Evolution of Hominins

The fossil record provides evidence of the evolution of the Hominin lineage leading to *Homo sapiens* - that is, the lineage from the split with the common ancestor of human and chimpanzees. There were two main schools of thought regarding the origin of *Homo sapiens*: Darwin thought humanity arose from Africa (due to presence of chimpanzees and gorillas), while other prominent scientists thought that humans arose out of Asia (due to presence of orangutans and siamangs).

Early applications of the molecular clock (by Sarich and Wilson at UC Berkeley) suggest the chimpanzee-hominin occurred 7 million years (mya) ago: the last common ancestor between chimpanzees and humans existed around 7mya. Therefore, humans are **not** descended from chimpanzees: the chimpanzee lineage has been evolving independently as long as our lineage has. Our common ancestor did not look like either chimpanzees or humans: for example, consider *Ardepithecus ramidis* from 4mya (discovered by Tim White, and visible in the display outside the Marian Koshland Biosciences Library). It is our ancestor, yet it does not look like us. It is neither a chimpanzee nor a human. The *Australopithecines* are probably paraphyletic with the *Homo* line.

When looking at the graph below, note that it is not a phylogeny or even a cladogram: there is still much debate on the phylogeny and even the taxonomy of these different species.

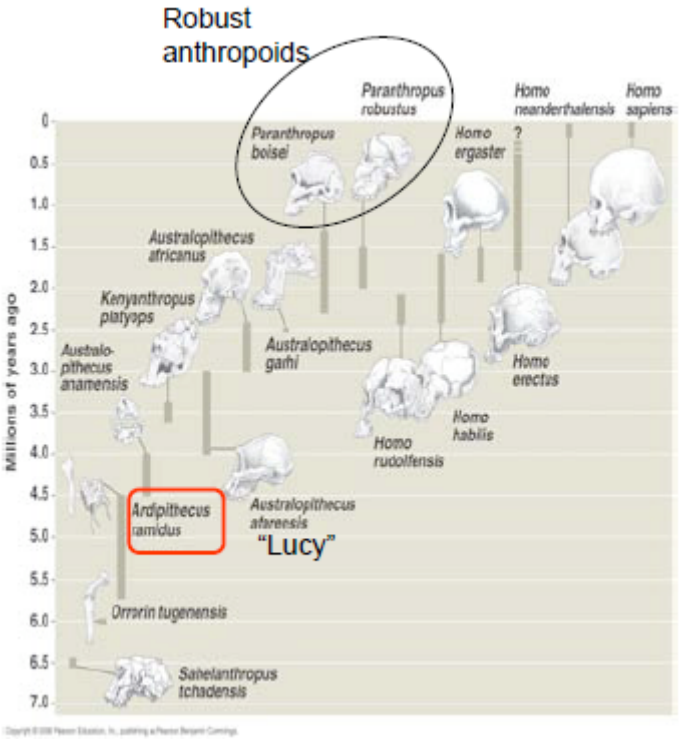


Figure 1: Plot of different hominins and their temporal location
Campbell, Fig 34.40, *Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings*

Key hominin features include bipedalism (walking upright on two limbs) and smaller canines. There was a large increase in hominin diversity about 4-2mya.

Evolution of *Homo*

Key *Homo* features include an increasing cranial case that allowed for a larger brain, decreased sexual dimorphism relative to their ancestors (and to robust hominins), and more terrestrial behavior (walking on the ground rather than swinging through trees). Note that larger braincases came about later, although there is a debate in anthropological circles regarding whether hominins developed walking or larger brains first.

Homo erectus was first discovered in Indonesia (Java and Peking; you may have heard of the specimen known as "Java man"). However, the Leakeys (an archeologist family) discovered *Homo erectus* at a site called Olduvai Gorge in Africa. They also found *Homo habilis* (older) and *Paranthropus boisei* (even older) at that site. *Homo erectus* had a larger brain size than preceding hominins. The most recent fossils of *Homo erectus* date back 27,000 years ago.

Homo floriensis was discovered in 2003 on the isle of Flores in southeast Indonesia. This was a small hominin, about a meter tall, with a lower braincase size than expected just from extrapolating from a brain: body ratio. Dating indicates the specimen is 12,000 years old, which is very recent, and overlaps *Homo sapiens*. (For context, consider that humans may have been practicing agriculture as early as 10,000 years ago). Therefore, could this be a diseased microcephalic *Homo sapiens*? This possibility is rejected if you examine other aspects of anatomy that have noticeably different characteristics than *Homo sapiens*.

