and "fully syntactic language", while Neandertals did not.
2 Neandertals had limited capacity for innovations.
3. Neandertals were less efficient hunters.
4. Neandertal weaponry was inferior to AMH projectile technology.
5. Neandertals had a narrow diet, unsuccessful in competition with AMH with their more diverse diets.
6. The use of traps and snares to capture animals was the exclusive domain of AMH.
7. AMH had larger social networks.
8. The initial AMH populations entering Neandertal territory were significantly larger than regional Neandertal populations.
9. Hafting by AMH required complex procedures indicative of modern cognition, while Neandertals hafting was a simple procedure using naturally available glues.
10. Cold climate around 40 ka was a factor in Neandertal decline.
11. Eruption of Mount Toba volcano at 75 ka played an indirect role in Neandertal extinction.

(a) See Text S1 Hypotheses 1–11 for details.
doi:10.1371/journal.pone.0096424.t001

Villa P, Roebroeks W (2014) Neandertal Demise: An Archaeological Analysis of the Modern Human Superiority Complex. PLoS ONE 9(4): e96424. doi:10.1371/journal.pone.0096424
http://127.0.0.1:8081/plosone/article?id=info:doi/10.1371/journal.pone.0096424

1856: Neandertal 1
Neander Valley, Germany, 40K

Homo neanderthalensis
(Neandertal 1, type)
Discoverer: Local workers
Locality: Feldhofer grotto, Neander Valley, Germany
Age: 40K
Date: 1856

Neandertal 1 skeleton

Enormous Neandertal Range

Homo heidelbergensis: spear hafting

- 500,000 old stone tips at Kathu Pan, South Africa
- Evidence of use of multicomponent technique needed to make stone-tipped spears (hafting), also points to ability to think and plan ahead

Cutting edge technology: early humans were lashing stone tips to wooden handles to make spears about 200,000 years earlier than previously thought, new research suggests. Photograph: Jayne Wilkins

New View of Neandertal: Neandertals were not technologically and cognitively ‘‘disadvantaged’’

- Diverged from a common ancestor, *Homo heidelbergensis,* 500k years ago
- 250,000 to 40,000 K in Europe and Asian; never in Africa
- Accomplished large game hunters, who survived in a wide range of environments subsisting by hunting a wide range of animals in a variety of topographical settings
- Lived in small, familial groups in single valleys.
- Shorter limbs, a wider, barrel-shaped rib cage, a reduced chin and a very large nose; they were much stronger than moderns; some had red hair and blond hair, along with a light skin tone

Villa P, Roebroeks W (2014) Neandertal Demise: An Archaeological Analysis of the Modern Human Superiority Complex. PLoS ONE 9(4)

Neandertals

- Larger brain: average cranial capacity of 1600 cc

- Larger body: (men = 65'; women = 60') & 171 lb for males and 146 lb for females; needed more energy to survive than any other species of hominid.

- Higher energy needs: needed up to 100 to 350 kcal per day more than us.

Neandertal spears

- Used large bayonet style spears
- Use of adhesive: used fire to synthesize birch pitch from bark for hafting flint flakes, through a process that involved distillation in the absence of oxygen, as early as 200K (ability to plan ahead)
- Stronger in one arm than the other (evidence of 2 handed thrust)
- Mainly right handed
- Of 500 fossil skeletons, all 50% of adult fossils have broken mended bones in upper torso (like American rodeo rider injuries); no gender difference

Newer Neandertal Findings

- Traces of twisted fiber, suggesting the manufacture of cordage or string (use? - nets, traps and bags)
- 50K tools made from deer ribs in France; bone lissoirs or smoothers, still used by leather workers today
- Language: Neanderthal hyoid bone was basically indistinguishable from our own, part of the vocal tract; same FOX2 gene
- Collapsed cave evidence: organized and tidy home with separate spaces for food prep, sleeping, making tools & socializing.

Homo neandertalensis

- Neanderthals could make fire and built shelters with wooden frames.
- Buried their dead, apparently with ritual — graves containing flowers?, the pigment red ochre, and the bones of large game animals are known; Neanderthal child burials were more elaborate than those of adults
- Historical idea that N toolkit did not change for 200K, but now evidence of regional differentiation, cultural traditions and technological changes through time; (old MH only) blades, bladelets and microlithic points at Combe Grenal

Expanded Neandertal Cuisine

- Used toothpicks (left marks)
- Teeth plaques reveal N ate 80% meat, 20% vegetables; including bitter plants (medicinal?); 2014 fossilized feces study indicates more plant usage
- Cave bear, deer, woolly rhinoceros, mammoth, wild cattle, reindeer, horse, wild ass, ibex, saiga, rabbits
- Barbecue: mammoth over cliff, pigeons at Gibraltar
- Vegetables: parsnip and burdock, mushrooms, berries; tubers, date palms
- Species closely related to modern wheat and barley, cooking them to make them palatable.
- At Gibraltar, paella without the rice: shellfish and fish

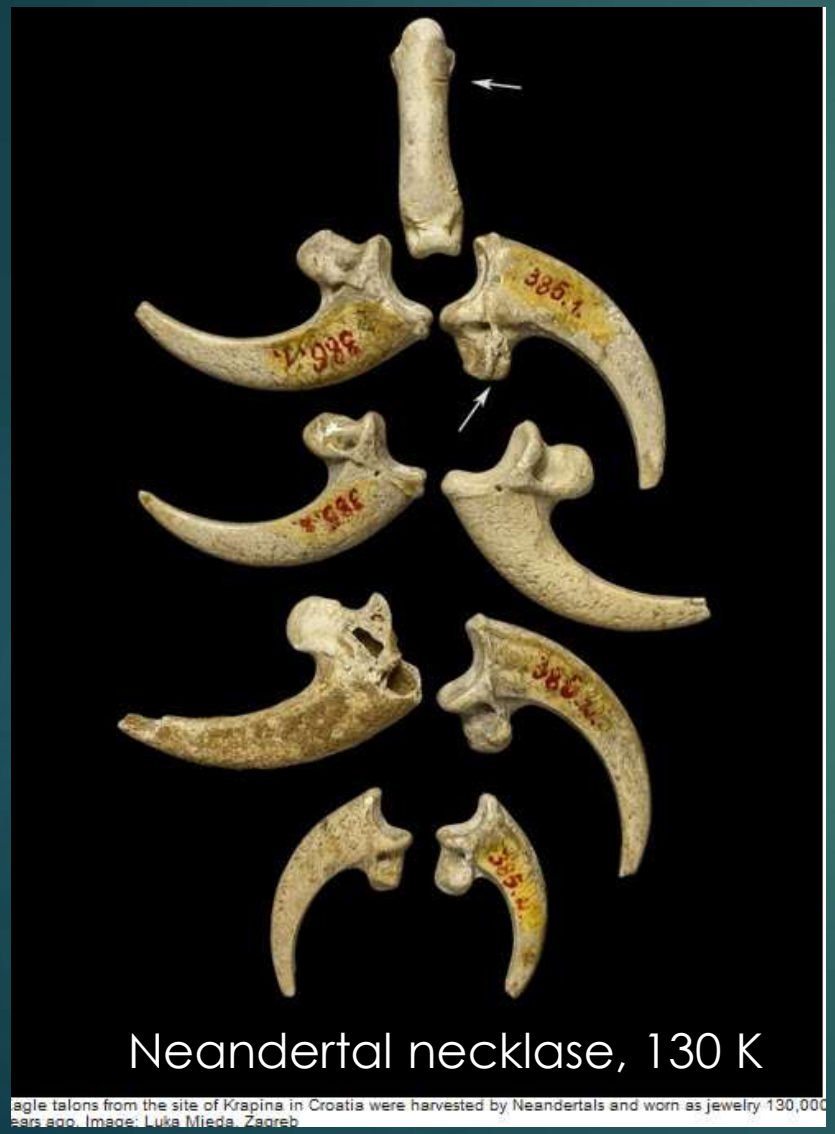
Newer Findings 2

- Divje Babe flute: cave bear bone, 60K
- "Old Man of La Chapelle“ missing a lot of teeth & bone regrowth
- Bigger eye sockets (related to larger occipital size) than moderns; better vision; bigger occipital lobe & less parietal?
- Blangero: Several key brain regions were smaller in Neandertals: gray matter surface area (which helps to process information in the brain), Broca's area (language), the amygdala (which controls emotions and motivation)., and less white matter

Neandertal Personal Decoration

- Corvid feather use
- Use of red ochre and manganese, 200K
- Fossil snail shell collected from at least 100 kilometers away that had been stained red, suspended on a string and worn as a pendant, 47K
- Modified shells used for jewelry, 50K

Evidence for Neandertal Jewelry: Modified White-Tailed Eagle Claws at Krapina, 130K



Neandertal necklase, 130 K

agle talons from the site of Krapina in Croatia were harvested by Neandertals and worn as jewelry 130,000 ears ago. Image: Luka Mlieda, Zagreb

Tradition of harvesting eagle talons: not for meat, but for symbolic decorations. Clearly Neandertal eagle talon jewelry from 130K: Clear evidence of symbolic thinking long before appearance of *H. sapiens* in Europe.

Davorka Radovčić, et al., 2015

Neandertals: Seafaring before MH?

- Neandertal tools found on the Greek Ionian islands of Lefkada, Kefalonia and Zakynthos and on Crete; Made wooden dugout canoes?

- Died out in Europe between 41,000 and 39,000 years ago - this coincides with the start of a very cold period in Europe and is 5,000 years after *Homo sapiens* reached the continent

George Ferentinos

1983: *Homo neanderthalensis*, at Kebara
Most complete Neandertal specimen

Homo neanderthalensis
(Kebara 2)
Discoverer: Lynne Schepartz
Locality: Kebara Cave, Israel
Date:1983
Age: 60K

Hyoid bone

Newer reconstructions

Last 4 Neandertal Strongholds

- Last populations of Neanderthals were concentrated in four strongholds
- (1-4 in order of importance). The south of Iberia stands out as the largest stronghold and it is within this area that the last Neanderthals survived.

Theories of Neanderthals' Fate: Part I

By 40,000: Neanderthals gone

- **Sudden climatic change**
  - **Large game dying out and Neanderthals hunting methods not suitable?**
- **Out competed by anatomically modern *H. sapiens*?**
  - **Better energy extraction methods**
  - **Shorter gestation periods**
- **Diseases brought by a.m. H. sapiens?**
- **Genetically absorbed into *Homo sapiens* without significant genetic contributions to modern populations?**

The Fate of the Neanderthals: Part II

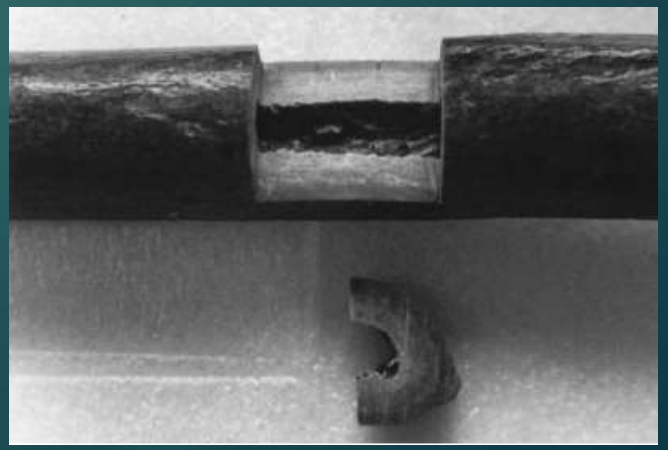
- Interbred with anatomically modern *H. sapiens* to produce modern Europeans?

