

Deep Time in Perspective: An Animated Fossil Hominin Timeline

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ABSTRACT

The lapse of deep, geologic time—a concept that Darwin struggled to explain to readers of *Origin of Species*—is all but ignored in paper representations of hominin evolution. Representational constraints inherent to books and journals may influence how hominin evolution is reconstructed. In an attempt to help overcome these issues, we created an alternative to the traditional phylogenetic diagram. First, in 2005, we built a database of nearly every significant fossil hominin discovery up until about 40,000 years ago. Then we animated a timeline of hominin evolution. The clock starts at 6.5 Ma with the *Sahelanthropus tchadensis* cranium. Time ticks by on the screen at the chosen rate until 6 Ma when symbols representing the *Orrorin tugenensis* specimens flash into view, and so on until the proliferation of anatomically modern humans in the Late Pleistocene. Our animated timeline provides a new way to experience deep time. Watching the movie with a generation of 20 years represented by one second takes over 90 hours, and it is difficult to interpret the resulting representation as a bush, or even as a tree, as is presently common.

INTRODUCTION

Phylogenetic trees have a long history of representing evolutionary hypotheses in the printed volume (Figures 1–3). Because they serve as a summary diagram for the tempo and mode of evolution, trees are included in nearly every biology textbook and they are significant tools for teaching hypothesis formation and testing (Wiley 2010).

From a sample of paleoanthropological trees in the literature, it is clear that authors use different techniques to capture and convey information about evolution. Some are artistic (Le Gros Clark 1955), while others travel down instead of up and even include the environment (Napier 1970). Robinson (1954) added dots to convey variation and fluidity and his tree accounts for geography, species relationships, and time. Day (1986) included population expansion and extinction in a three-dimensional model with cones. Falk (1992) preferred a cactus to the branching tree analogy. Grine (1993) accounted for disparate and emerging points of view. With the accumulation of new hominin fossils and taxa, it has become increasingly difficult to squeeze the hominin phylogeny onto one page of text. At present there are so many fossil hominin species that the tree is wider than it is long and has many branches (e.g., Wood 2002). As a result, the hominin phylogeny is now commonly represented as a bush with many contemporaneous lineages.

Limited to the printed page, representations of hominin evolution may be misleading. For instance, on an 8.5 x 11 inch piece of paper, in a chart scaled to 6 million years and depending on the orientation, the word “*H. rudolfensis*” in twelve-point font can represent 55,000–70,000 years. Even if represented by a single diminutive icon, a single fossil can take up 100,000–300,000 years of space on a phy-

logeny (e.g., Tattersall 1995). That is, a single individual can represent 5,000–15,000 generations (at 20 years per generation) on a phylogenetic tree.

In general, trees are drawn with aspects of geography, populations, branching patterns, and time. However, relative to the other components, time is difficult to grasp, let alone represent visually. This is even true for paleontologists who, like everyone else, have no applicable experience for frame of reference. Lamarck (1809) contemplated the difficulties humans have in comprehending deep time and, likewise, Darwin heavily stressed the concept in *Origin of Species*. He knew that deep time was a major obstacle to understanding evolution and wrote, “It is hardly possible for me to recall to the reader who is not a practical geologist, the facts leading the mind feebly to comprehend the lapse of time” (Darwin 1872: 294).

Educators have tricks for explaining deep time to students, using analogies like a mile, a football field, a large room, a day, or a year to encapsulate the history of the universe or Earth. Darwin describes an illustration of deep time posed by a colleague of his, Mr. Croll. In this exercise one is supposed to:

“take a narrow strip of paper, 83 feet 4 inches in length, and stretch it along the wall of a large hall; then mark off at one end the tenth of an inch. This tenth of an inch will represent one hundred years and the entire strip a million years. But let it be borne in mind in relation to the subject of this work, what a hundred years implies, represented as it is by a measure utterly insignificant in a hall of the above dimensions” (Darwin 1872: 269).

