An extended origin: climate, populations and palimpsests in the evolution of *Homo sapiens*

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DySoc/NIMBioS Webinar Series on "Human origins and cultural evolution: Celebrating the 150th anniversary of the Descent of Man"
• Asynchronicity of change
• Discontinuity in regional morphologies
• Shared derived features of all living humans
• Africa fossils of *Homo sapiens* significantly older than those from Eurasia
Manica et al. 2007.

Neanderthal mt DNA

Krings et al. 1997. *Cell*

Omo Kibish, Ethiopia, 200 Ka
Herto, Ethiopia, 160 Ka

Neanderthal nuclear DNA

Noonan et al. 2006 *Science*
Finger bone from Denisova Cave, Altai, that resulted in the first Denisovan genome in 2010.


Sima de los Huesos, Atapuerca, ~ 400 Ka

Meyer M et al. 2013. A mitochondrial genome sequence of a hominin from Sima de los Huesos. Nature
Denisovan genes in other hominins:

- 0.0% Denisovan in Neanderthals
- 0.2% Denisovan in modern Han Chinese, Dai of S China, Karitiana of Brasil
- ~4-6% Denisovan genes in PNG, Australia, Philippine Negritos

Other hominin genes in Denisovans:

- 0.0% modern human
- 0.5% Neanderthal (*** HLA)
- 0.5-8% ANCIENT (*Homo erectus*)
Out of Africa Multiregional model

Denisovans
Neanderthals
Africans
Europeans
Asians

Multiregional model
Homo erectus (or Homo georgicus)

Homo antecessor

Neanderthals

Modern humans

Denisovans

Middle Pleistocene 0.78 – 0.13 Ma

Early Pleistocene 2.6 – 0.78 Ma
1. Separation of Neanderthals and Denisovans (~450 Ka [381-473 ka])
2. Separation of *sapiens* lineage from the Neanderthal/Denisovan lineage (~700 Ka [550-765 Ka])

*al*. 2014. The complete genome sequence of a haul from the Altai Mountains. *Nature*
Afro-European interactions – partial dispersals out of Africa

**Y chromosome**

**mtDNA, Hohlenstein-Stadel**
Mode 3 Dispersals Model

Mapping a period of multiple Afro-European contacts

**Apidima Cave fossils provide earliest evidence of Homo sapiens in Eurasia**

Apidima, Greece, ~210 Ka

**Misliya, Israel, ~190 Ka**
Climate change and the Early-to-Middle Pleistocene Transition (EMPT)

- Long-term cooling of sea-surface temperatures
- Increase in amplitude of glacial cycles
- Shift from 41,000 to 100,000 year mode
- Shift to asymmetric glacial cycles: short warm and long cold phases with abrupt endings (terminations)

Onset of global glaciation; SAHARA; expansion of East African grasslands

Walker Circulation

EMPT

Holocene

Years before present

Average global temperature (°C)
Climate change and the Early-to-Middle Pleistocene Transition (EMPT)

Average temperature relative to today in °C at 45° N to 80° N latitude

EMPT
Shift from 41,000 to 100,000 yr long cycles

Current

Cold ------ Hot
TROPICS

- Hydrological response to orbital eccentricity/precessional cycles
  - EFFECT: amplification or dampening of tropical monsoons

- **eccentricity minima**: weak monsoons at precessional timescales, increased aridity in East Africa, “Yellow Sahara” phase

- **eccentricity maxima**: increase in tropical climate variability at 100,000 and 400,000 yr cycles [independent of continental ice volume] with alternating strongest and weakest monsoons [alternating “Green Sahara” and “Desert Sahara” phases]

Adapted from Grant et al. 2017. A 3 million year index of North African humidity/aridity and the implication of potential pan-African Humid periods. *Quat Sc Rev*
Megadrought at the end of the EMPT – fragmentation of African populations; separation of *sapiens* and Neanderthal-Denisovan lineages.

Schlebusch et al. 2017. Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago. *Science*
Megadrought at the end of the EMPT – fragmentation of African populations; separation of *sapiens* and Neanderthal-Denisovan lineages

Expansion and structuring of *sapiens* populations in Africa (and partial dispersals out of Africa)

Green Sahara

Expansion and structuring of *sapiens* populations in Africa (and partial dispersals out of Africa)
Local or pan-African?

Scerri EML et al 2018. Did our species evolve in subdivided populations across Africa, and why does it matter?

Major diversity amongst African hominins 400-200 Ka

- Irhoud 315 Ka
- Florisbad 260 Ka
- Kabwe 300 Ka
- Eliye Springs 350 Ka
- Ndutu 400 Ka
- *naledi* 330-250 Ka

- Omo Kibish, Ethiopia, 200 Ka
- Herto, Ethiopia, 160 Ka
What defines ‘modern humans’?