- Had sex with humans circa 50K ago in Middle East; N genes into Homo sapiens; only have taken between 197 and 430 liaisons between ancient humans and Neanderthals to fill 1-3 percent of modern Eurasian genomes with Neanderthal DNA

Matthias Krings: DNA Sequencing of Neanderthals

- 1997: First Neandertal mitochondrial DNA sequenced (~400 bases) from Feldhofer Neanderthal, 40K

- Not our ancestors: proved modern humans and Neandertals are different species, which diverged from humans 690-550K ago



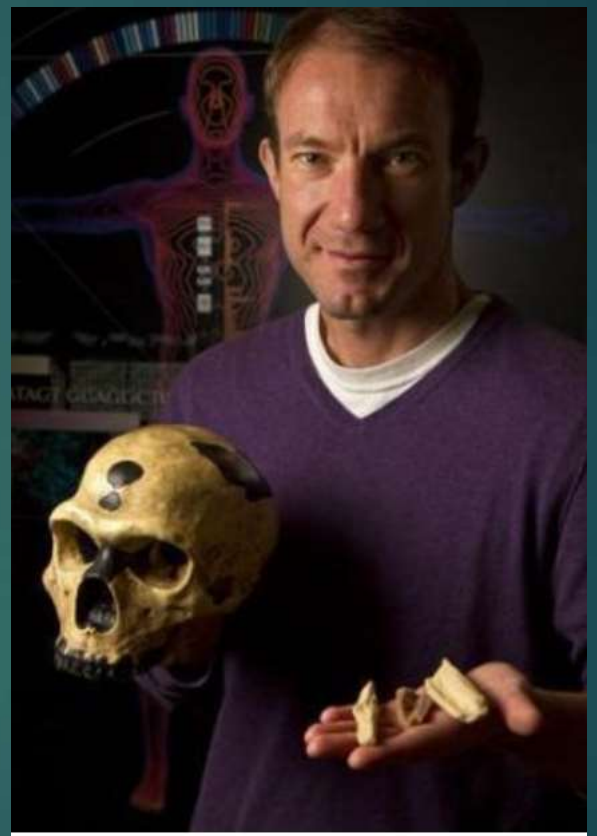
Svante Paabo (1955-): Evolutionary Genetics

- Swedish biologist specializing in evolutionary genetics
- Student of Allan Wilson
- Director of genetics at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany)
- A leader in the field of molecular evolution & one of the founders of paleogenetics, studying FOX2 gene, ancient DNA from mammoths, the giant sloth, Neanderthals, & Denisovians.

- 1997: retrieve DNA from Feldhofer Cave Neanderthal; N = different species

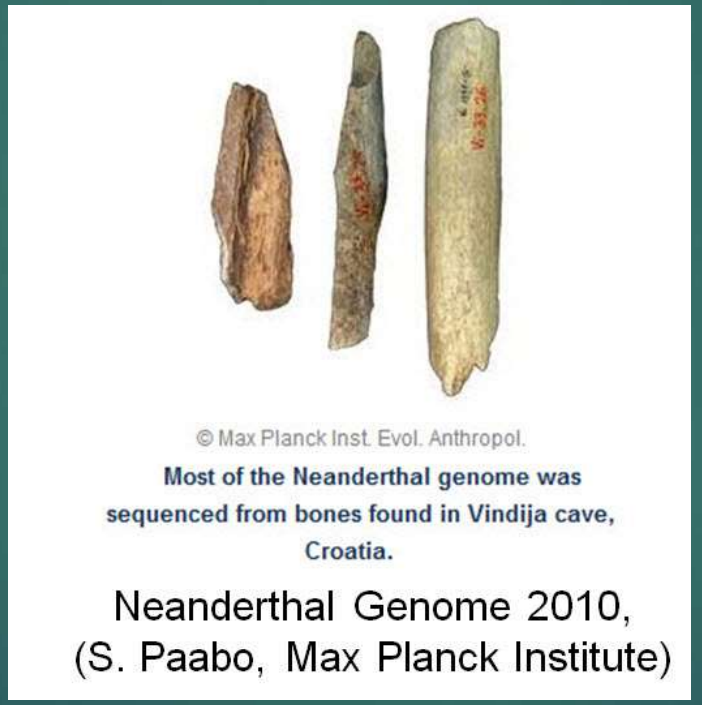
Richard Edward Green: 1-4% Neandertal DNA in modern humans

- Computational biologist; UC Santa Cruz
- 2010: proved gene flow from Neanderthals to modern humans between 50-80K ago
- 2010: Found 1 to 4 % of the genomes of non-Africans is derived from Neanderthals, meaning that the admixture occurred early on, probably in the Middle East
- Current revision: 1.5–2.1%



Richard E. (Ed) Green, a computational biologist in the Baskin School of Engineering at UC Santa

2010: Neandertal Genome:
You have about as much Neandertal DNA as people inherit from a 4th G-grandparent.



© Max Planck Inst. Evol. Anthropol.

Most of the Neanderthal genome was sequenced from bones found in Vindija cave, Croatia.

Neanderthal Genome 2010,
(S. Paabo, Max Planck Institute)

All modern non African humans have 1.5 to 2.1% Neandertal DNA; but not same 1-2%; modern humans hold 35-75% of N genome

Neandertal DNA

- Genetic diversity among Neanderthals was about one-fourth that of MH; lived in small, isolated groups
- 87 genes difference with modern humans but several are involved in brain development and function
- Genome is 99.7% identical to modern humans; these two different species shared a common ancestor about 500,000 years ago.

Complex History of Admixture between Modern Humans and Neandertals

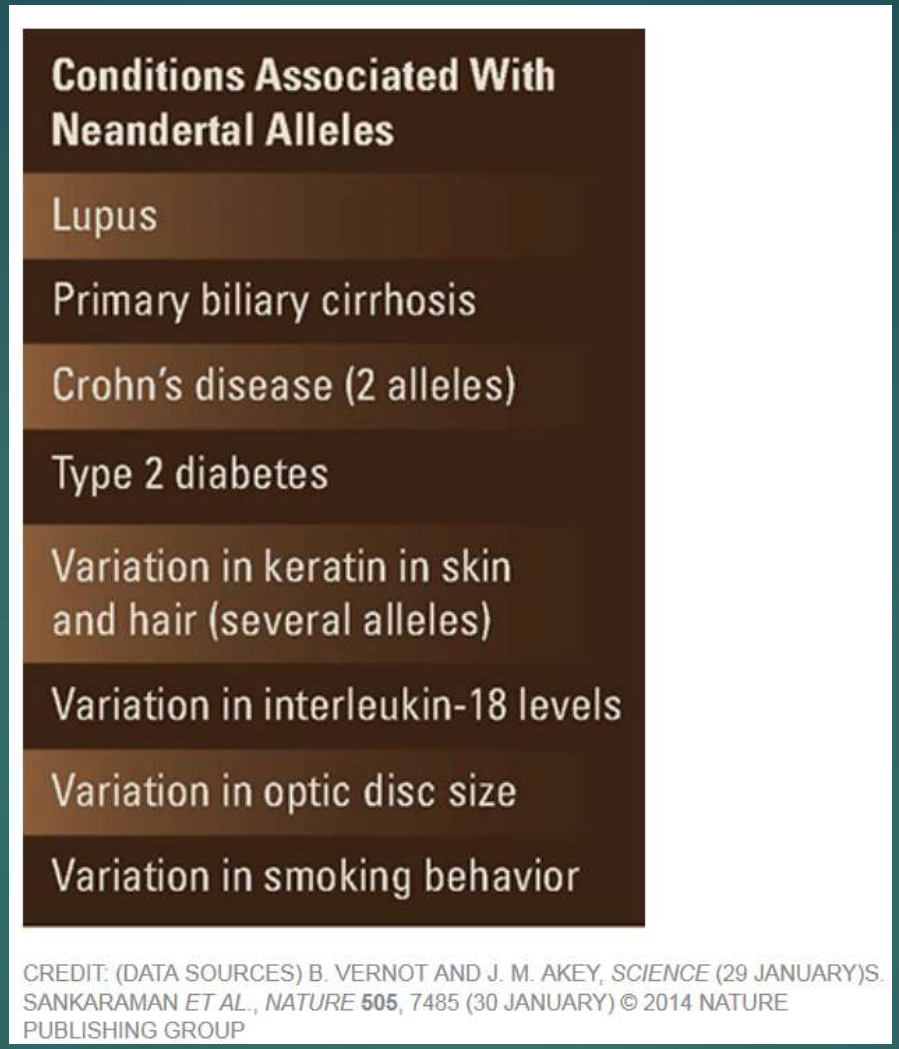
- More Neandertal genes in Asians than in Europeans
- Ancient East Asians mixed and mingled multiple times with Neandertals
- East Asians got a double dose of Neandertal ancestry. That's the conclusion of two new studies seeking to explain why East Asians inherited 15 to 30 percent more Neandertal DNA than Europeans did
- East Asians' ancestors interbred with Neandertals more than once.

Neandertal DNA

- Interbreeding of Neandertals and modern humans may have helped modern humans to adapt to non-African environments but also introduced alleles that were not tolerated and contributed to male N hybrid sterility (no N genes in male germ area) thus reducing the proportion of Neandertal ancestry.

- A role in the development of the immune system of modern humans (HLA)

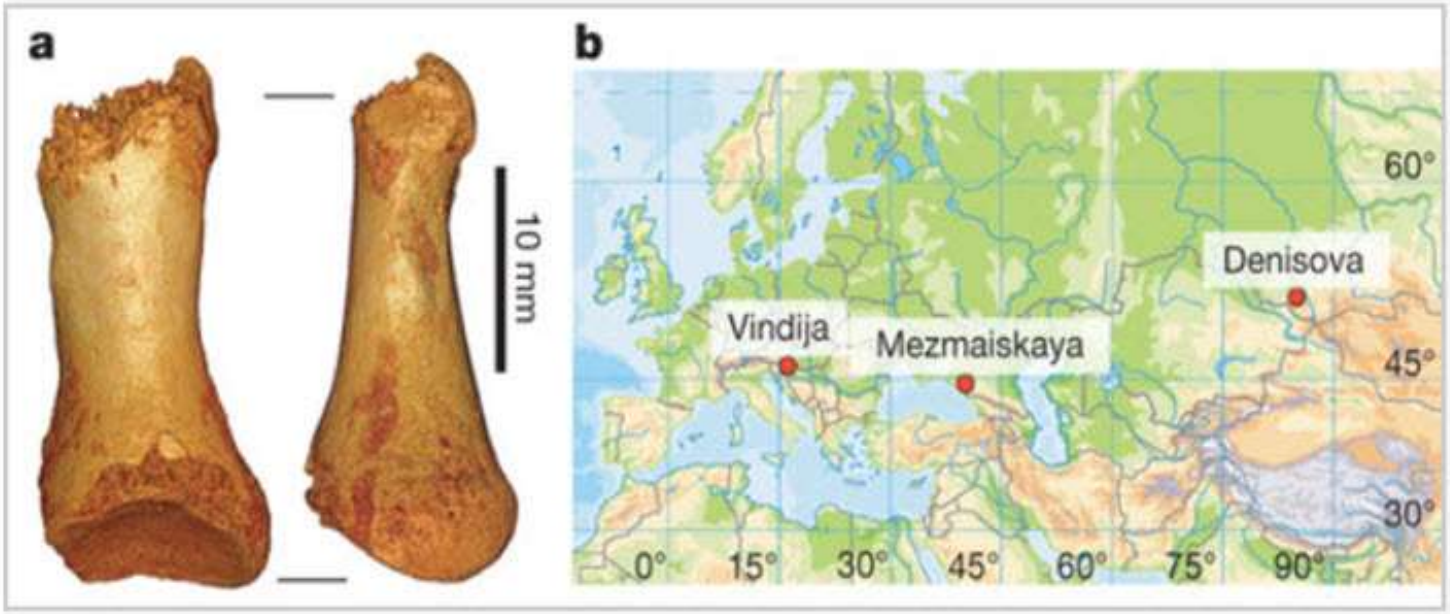
- Keratin filaments: some from N
- A role in UV-light adaptations



CREDIT: (DATA SOURCES) B. VERNOT AND J. M. AKEY, *SCIENCE* (29 JANUARY)S. SANKARAMAN *ET AL.*, *NATURE* **505**, 7485 (30 JANUARY) © 2014 NATURE PUBLISHING GROUP

Recent research has suggested that Neandertal DNA is slightly detrimental to modern humans, making some people more prone to certain diseases

2014: Reason for Neandertal Demise:
Low population number with interbreeding



Denisova: woman's toe bone = Neandertal 130K;
Clear inbreeding = her parents were closely related,
possibly half-siblings or another near relation.

Chromosome 21: M & F genetically related (19 Mb base pairs with no difference)

- Half siblings
- Grandfather-granddaughter
- Aunt-nephew
- Double first cousins

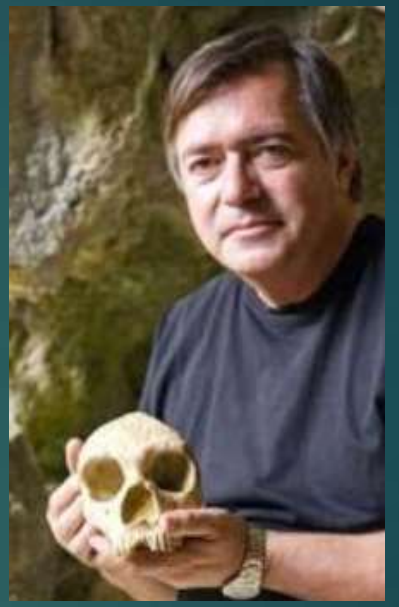
Some other archaic DNA (H. erectus?)