Another possibility is that *Homo floriensis* is indeed separate species (perhaps descended from *Homo erectus*) that has undergone **island dwarfism (aka insular dwarfism)**, a process where a community of large animals on an island experience a reduction in size. (The reverse can also occur, where small animals experience an increase in size.)

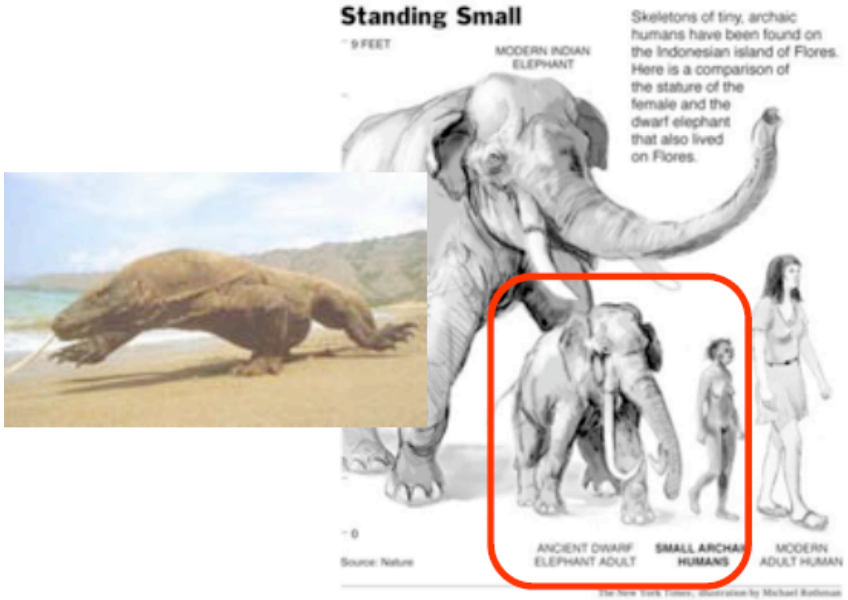


Figure 2: Giant lizards, tiny elephants (*Stegodons*), and *Homo florensis*
New York Times

Another example of insular dwarfism would be the elephants on the isle of Flores, as dwarf elephants (stegodons) were found in the fossil record on that isle. (Giant lizards similar to komodo dragons were also found on the island.) There are two possible mechanisms: a gene expression response to environmental stress that results in a smaller animal, or that there is a

selective pressure for smaller individuals because they require less food to survive, and are more likely to survive to reproductive age. This exemplifies that humans evolve much as other species.

Migration of *Homo Sapiens*

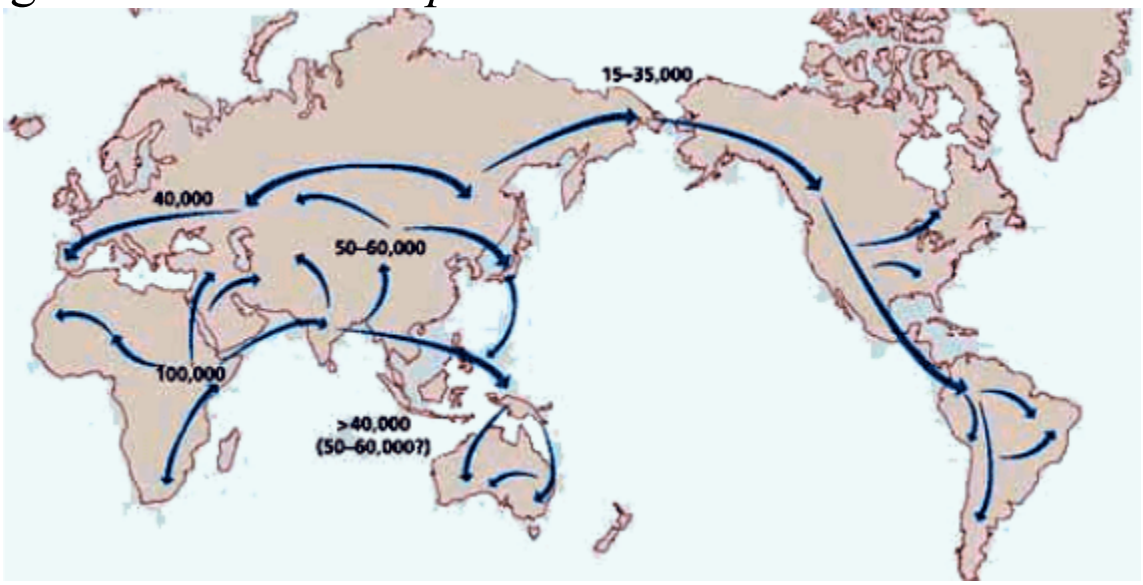
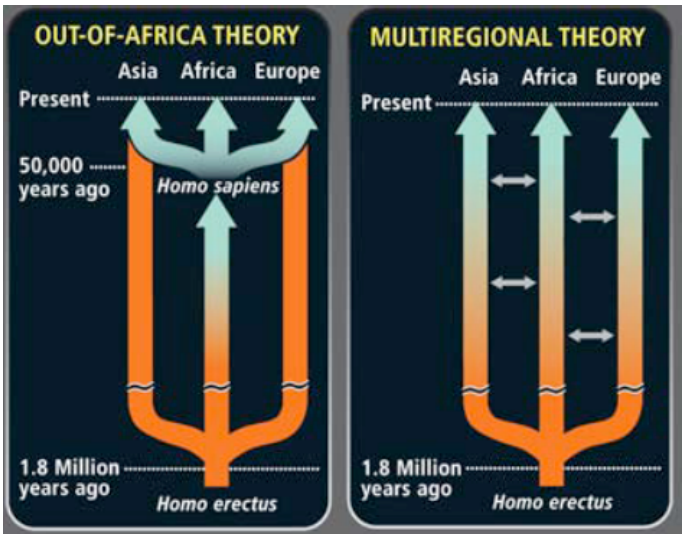