Demonstrations like this offer a glimpse into the expanse of deep time and can conjure up a feeling of awe, but

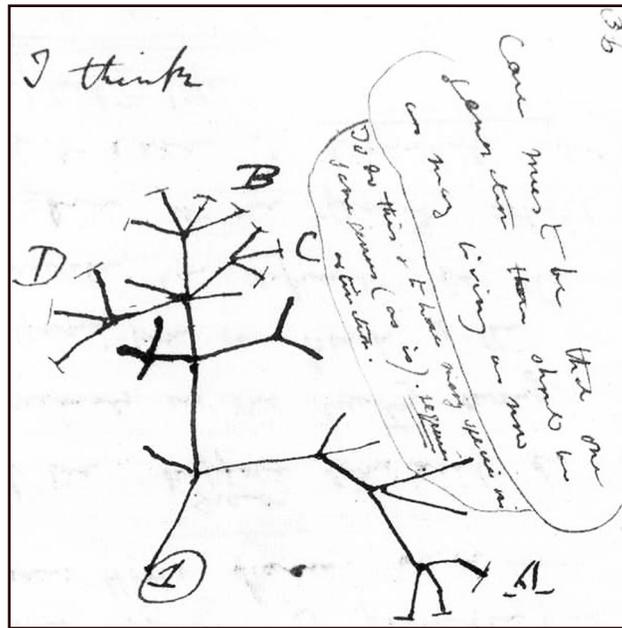


Figure 1. Notebook B: [Transmutation of species (1837–1838)] (Darwin 1837) [source: http://commons.wikimedia.org/wiki/File:Darwins_first_tree.jpg].

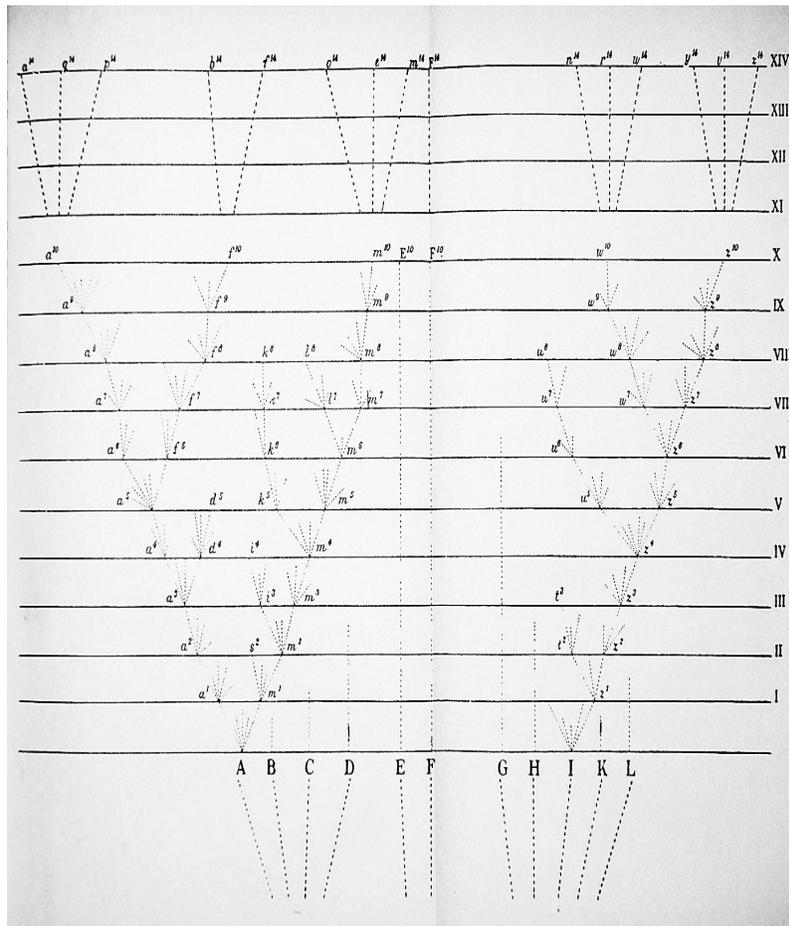


Figure 2. Origin of Species (Darwin 1859) [source: http://commons.wikimedia.org/wiki/File:Darwin_divergence.jpg].