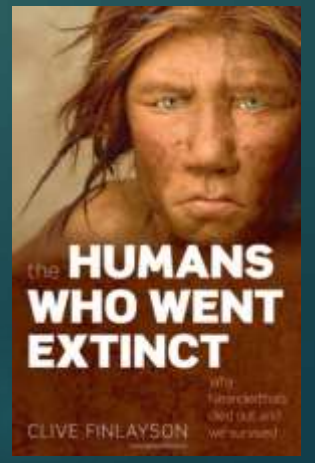
Pruefer et al., , Nature, 2014

Clive Finlayson: Defender of Neanderthal Abilities

- English paleontologist
- Director, Heritage Division, Gibraltar Museum
- Co-director (with C.B.Stringer, J. Rodriguez Vidal and F.Giles Pacheco) of the Gibraltar Caves Research Project 1991-present

- Gorham's Cave, Gibraltar, which has been claimed to contain the most recent Mousterian assemblages known to date (Finlayson et al. 2006)
- Author: *Humans who went extinct*





Neanderthals & Corvid feathers

Clive Finlayson models griffon plumage. The ulna was removed from the carcass with a flint tool and the feathers left intact. Most of the birds Neandertals used were smaller and thus perhaps better suited to headdresses. Image: Kate Wong

2012 *PLOS ONE study:* 1699 fossil sites in Eurasia and north Africa spanning the Pleistocene epoch.

Neandertals across western Eurasia were strongly associated with corvids and raptors (vultures and their relatives

Bonelli's eagle is one of the raptor species Neandertals hunted, presumably for its dark feathers. Image: Clive Finlayson

Neanderthal Disappearance: circa 45 K

- Nature article: European Neanderthals could have disappeared between 41,000 and 39,000 years ago, according to the fossil remains found at sites located from the Black Sea in Russia to the Atlantic coastline of Spain.
- Could have disappeared in the Iberian Peninsula, close to 45,000 years ago (data found at the El Salt site in the Valencian Community (Spain).)

- No evidence of the existence of the Neanderthals in the Iberian Peninsula later than 43,000 years ago
- Drawn out over several millennia, there was a gradual disappearance of diminishing populations which coincided with a change in the climate creating colder and more arid environmental conditions.
- Anatomically modern humans probably had no role in this disappearance, although they overlap for 2500-5000 years

Bertila Galván, et al., 2015

2014: Neandertal Art

Gibraltar Cave, 2014

El Castillo, Spain

Neandertals became part of us

Cautionary Tale: Large brains & climate change

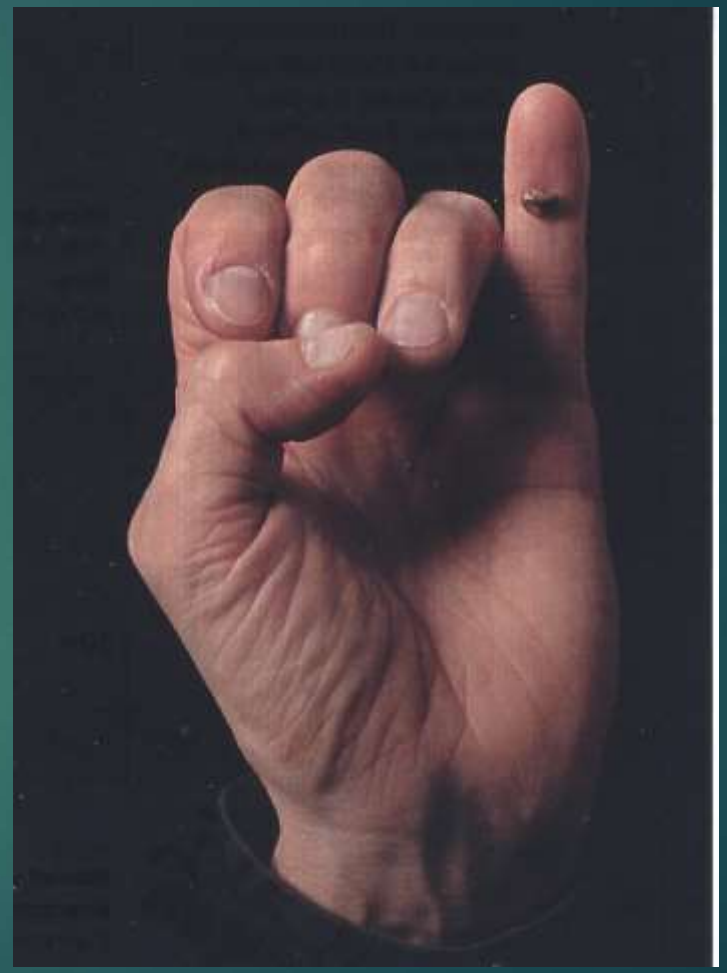
- You can be a smart, large brained hominid, and still go extinct.
- Neandertals were probably as smart as us, but climate change (4 degrees colder) may have killed them off.
- What about another large brained hominid, *Homo sapiens*? Climate change is on its way to 2 degrees hotter.

Homo Denisova

Denisova Cave, Siberia

2008: X Woman (girl), 63-83 T yo

Pinkie bone, 30-48K, Denisova cave



Paabo's hand & bone
Laid around in lab for 1 year

2010: Homo Denisova

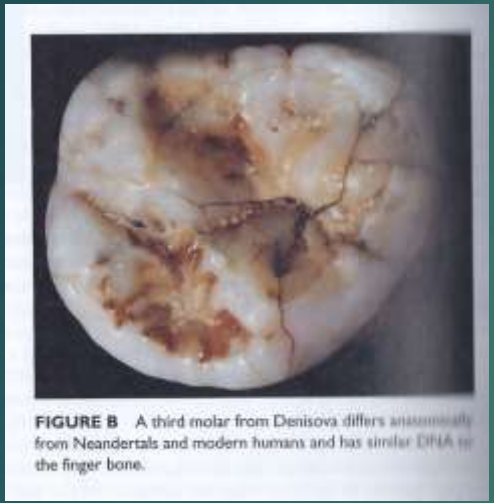
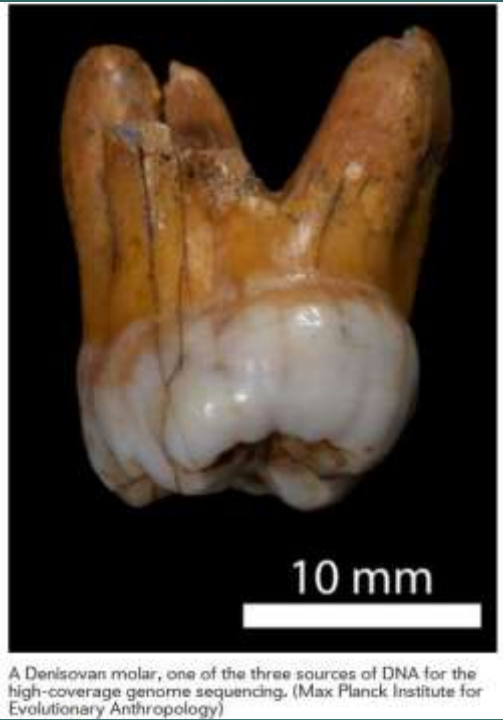


FIGURE B A third molar from Denisova differs anatomically from Neandertals and modern humans and has similar DNA to the finger bone.



A Denisovan molar, one of the three sources of DNA for the high-coverage genome sequencing. (Max Planck Institute for Evolutionary Anthropology)

FRAGMENT OF A FINGER: This replica of the Denisovan finger bone shows just how small of a sample the researchers had to extract DNA from. *Image: Image courtesy of Max Planck Institute for Evolutionary Anthropology*

Pinkie Bone, 30-48K,
Denisova Cave

Krause et al. 2010: When the mitochondrial DNA of the bone was sequenced in 2010 however, it belonged neither to a Neandertal nor to a modern human. A new species, *Homo denisova*

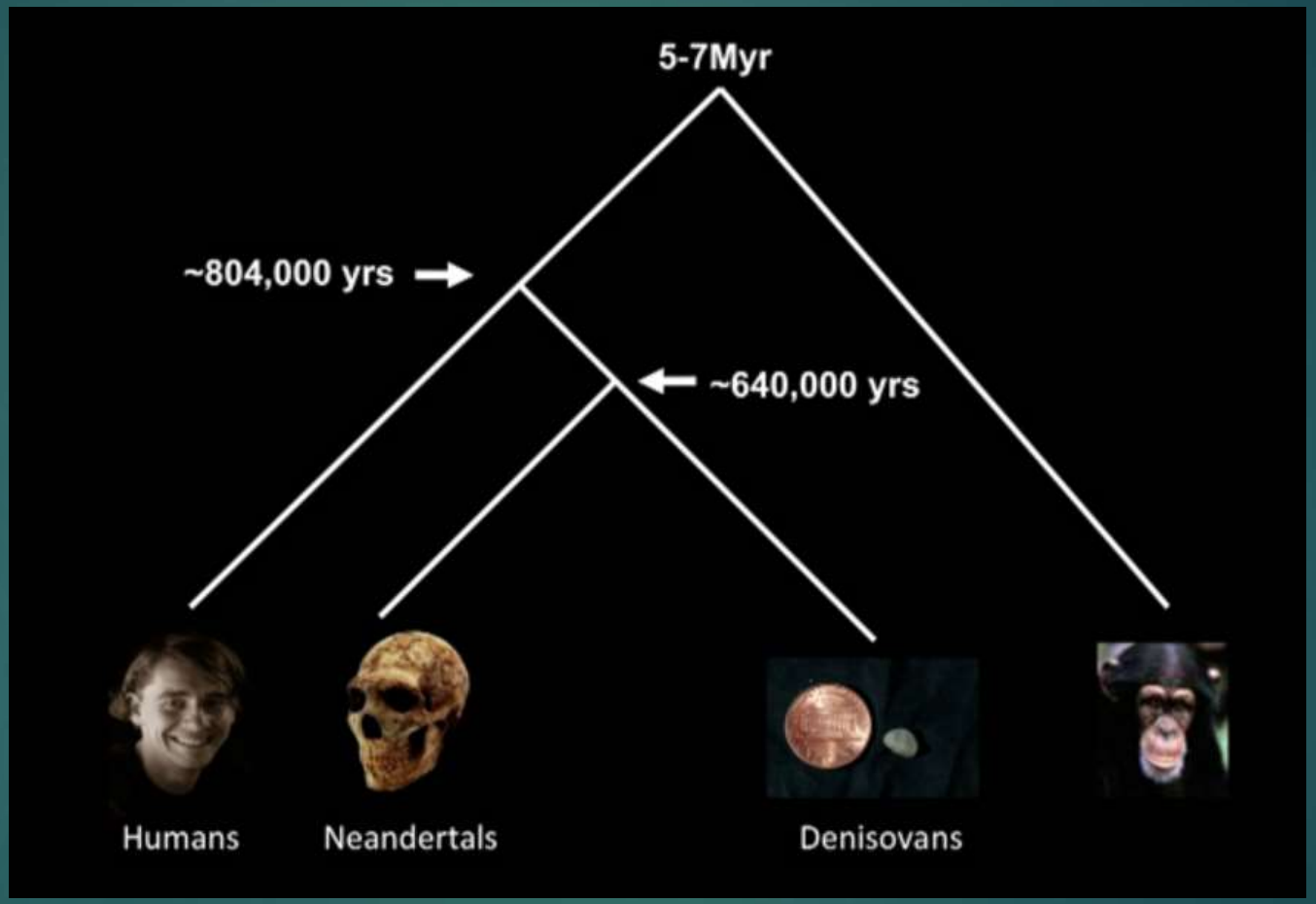
Great Migrations out of Africa

- ? Of Austalopithecines leaving -- Homo floresiensis
- 1.8 M – Homo erectus leaves
- Homo Denisova leaves
- Some Homo heidelbergensis leave
- Circa 50K - Homo Sapiens