Figure 3: Map of *Homo sapiens* migration across the continents
Lecture 12, *Craig Moritz*

Following is a timeline based on fossil evidence, but it is supported by molecular data as well.
160 kya: Homo sapiens in Ethiopia
100 kya: migrates out of Africa into the Middle East and across South Asia
80 – 40 kya: migration from India to Australia, possibly interacting with *Homo erectus* in Indonesia
40 kya: migration into West Europe and across the range of *Homo neanderthalensis* (don't go further north, because "further north" is covered by a glacial sheet)
35 – 11 kya: 1 or 2 migrations across the Bering land bridge
3.5 – 1 kya: Polynesian migrations (pacific isles, Australia, New Zealand, Maori)



There are two migration theories, the **multiregional** and the **out-of-Africa** theories. The second theory is the one more supported by molecular data.

The **multiregional** theory states that *Homo sapiens* arose independently in several locations from distinct populations of *Homo erectus*.

The **out-of-Africa** theory states that *Homo sapiens* arose in Africa and migrated out across the continent. Evidence for this includes high genetic diversity in African populations relative to non-African populations. (Think back to founder effects and population bottlenecks as to why this evidence supports the out-of-Africa theory.)

Figure 4: Multiregional and out-of-Africa theory

Interactions of *Homo sapiens* with *Homo erectus* and *Homo neanderthalensis*
Homo sapiens' eastward colonization took them through the range of *Homo erectus*, which still existed in the Indonesian archipelago, and *Homo floriensis* as well. Their northern colonization brought them into the range of Neanderthals. Did *Homo sapiens* eradicate those other species? Or did they interbreed and thus absorb them into our population? Genome sequencing of recoverable DNA from fossils is underway to try to answer this question.

Are humans still evolving?

As the architects of our own environments, are we still subject to natural selection? The answer is yes, just in different ways. Consider that the human population size has greatly increased, as has the ability for humans to migrate. Thus, while it has been relaxed, natural selection is likely now more important than genetic drift.

Consider also **lactose tolerance**. Lactase is an enzyme juvenile mammals have that breaks down lactose, allowing them to digest milk. Cats are the only mammals that maintain their lactase production into the adult stage of their life cycle – along with some humans, that is. Lactose intolerance is a retained ancestral condition; molecular comparison of the genes for lactase production show that the traits allowing human adults lactose tolerance arose independently in Northern Europe and in Africa at around the same time less than 5000 years ago. Lactose tolerance is a very advantageous trait that has quickly been spreading throughout the human population.

Evolution and modern medicine

There are different factors to consider when considering diseases. Medicine has traditionally been focused on **proximate factors:** how did you get the disease, how does the disease work mechanistically and biologically, and how can we stop the disease? However, disease also has **ultimate factors:** what gave rise to this disease? In what populations did it evolve?