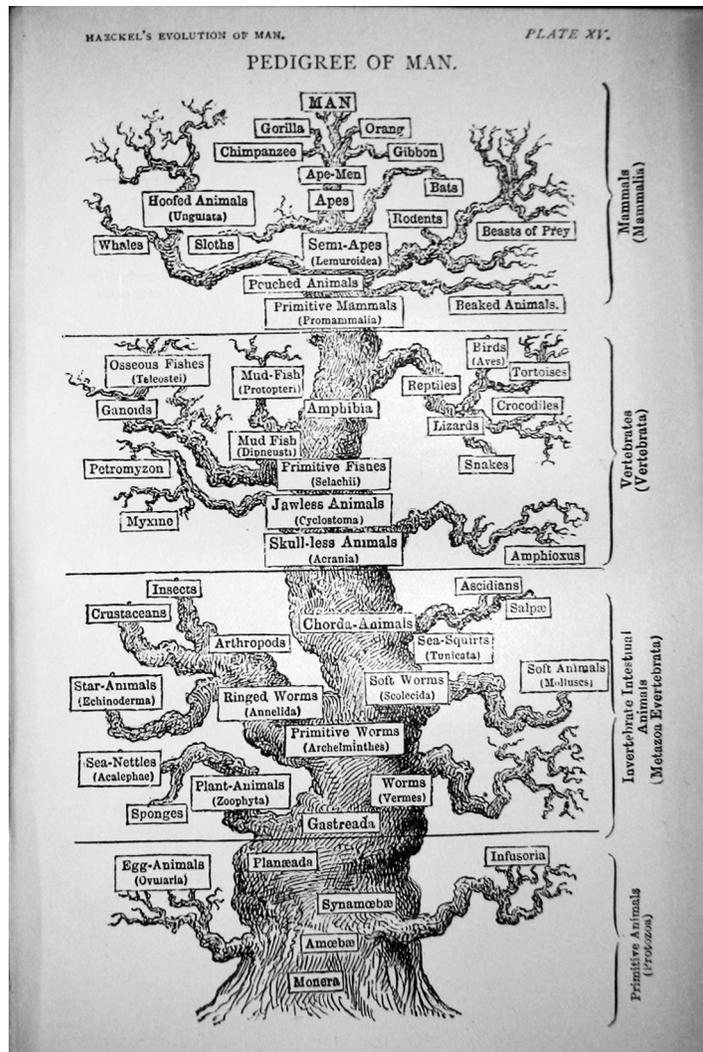


Figure 3. *The Evolution of Man: A Popular Exposition of the Principal Points of Human Ontogeny and Phylogeny* (Ernst Haeckel 1897) [source: http://commons.wikimedia.org/wiki/File:Pedigree_of_Man_English.jpg].

they are still insufficient and the live experience is difficult to reproduce in a book or journal. Moreover, it is possible that the constraints inherent to printed media are influencing phylogenetic reconstructions of hominin evolution by shaping or limiting the formation of testable hypotheses. In an attempt to help overcome these issues, we created an alternative to the printed tree.

MATERIALS AND METHODS

In 2005 we built a database in Microsoft Excel® (Supplements 1 and 2 available with this article at: http://www.paleoanthro.org/journal/contents_dynamic.asp) of the majority of significant fossil hominin specimens from dated sites beginning with the late Miocene *Sahelanthropus* cranium and going up until about 40,000 years ago. Then, along with programmer colleagues, we created a movie using the software Shockwave® that turned the record of hominin fossil specimens and their ages into an animated timeline (Supplement 3 [file called “timeline”] available with this ar-

ticle at: http://www.paleoanthro.org/journal/contents_dynamic.asp).

The constraints inherent to our design as well as the software required us to stop thoroughly cataloging fossil hominin specimens around 40,000 years ago. At the end of the Pleistocene, the hominin fossil record becomes too dense to display in its entirety in this format.

Icons in the movie were designed to be as generic as possible while still being informative. Skeleton icons represent complete and nearly complete skeletal remains; skull icons represent complete and nearly complete skulls and crania; partial skull icons represent skull fragments; full tooth row icons represent nearly complete maxillae and mandibles; partial tooth row icons stand for jaw fragments; and a single molar icon stands for an isolated tooth. The movie pauses with each fossil to allow the viewer to see it. Like with printed trees, the fossil icons exist in the movie for longer than the individuals existed on Earth, otherwise the viewer could not see them flash across the screen.