Denisovans

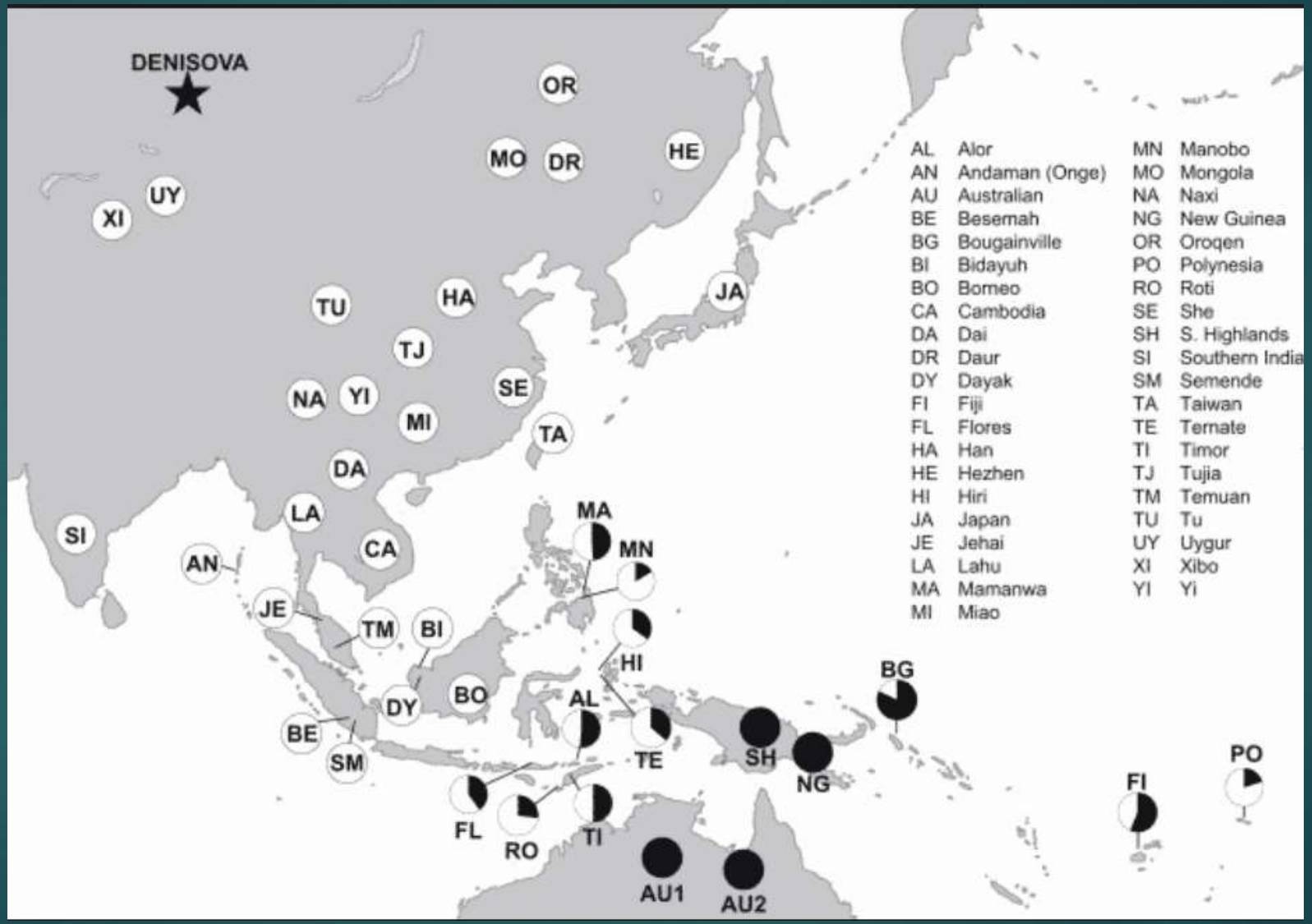
- Result of an earlier migration out of Africa, distinct from the earlier out-of-Africa of *H. erectus* and later migrations associated with modern humans,
- They ranged from Spain to Siberia to Southeast Asia.
- 3% to 6% of the DNA of Pacific Islanders and Aboriginal Australians deriving from Denisovans.
- DNA shows they had dark skin, brown hair and brown eyes

Time to Common Ancestors

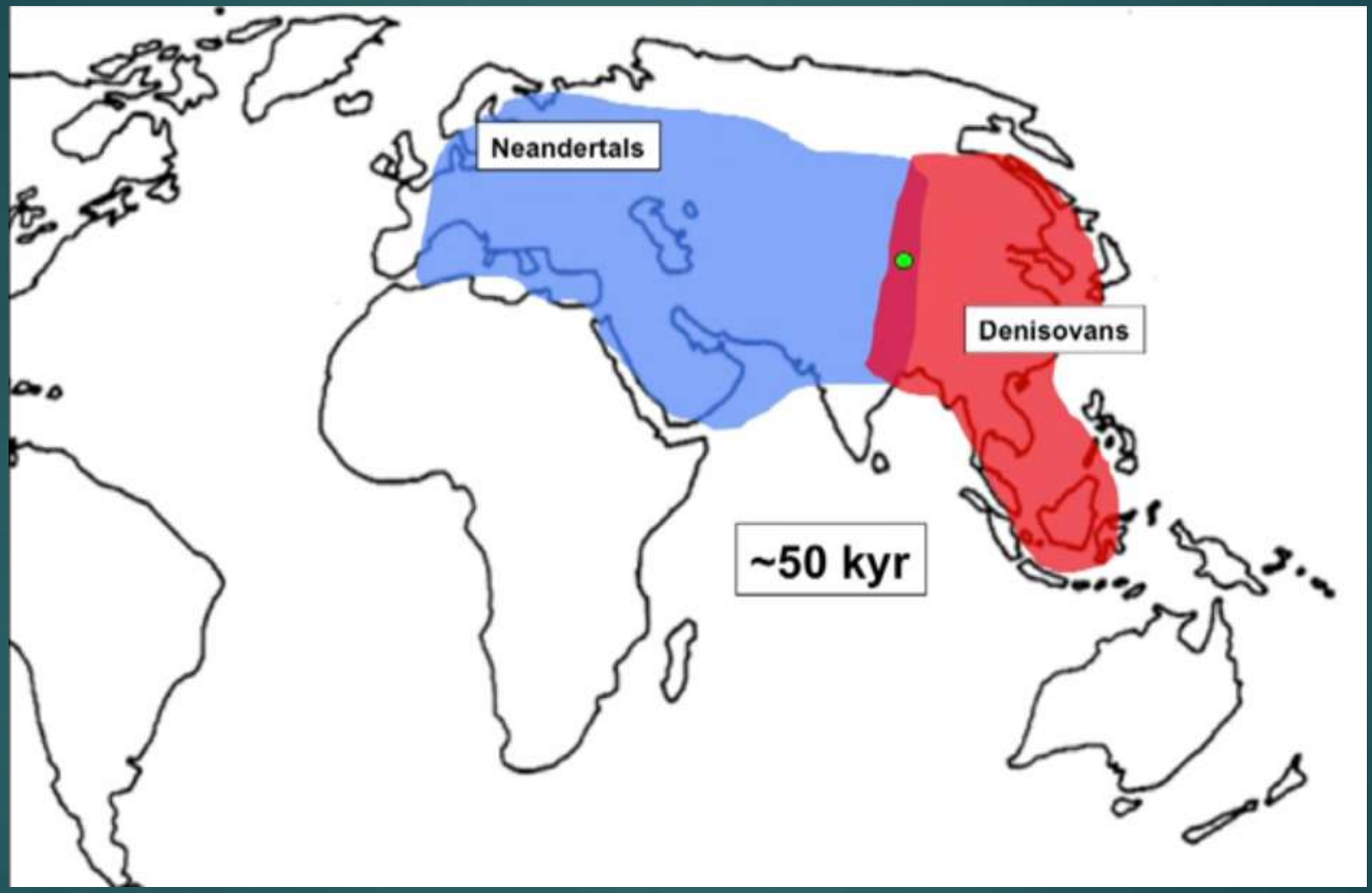


- Denisovans related to both N and MH; both N & D had long independent histories; genetic diversity in these archaic hominins was extremely low