Evolutionary medicine has the following principles:

1. Understanding the evolutionary basis of diseases and the human phenotype can improve disease diagnosis, prevention, and treatment.
2. Variation in human phenotypes result from genetic variation and environmental influences on development.
3. Natural selection acts to maximize reproductive fitness, not health and longevity.

For more background on Evolutionary medicine, see the book chapter by Zimmer (2009) posted on the course website on the Evolution schedule under Lecture 12.

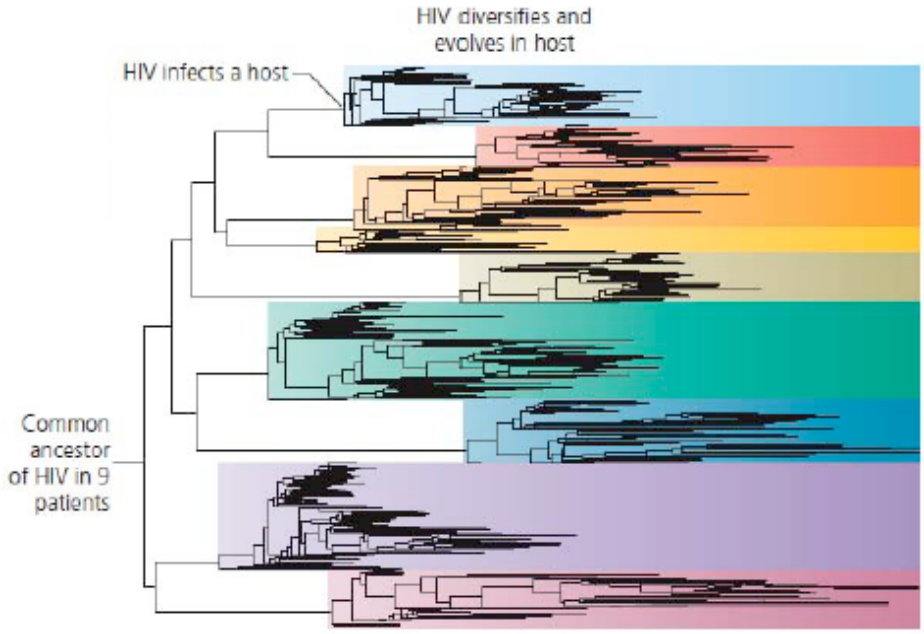


Figure 5: Rapid HIV evolution within hosts
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We have already discussed the evolution of antibiotic-resistant pathogens. Another example involves HIV: once HIV infects a host, it undergoes rapid evolution within the host, creating many different strains within the host. There is not one virus to combat, but many, all with different properties.

Evolutionary mismatches: Some previously evolved human traits do not match our current environment due to rapid changes in human life-history (nutrition). For example, while sugar and fat were scarce resources in our evolutionary past, we now have constant access to a large supply of fat and sugar. If we eat all the fat and sugar we desire, we become obese or suffer from related conditions.

Consider: Like other species, *Homo sapiens* evolved to reach reproductive age and rear offspring, not to live beyond that. But now that we survive well past that age and reach a life-cycle stage that's never been selected for. Our bodies still suffer aging and eventual organ failure, but we also have conditions such as type II diabetes, cancers, and autoimmune deficiencies. These conditions may be the side effects of genes which allow us to reproduce earlier, but the negative results of which were never an issue before, simply because humans did not live that long – in effect, the short term reproductive gains always outshadowed the long-term damages.

The **Thrifty Gene hypothesis** explains obesity in some populations. Certain groups have genes which ensure efficient metabolic processes, allowing infants to survive having scarce nutrition and nourishment. But when subjected to a diet rich in nutrition, fats, and sugars, they then make too much use of the available resources, becoming obese.

The **Hygiene Hypothesis** states that, with our constant battle to sanitize our living conditions, we have eliminated beneficial bacteria that we used to live in a symbiotic relationship with. As a result, we are now hypersensitive to any bacteria, and even to our own body, leading to auto-immune disorders..

Further Courses in Evolution:
IB C149 (Molecular Ecology)
IB 160 (Evolution)
IB 161 (Population Genetics)
IB 162 (Ecological Genetics)
IB 163 (Evolutionary Medicine)
IB 164 (Human genetics)
Anthro 1 (Biological Anthropology & human Evolution)