Taxonomic labels were purposefully omitted from the database and the movie because our intention is to rhetorically critique species distinctions and phylogenetic reconstructions that ignore deep time. However, because a simple narrative may enhance the viewing experience, one is provided here.

From between 7–6 Ma to about 4 Ma, the movie displays fossils that have been attributed to the genera *Ardipithecus*, *Sahelanthropus* and *Orrorin*. Dental features link these small-bodied apes to later hominins. Then from about 4 Ma until about 2.5 Ma, the fossils belong to the genus *Australopithecus*. During this period bipedal adaptations metamorphosed the postcranial skeleton and two distinct lineages arose—the robust australopithecids (“*Paranthropus*”) and the genus *Homo*. The robust australopithecids, with their large molars and jaws, adapted to hard, tough diets and then went extinct around 1.0 Ma. With their fully bipedal skeleton, hominins in the genus *Homo* (e.g., *H. habilis*, *H. erectus*, *H. neanderthalensis*) made and used stone tools as they added meat to their diet. It is during these last two million years that the brain made a significant expansion and body size variation reached modern levels. Species in the genus *Homo* are the only hominins to be discovered outside of Africa and have the only surviving member, *Homo sapiens*.

RESULTS

Viewers of the timeline may begin by following these steps: (1) Click on the file called “timeline;” (2) When the file is opened, the movie immediately begins running. The movie can be stopped and restarted at any time by clicking on the red button.

To watch the movie at its swiftest pace, the viewer can click on the drop down menu and set the speed to 50,000 years per second. This is equivalent to 2,500 generations per second, with each generation being 20 years long. At this pace the viewer can witness the entire timeline of hominin evolution in just over six minutes.

However, if the default rate of one generation (20 years) per second is chosen, the movie crawls by at a much slower pace. After two minutes have lapsed, the viewer will have experienced only about 2400 years and will see very few icons. At this rate, watching the entire 6.5 million years of the timeline will take about 93 hours of relatively deep time.

DISCUSSION

When the movie is watched at the fastest pace viewers may appreciate, perhaps better than they had before, just how large the fossil record for human evolution is. Conversely, when the movie is watched at the slowest, default pace, it becomes clear to the viewer that the hominin fossil record—like the entire fossil record—is mostly space.

The gaps in the record, which reflect taphonomic issues, diminish neither the time and resources invested by paleontologists, nor the wealth of valuable information that has been gleaned from the fossil record. Instead, the long intervals that are devoid of fossils remind viewers that con-

ventional phylogenetic trees and diagrams—distinguishing fossil species and representing ancestor-descendant relationships—are working hypotheses that must be tested regularly through new analyses and new discoveries.

Gaps do not appear to exist when the hominin taxa are crowded into a tree on a single book page. However, the movie plods along through vast stretches of absolutely nothing, sometimes during periods of hominin evolution that are often considered to be rich and diverse. For example, many scholars would agree that two million years ago was characterized by a modest hominin radiation, and many would call it one of the bushier periods in human evolution. However, in the animated timeline, two million years ago is mostly dead air—illustrating better than printed trees and better than Mr. Croll’s long strip of paper how, “The crust of the earth is a vast museum; but the natural collections have been imperfectly made, and only at long intervals of time” (Darwin 1872: 162).

Like printed trees, the animated timeline is not without its limitations and additional information could be useful. For example, by making the stage a map of the world, and by flashing the fossils at their respective sites, the movie could account for geography. Color coding the fossils according to hypothetical evolutionary lineage, and connecting those fossils with dotted lines, would call attention to gaps in fossil evidence for lineages. If those lineage connections were added, the timeline would look nothing like a bush or a tree and, instead, hominin evolution would look more like a few thin blades of grass.

CONCLUSION

The dramatic changes and the complex branching events that occurred over the last six or seven million years of hominin evolution (and that will carry on into the future) are beyond our complete comprehension without a firm grasp of deep time. However, with tools like an animated timeline of the fossil record we can better appreciate and account for our brief glimpse of the process.

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