Spread of Denisovans

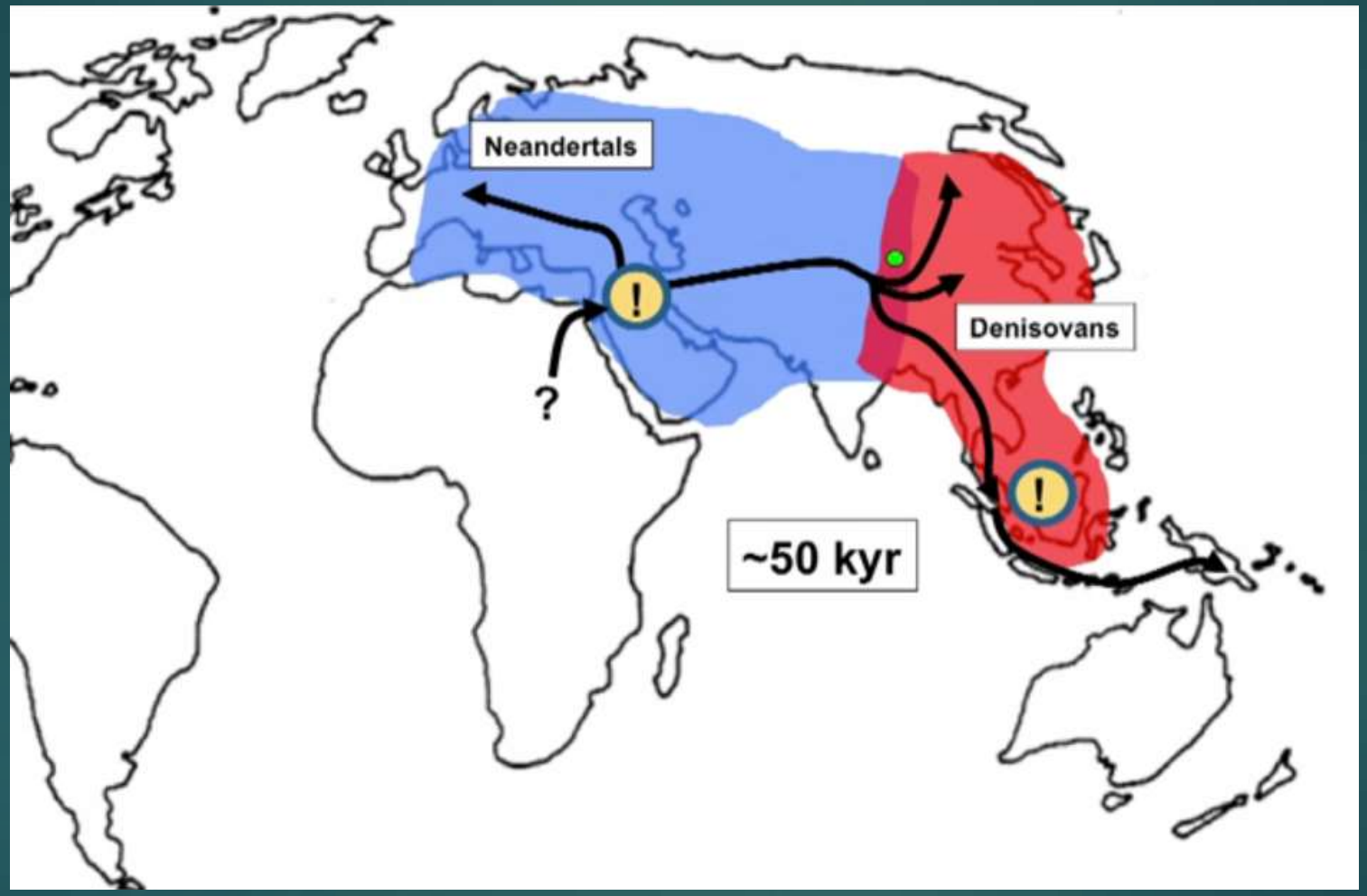


Neandertal & Denisovan Territories



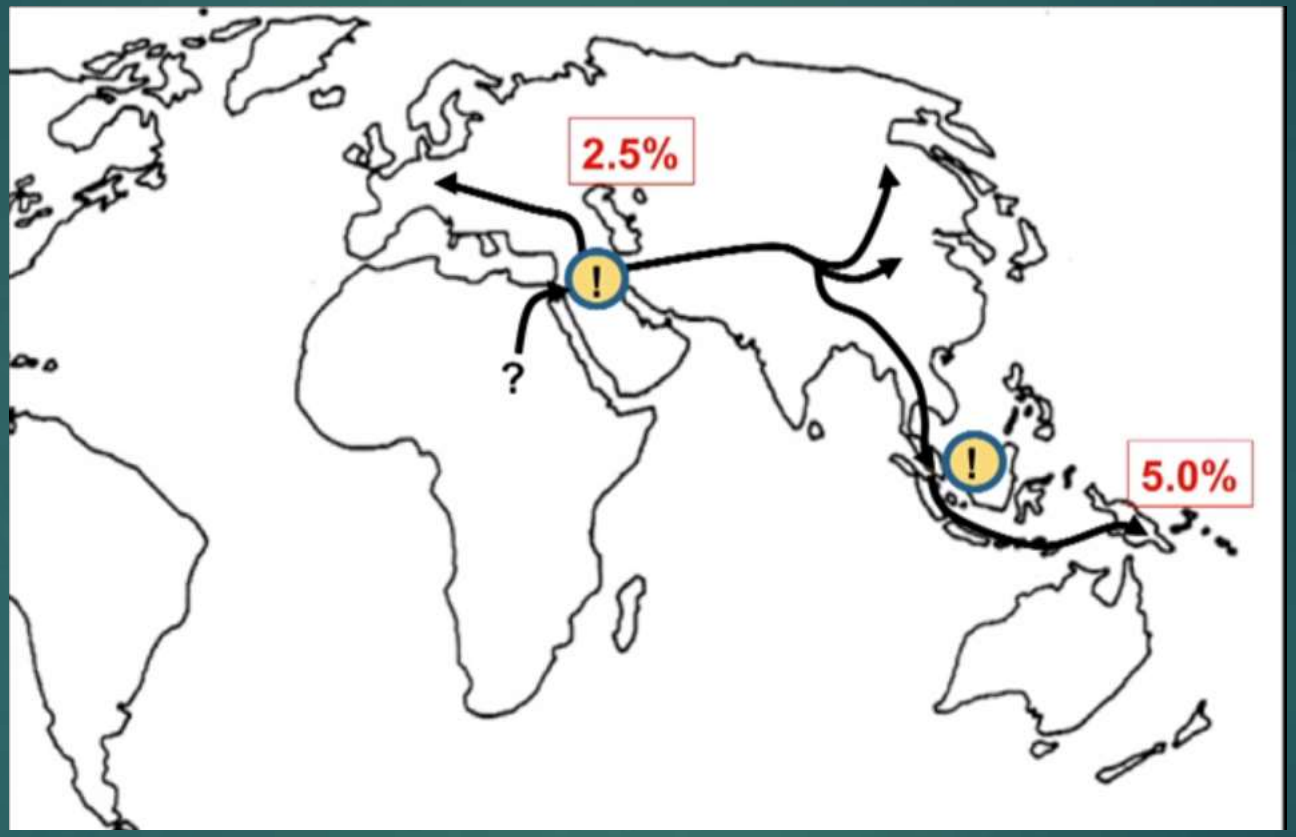
What world looked like when MH came out of Africa: N in West, D in East; Both in southern Siberia

Modern Humans make their move & mix in



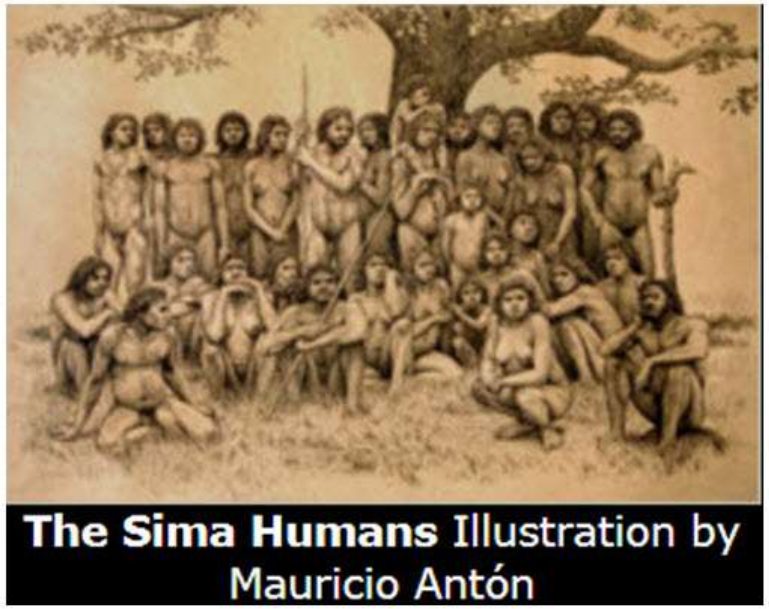
MH mixed with both N and D in different places

And then there was one…



- N and D disappear as species, but live on in MH

Sima de los Huesos: Denisovan DNA



The Sima Humans Illustration by Mauricio Antón

Sima de los Huesos
Homo heidelbergensis hominins, 400K

2014: Oldest human mitochondrial genetic material: The thighbone of the 400K hominid from Sima de los Huesos, Credit: Javier Trueba

<u>Closer to Denisovan mtDNA</u> than to Neanderthal
mtDNA; Paabo theorizes : prior ancestor of N & D; Stringer: Antecessor interbred with unknown species who was ancestor to both D and Sima group

High altitude & Oxygen

Sherpas

Quechua of Andes

Amhara of Ethiopia

Elevation in hemoglobin concentration is not a universal response to high-altitude hypoxia at altitudes.

Sherpa hemoglobin: Denisovan Gene via women

Mt. Everest, 1953: Edmund Hilary & Sherpa Tenzing Norgay (Denisovan DNA) & fastest Darwinian evolution

Hypoxia gene, *EPAS1*, positive selection in Tibetans; hemoglobin & oxygen at high altitude; 3000 year divergence

Tibetans have an autosomal dominant Denisova gene for higher oxygen saturation. Evolved in 3000 years.

Women estimated with high probability to have high oxygen saturation genotypes have more surviving children.

Oxygen saturation has no heritability in the Andean natives.

East African highlanders of Ethiopia do not have it.

Homo sapiens - A Time of Crisis: 140,000 years ago

- Mega-drought
  - Much of African environment became desert like
  - Dramatic reduction of hominid populations. (down to 600 - 1200 breeding individuals)
  - Hominids forced into refuge areas (principally: south African coastline)
  - Began to exploit new resources (shellfish, penguins, also hunting/gathering on coastal plains) reflects a new versatility

Refuge Sites

- **Pinnacle Point, So. Africa (140 - 70 kya)**
  - **Earliest tools made from beach cobbles; later tools made from stone quarried 20+ km away, then heat treated**
  - **Some of earliest evidence *H. sapiens* living off sea (cooked shellfish) = 70,000 years ago**

- **Klasies River Caves, So. Africa (130 - 60 kya)**
  - **130-119 kya: systematic use of marine resources: ate shellfish, seals, penguins, hunted antelope, gathered plant foods (roasted in hearths built for the purpose)**
  - **Fire-blackened fragments of human skulls / other bones showing cut marks = Cannibalism**

Modern Genetic Diversity

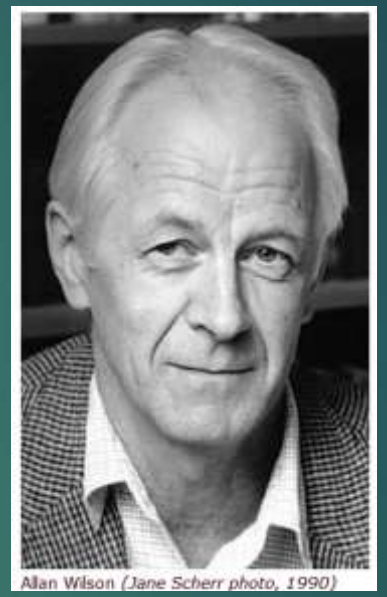
- Homo sapiens who left Africa were less genetically diverse than those who stayed.
- In fact, studies suggest that there's more genetic diversity in a single troop of 100 chimpanzees than in all 7 billion modern humans.
- When it comes to our DNA, all humans—regardless of race, color, or nationality—are 99.9% alike.

Allan Wilson & Rebecca Cann: Mitochondrial Eve hypothesis

- 1987: *Nature* article:

- Mitochondrial Eve hypothesis: 160 K origin for all modern humans based on a study of mtDNA haplotype links.

- We are African by DNA


Allan Wilson (Jane Scherr photo, 1990)

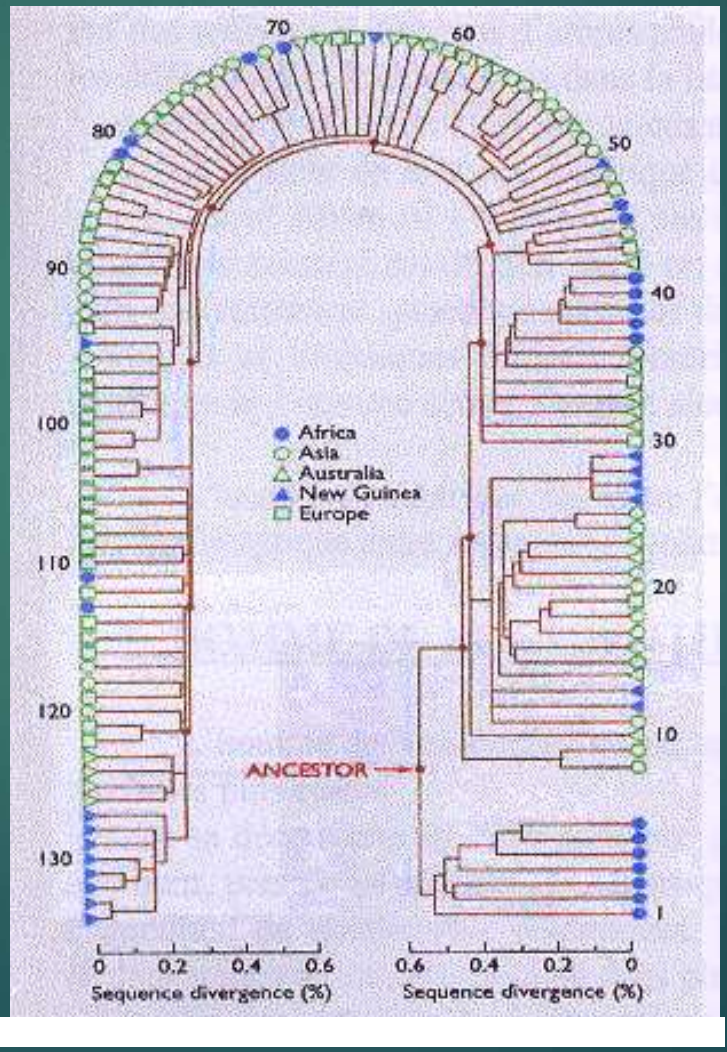
Death blow for multiregionalism

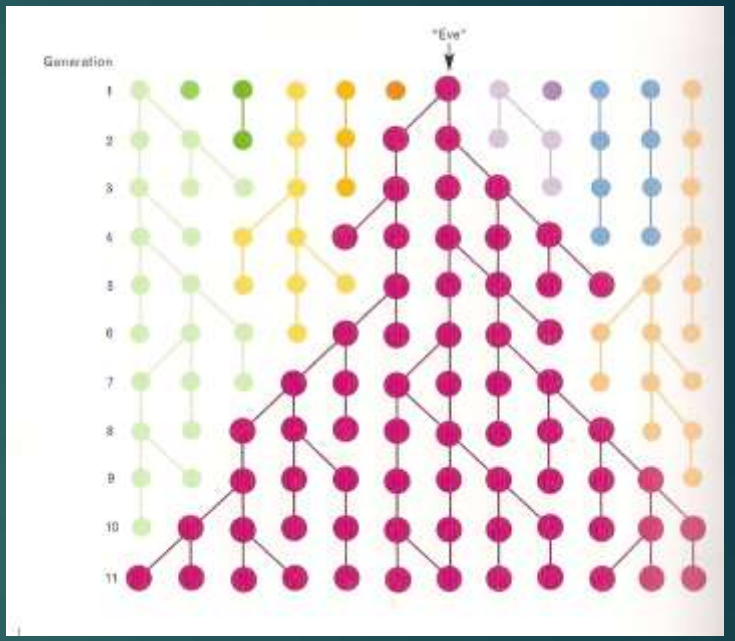
Mitochondrial Eve

- 147 individuals from five geographic populations: Europe, Africa, Asia, Australia,
- New Guinea