**Palaeontological definition of modern humans**
- Comparatively tall and narrow body
- Large brain hominin
- Tall rounded cranium*, with relatively vertical forehead
- Comparatively reduced cranial superstructures
- Small face positioned under the vault
- Mental eminence on mandible*

* Apomorphies of *Homo sapiens*
The globular modern human head

- A quantitative measure of the globular modern human head
- Genetic association of values of this “index of endocranial shape” amongst Neanderthal introgressed genomic fragments in the genomes of 4468 Europeans
- Key SNPs correlations associated with reduced globularity
- Correlated SNPs: affect neural expression of 2 genes linked to neurogenesis and myelination

Expanding the list: Body size and life-history

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- Comparatively tall and narrow body
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- Mental eminence on mandible*
- Unique life-history*

THE HUMAN LIFE CYCLE

Sustained foetal brain growth rates

Conception Birth Weaning Adolescence First reproduction Menopause Death
Prenatal Infancy Childhood Puberty Adulthood Senescence

Longer infancy, with sustained brain growth

Stature: KNM-WT 15000 159 ± 7 cm, DMANISI (D2700/D2735) 153.1 cm

Body mass: KNM-WT 15000 49.2 kg, DMANISI 41.2 kg

Curves: 438 Sudanese children 7-10 years old
Ancestral *Homo* life-history

Ancestral *Homo*: large size, encephalised, fast growth

- **Energetically very demanding** – diet shift, carnivory
- **Ecologically effective** – early independence, predator risk minimisation
- **Socially and behaviourally challenging** – likely increase role of social cohesion, provisioning, innovative solutions (cooking?)
Modern human life-history:

- Relatively higher energy budget and reproductive output than apes (“fast”)
- Long juvenile period and lifespan (“slow”)

**UNIQUE**

Retzius Periodicity (RP): number of days between the deposition of successive long-period growth lines in teeth (striae of Retzius in tooth enamel)

- histological manifestation of a neuroendocrine biorhythm (Havers-Halberg oscillation)
- closely related to body mass and BMR, role in regulating pace of life-history in mammals

Unique human life-history

*Homo sapiens*: large size, encephalised, slow growth

- **Energetically efficient** – budgeted development through longer ontogeny
- **Ecologically challenging** – longer dependence on mother, big risk of predation
- **Socially and behaviourally very demanding** – provisioning of mothers with dependent children, social cohesion and belonging, major pressure on technological solutions, increased dependence on learning social norms and skills, increased importance of social memory

The evolution of modern human hunter-gatherer societies?
- Role of kin and non-kin
- Family units, foraging units, social units – multilevel societies
- Shared social norms, social identities, and social histories

Green Sahara

Significant adaptive change shaping the origins of *Homo sapiens*

Behar et al. 2012 AJHG
Major outstanding issues
Who was the last common ancestor of humans, Neanderthals and Denisovans (HND)?

Probably between 900-700 Ka
- Period of extreme aridity in Africa: population fragmentation
- A time when the human/Neanderthal/Denisovan lineage co-existed with another hominin in Africa
  - North vs sub-Saharan Africa?
  - *Homo antecessor*?

African fossils from this period: too few, each different

Mounier A & Mirazon Lahr M 2016. Virtual ancestor reconstruction: revealing the ancestor of modern humans and Neandertals. JHE
Where were the ancestors of Neanderthals/Denisovans before they split?

MODEL 1: Neanderthal and Denisovan lineages separate during the process of out-of-Africa dispersal

- time of split = time of dispersal out of Africa
- Implies that ancestor of NEA-DEN lived in Africa between 700 and 450 Ka
  - Too late to fit the fossil record? Earliest ages (Ceprano, Sima) ~430 Ka; Petralona?
  - Implies the rich, African looking (full of cleavers, absent in Europe) Acheulean at GBY was an earlier (limited?) dispersal

MODEL 2: Neanderthal and Denisovan lineages separate in Eurasia some time after the out of Africa dispersal

- time of dispersal out of Africa much before split NEA x DEN
- Implies that ancestor of NEA-DEN lived somewhere in Eurasia between 700 and 450 Ka
  - What Eurasian fossils match the LCA of NEA & DEN?
  - Earliest “non-erectus” fossils in China ~350 Ka – where were the Denisovans before?
What was the adaptive niche of African small-bodied *Homo*?
Which Last Common Ancestor (LCA) are we looking for?

African hominins 400(?) – 250 Ka
1. Eliye Springs, West Turkana, Kenya
2. Kalakoel 3, West Turkana, Kenya
3. Ndutu, Tanzania
4. Kabwe, Zambia
5. Florisbad, South Africa
6. Jebel Irhoud, Morocco
7. *Homo naledi*
How deep is the population structure of African *Homo sapiens*?

Schlebusch et al. 2017. Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago. *Science*

An extended origin

1. Elements of the ‘out of Africa’ model that are consistent with new data
   • Modern humans have a recent African origin
   • The main dispersal of modern humans took place in the last 100,000 years and largely replaced Eurasian hominins

2. New insights
   • The lineages leading to modern humans on the one hand, and Neanderthals/Denisovans on the other originate during a megadrought in Africa
   • Modern humans dispersed out of Africa multiple times, to different spatial extents and evolutionary impact
   • The modern human occupation of Eurasia included some assimilation of local archaic populations
   • All modern humans share unique brain shape and a unique life-history with major implications towards behaviour and sociality

3. Points of debate
   • LCA of sapiens/Neanderthal/Denisovans
   • Spatial/demographic parameters of African origins
   • Adaptation in the sapiens lineage
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