have been analysed by high-resolution restriction mapping

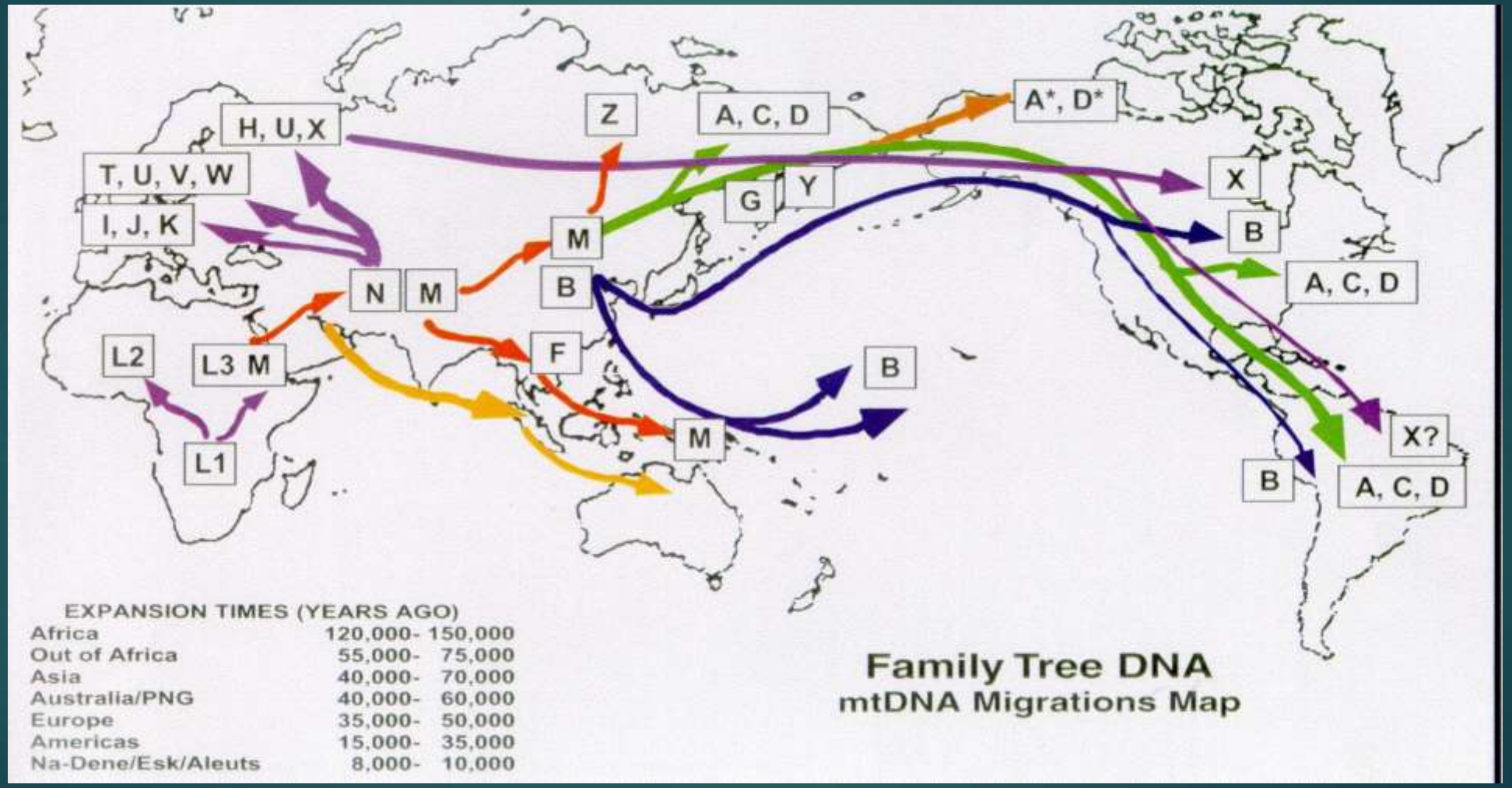
Sub-Saharan African individuals present the most variable mtDNA sequences





Cann et al; Nature 1987

Mitochondrial haplogroups



Homo sapiens

- H. sapiens entry into Europe: 44 to 46 K years ago.
- They crossed the continent from the Balkans to the Atlantic in 2500 years; overlapped Neandertals for 5000 years
- 77,000-year-old mattress composed of thin layers of sedges and grasses
- In a 100,000-year-old paint workshop: all of the raw materials needed to make paint, as well as abalone shells used as storage containers

European Caves of Lascaux and Altamira

The Hall of Bulls
c. 17,000 BC
Lascaux, France

Altamira Bison
c. 15,000 BC
Altamira, Spain

The 2nd oldest portrait of man - a 32.000 year old hand print found in Chauvet Cave, France.

2014: Indonesian, 39,000 y.a.

Babirusa

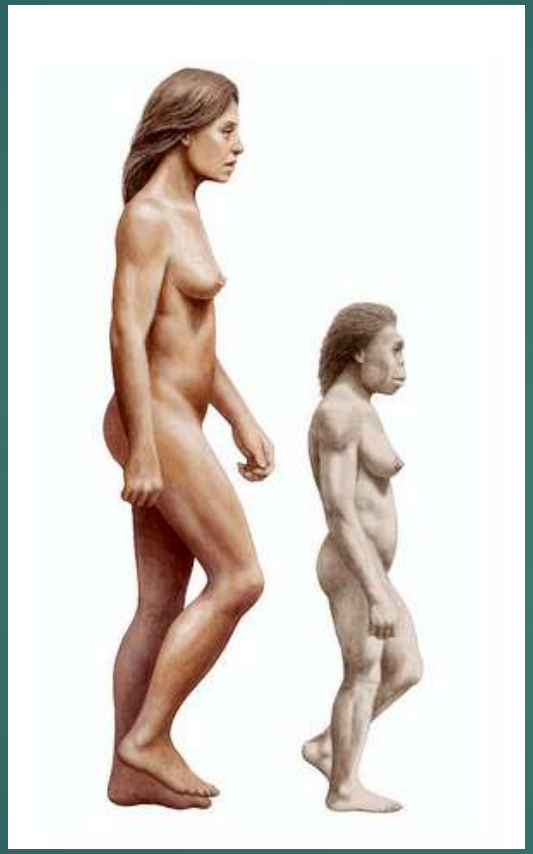
Homo floresiensis

Michael Morwood & Peter Brown: *Homo floresiensis*

- Australian paleontologists
- 2003: Island of Flores, Indonesia, discovered *Homo floresiensis*

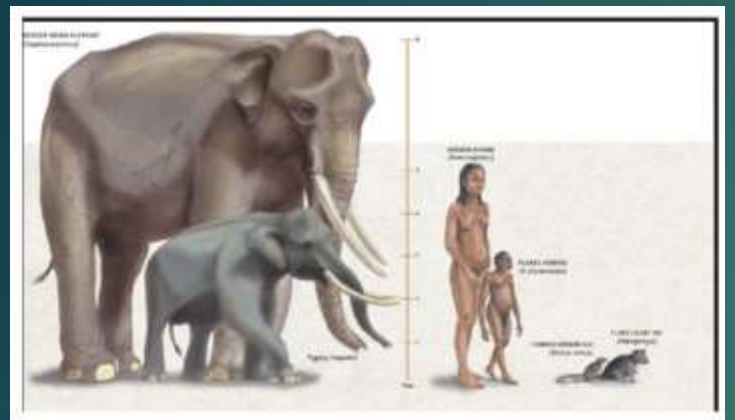
Cranial capacity of only 417 cc

*Homo floresiensis: 100*K to 17K on Flores



Homo floresiensis therefore lived concurrently with modern humans (*Homo sapiens*) for at least 82 K and *H. neanderthalensis* for 60K years.

Flores, Indonesia: Strange island



Island dwarfism on Flores, Indonesia

Homo floresiensis & Large rats

H. Floresiensis & giant storks

Giant Komodo dragons on Flores

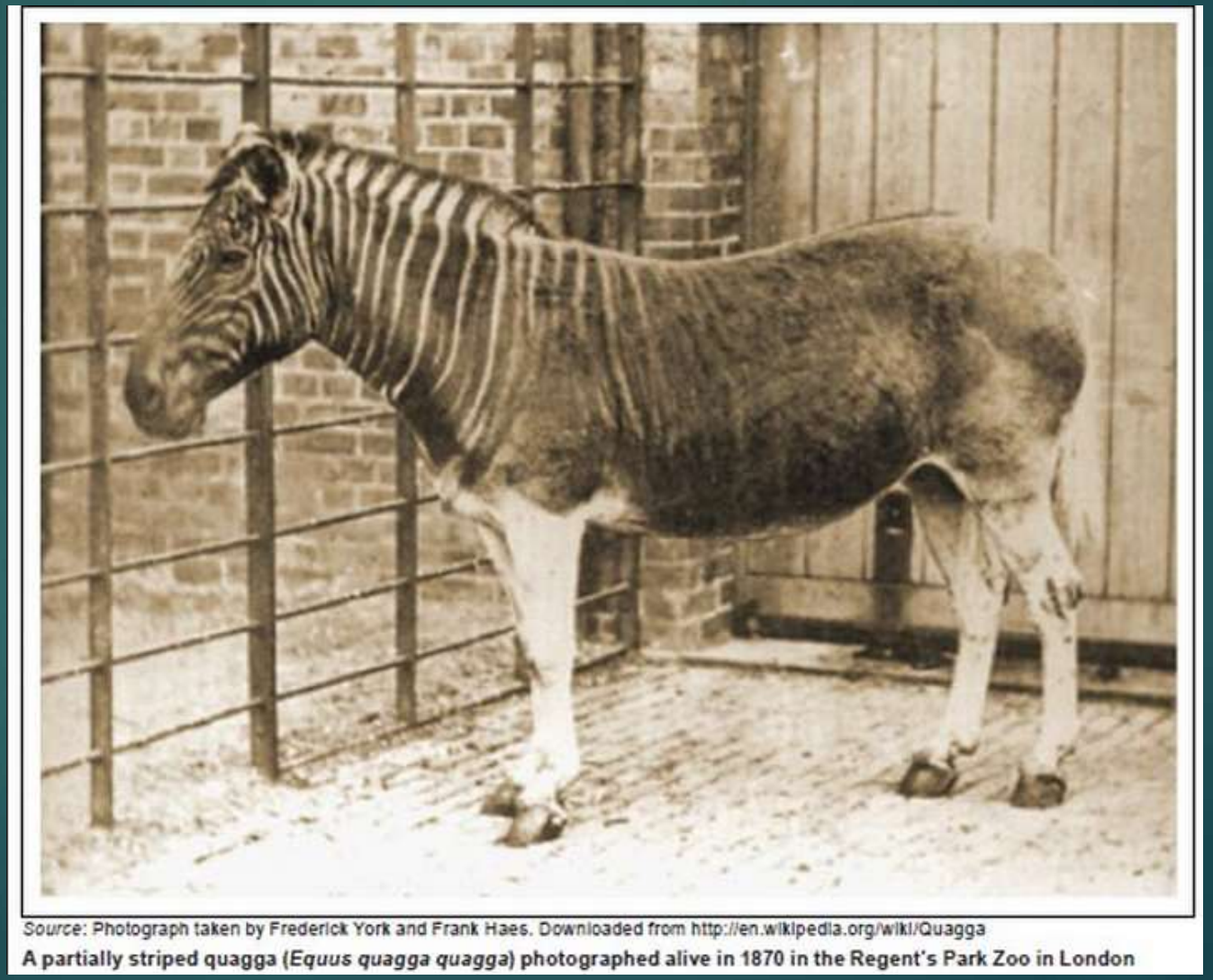
Giant rats, dwarf elephants, 6 foot storks, giant Komodo dragons

Paleogenetics

Does Illumina Have the First $1,000 Genome?

Long fall: After many years of decline, the cost of sequencing a genome had leveled off, but may dive again (dashed line) if Illumina's promise of a $1000 genome holds up.

Extinct Quagga: 1st mDNA



Source: Photograph taken by Frederick York and Frank Haes. Downloaded from http://en.wikipedia.org/wiki/Quagga

A partially striped quagga (*Equus quagga quagga*) photographed alive in 1870 in the Regent's Park Zoo in London

Charlie Vella's DNA

- Born on island of Malta, 1944
- Ancestry is Maltese back to 15th century
- Malta & Sicily conquered by Arabs in 869; expelled by Normans in 1224. Maltese language is sub-dialect of Arabic

- FamilyTreeDNA:
  - Paternal Haplogroup: I-Z161 J-M67 -- Z161 is thought to have been propagated around Europe by the Danish Vikings (Britain, Normandy, Sicily)
  - Maternal Haplogroup: T2b7a -- Middle Eastern

- 88.7% European; 7.8% Middle Eastern & North African; 0.8% Sub-Saharan African

- Neandertal: 2.7%

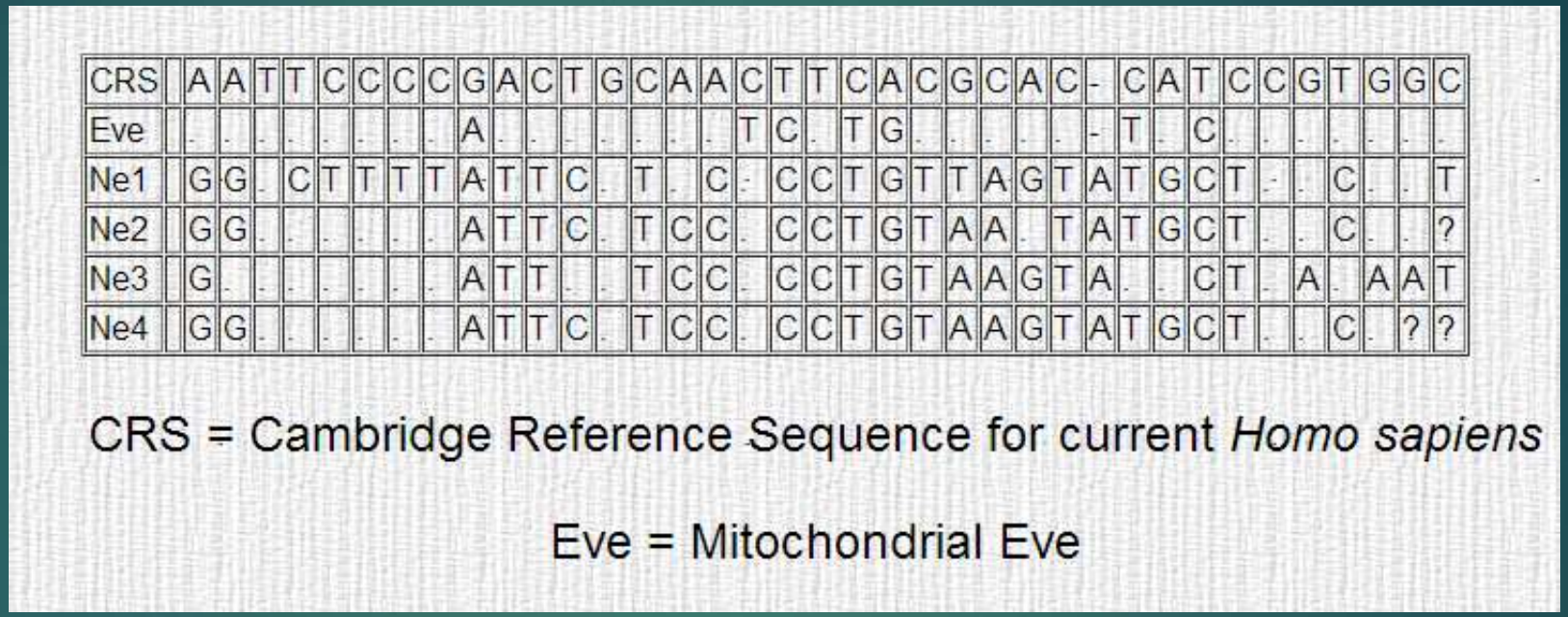
Genetic Differences in World: Most variation in Africa

- Most genetic variation in Africa & less everywhere else (with 10x more people & less genetic variation); All outside Africa, have genetic relatedness to inside Africa

Some African DNA is unique

- In Africa, component of genetic variation with no close relatives anywhere else
- But some backflow into Africa: Eurasian genes in San

Neandertals are not our ancestors; a different species; diverged 317-741 MYA



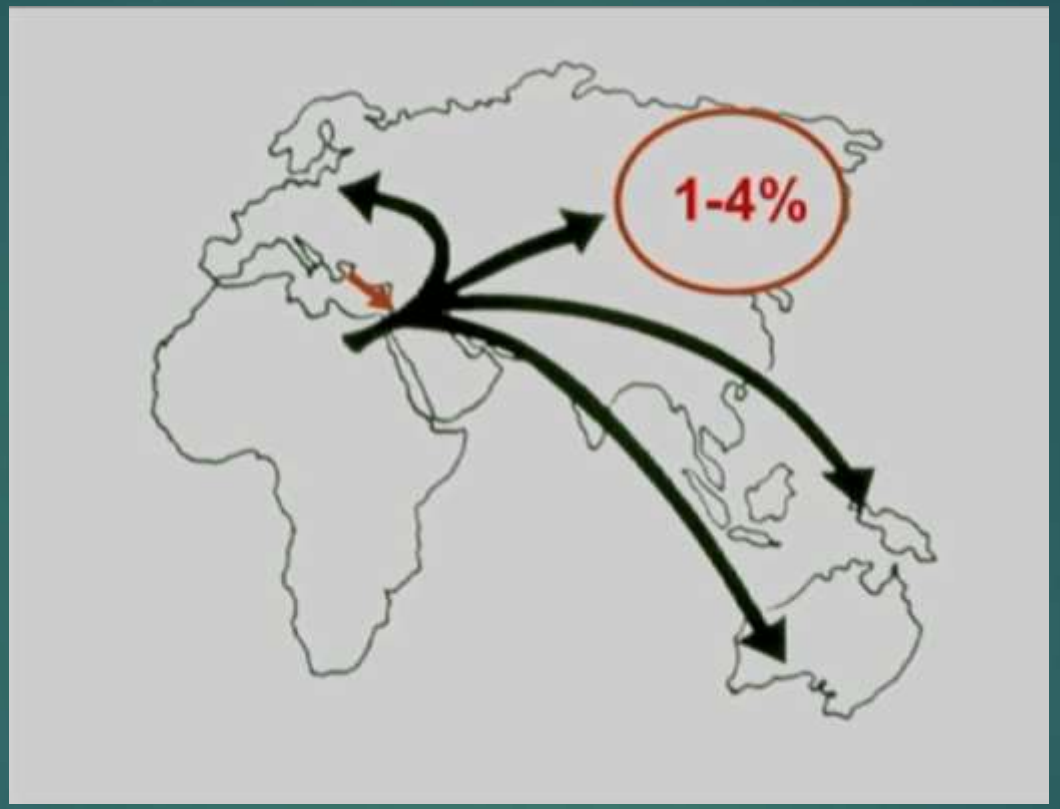
CRS		A	A	T	T	C	C	C	C	G	A	C	T	G	C	A	A	C	T	T	C	A	C	G	C	A	C	-	C	A	T	C	C	G	T	G	G	C
Eve		.	.	.	.	.	.	.	.	A	.	.	.	.	.	.	.	T	C	.	T	G	.	.	.	.	.	-	T	.	C	.	.	.	.	.	.	.
Ne1		G	G	.	C	T	T	T	T	A	T	T	C	.	T	.	C	-	C	C	T	G	T	T	A	G	T	A	T	G	C	T	-	.	C	.	.	T
Ne2		G	G	.	.	.	.	.	.	A	T	T	C	.	T	C	C	.	C	C	T	G	T	A	A	.	T	A	T	G	C	T	.	.	C	.	.	?
Ne3		G	.	.	.	.	.	.	.	A	T	T	.	.	T	C	C	.	C	C	T	G	T	A	A	G	T	A	.	.	C	T	.	A	.	A	A	T
Ne4		G	G	.	.	.	.	.	.	A	T	T	C	.	T	C	C	.	C	C	T	G	T	A	A	G	T	A	T	G	C	T	.	.	C	.	?	?

CRS = Cambridge Reference Sequence for current *Homo sapiens*

Eve = Mitochondrial Eve

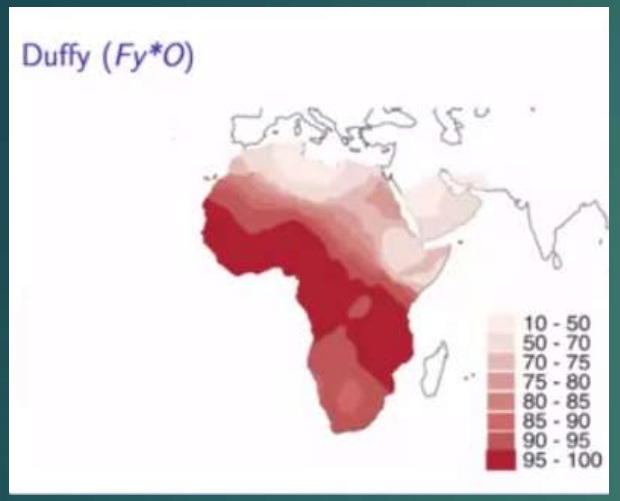
- MH, mEve, 4 N: Clearly, *Homo sapiens* and *Homo Neanderthals* are quite different, whereas the Neanderthals represent a pretty homogeneous group. The implication is that Neanderthals are not the ancestors of modern humans. A divergence time for the two lines is estimated at 317 to 741 MYA

1-4% N DNA in Non African MH

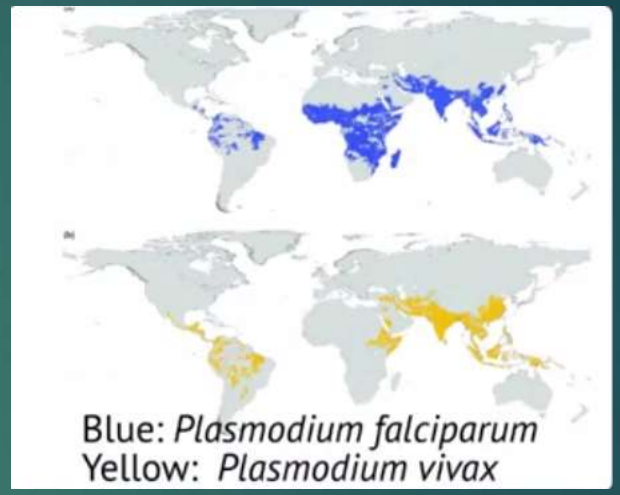


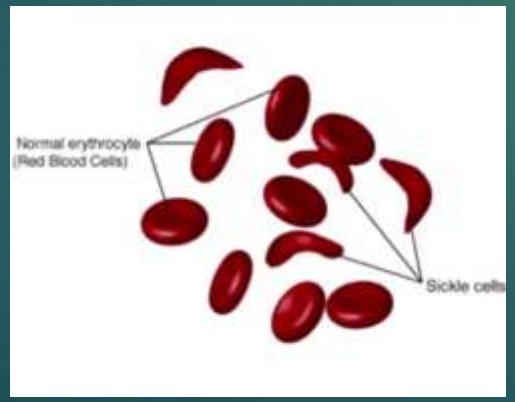
Model: when MH left Africa, interbred with N in Middle East, then carried N genes Into rest of world; 20% more Neandertal DNA in Eurasia than in Europe

Malaria Resistance ~30K ya; many mutations to defend vs Malaria i.e. sickle cell allele



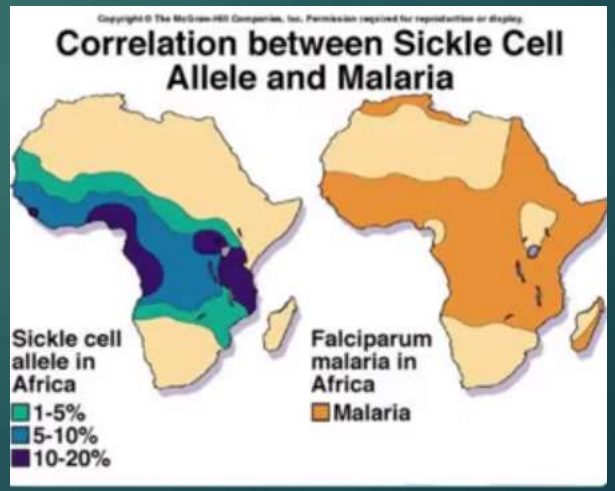
Up to 90% of Subsaharans carry Duffy O blood antigen





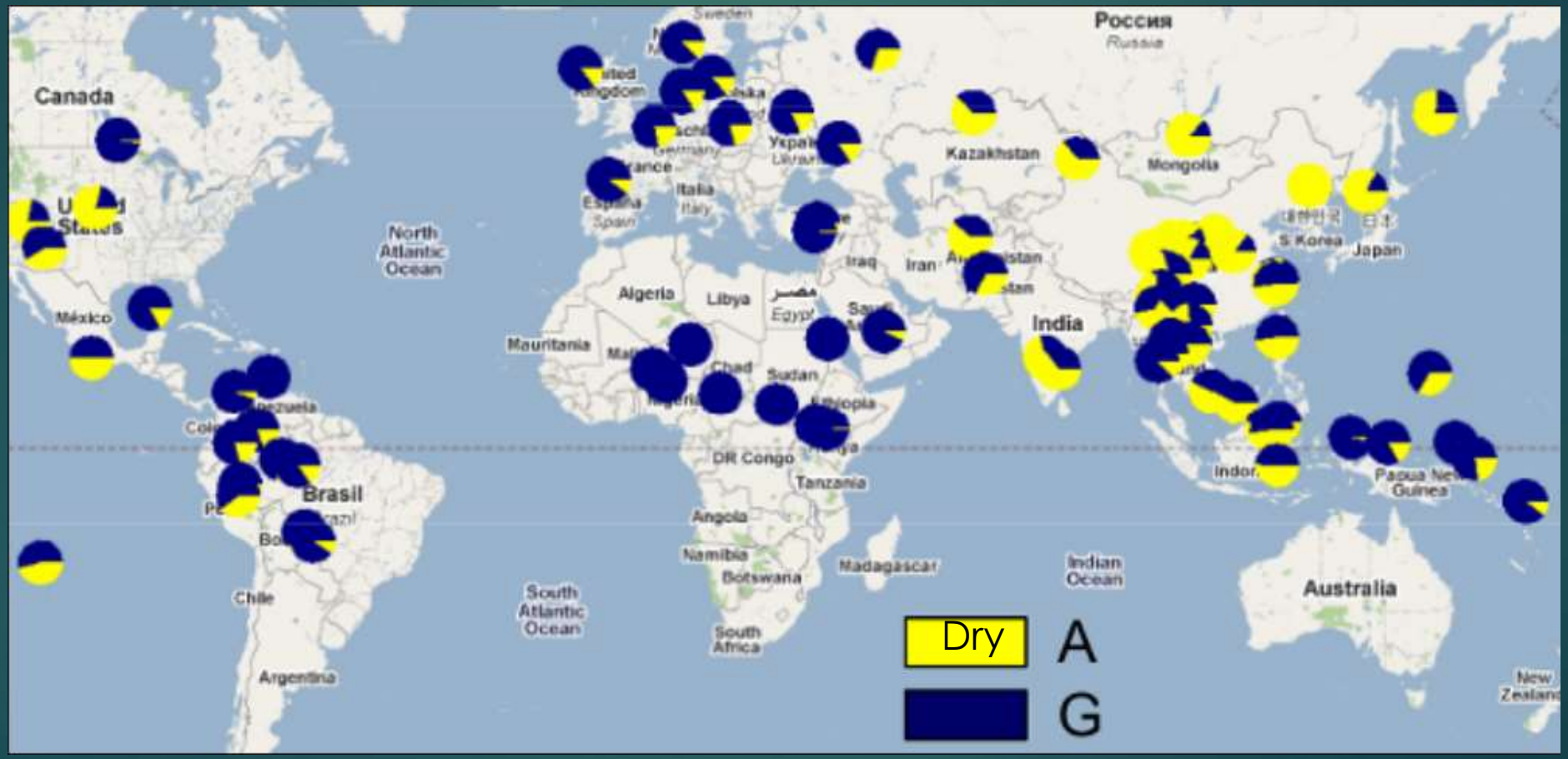
<u>1 Sickle cell allele = Immunity to Malaria</u>;

2 Sickle cell alleles = SC anemia

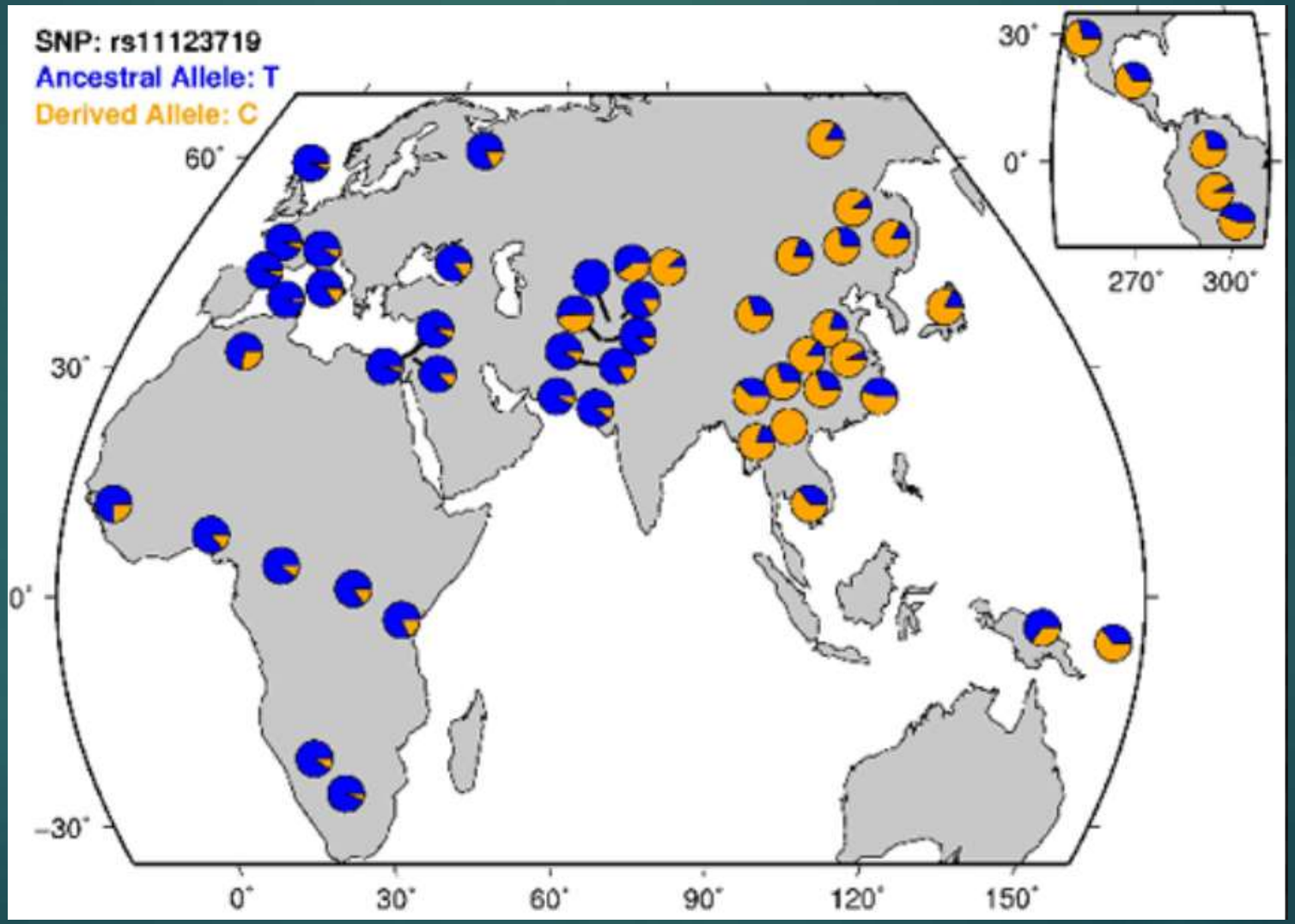


Many hemoglobinopathies

Sticky Ear Wax dominance;
Dry version new ~20-30K

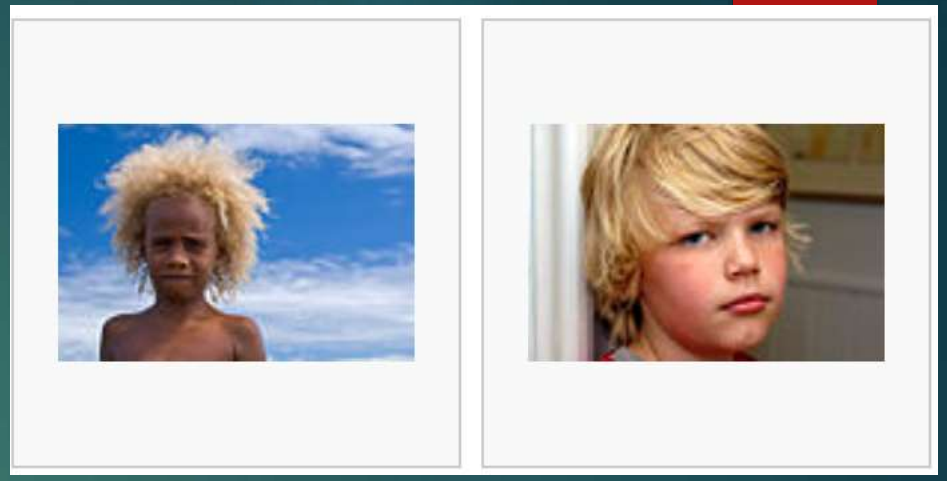


EDAR gene (Thick Hair Variant): China & Americas

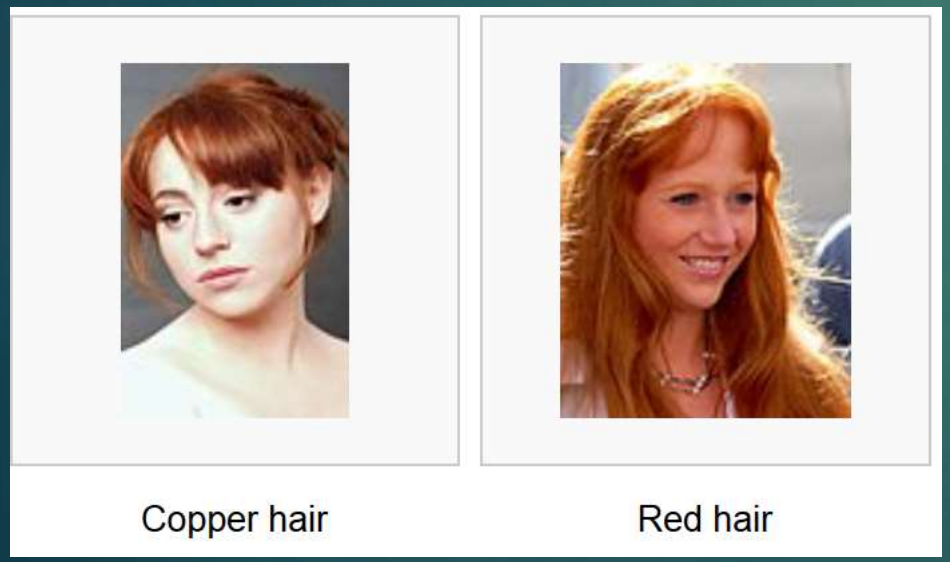


New gene variants ~20T

Human hair, eye, and skin color all come from a pigment called melanin (more = darker). We all had brown eyes originally. Entry into northern latitudes: lighter skin, red hair (MC1R)& skin cancer



Blonde Hair evolved 2x; 5–10% of people from Melanesia



Better production of vitamin D

Blue eyes evolved before light skin; gene turns off the mechanism which produces brown melanin pigment; ancestor probably lived around 8,000 ya near Black Sea; All blue eyed Europeans are genetically related.

Modern Human mutations

- Novel features found in MH (& not prior species):
  - 31,289 SNPs
  - 25 insertions/deletions
  - 45 splice sites
  - 3117 regulatory regions
  - 96 amino acids (CCCDs)

- Paabo: "The dirty little secret of genomics is that we know next to nothing about how a genome translates into the particularities of a living and breathing individual."

Modern Human Differences

- 87 proteins are unique to MH
- Functions overrepresented in neuron development (CASC5, SPAG5, RIF184)
- Ways to identify human specific genetic changes:
  - A. Clone a Neandertal: technical & ethical issues
  - B. Find "backmutations" (point mutation that restores the original sequence) in humans
  - C. Engineer H & N changes in stem cells
  - D. H & N genes in mice

5 Lessons from Hominid Evolution

- Do what Lucy did: physical exercise is best protection vs. dementia
- Climate change was major factor in extinction of many human species
- Sixth extinction event is underway: 99 % of all animals have gone extinct;
- Killing the planet: climate denial, rising carbon dioxide levels, anti-evolution thinking, habitat destruction
- Help sustainability: use less lights, recycle, drink tap water, drive less/use less gas, walk, unplug, buy local food

Downloable Evolution Talks

- www.charlesjvellaphd.com
  - What's New in Hominid Evolution 2015
  - Hominid Evolution 2015
  - A Brief Biographical History of Paleoanthropology