The Bonobo Genome and Rewinding the Tape of Life

By Ricki Lewis | June 14, 2012

When I wrote for *The Scientist*, I covered the debuts of several genome sequences – fruit fly, rat, pufferfish, and the plague bacterium, to name a few. An illustration in my human genetics textbook resembles the intro to The Brady Bunch, a checkerboard of nine new genomes with each edition, now with more than 1,000 to choose from. In just the past few weeks, several salad ingredients have had their genomes unveiled.

But the genome sequence to intrigue me the most, except for our own, is that of the bonobo, aka *Pan paniscus*.

A bonobo looks like a sleeker, smaller-headed, longer-legged chimpanzee (*Pan troglodytes*). Discovered as a skull specimen in the Tervuren museum in Belgium in 1929, rather than in its home in the Democratic Republic of Congo, south of the Congo River, the bonobo was once considered a pygmy chimp. But as anthropologists catalogued distinctions, the animal got its own species name, in 1954.

Bonobos have had roles in recent fiction. These include Robin Cook's 1998 Chromosome 6, in which the unfortunate primates provide spare parts for wealthy humans; the supporting role Koba in last summer's Rise of the Planet of the Apes; and in Sara Gruen's wonderful Ape House.

Chimps and bonobos have stark behavioral differences, especially in the sexual arena. Bonobo authority Frans de Waal dubbed them the "make love, not war" primates, calling them "a belated gift to the feminist movement" in the March 1995 Scientific American. And they are sensitive souls, he wrote. During World War II the bonobos in a zoo in Germany dropped dead from fear at the sounds of falling bombs; the chimps were oblivious. Bonobo females dominate their peaceful societies and move among them, while males remain attached to their mothers for life. *Male chimps are aggressive, battling for dominance and forming roving gangs.*

Ape Genomes

We three – chimps, bonobos, and people — are intimately related. We share **98.7% of our genome sequence with these other two ape species.**

Kay Prüfer and Janet Kelso of the Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany and their colleagues, including Svante Pääbo, sequenced the genome of a female bonobo named Ulindi, from the Leipzig zoo. And the genome held quite a surprise.

Partial sequencing had revealed that we parted ways from chimps and bonobos about 5-7 million years ago; they parted from each other about 2 million years ago. *Many researchers expected the bonobo genome to be a subset of the chimp genome, with perhaps a few DNA base changes after their split.*

But it isn't so straightforward. "We've discovered that on average the genomes of bonobos and chimpanzees are equally distant from human, but for particular regions of the genome, composing a total of 3% of the human genome, this relationship is unequal: for **some regions of the genome humans are closer to bonobos than they are to chimpanzees, while in other regions humans are closer to chimpanzees,**" Drs. Prüfer and Janet Kelso told me in an e-mail. Chimps and bonobos could have retained different subsets of gene variants at the time of their separation, but since all the variants descend from the ancestor common to all three of us, we can indeed share DNA sequences with one Pan but not the other.

Geography may explain the curious evolutionary journeys of chimps, bonobos, and us. Many anthropologists think that the Congo River divided the ancestral population that diverged, giving rise, eventually, to the two Pan species.

A Dave Matthews Analogy

I had a hard time envisioning how we could share some sequences with only chimps yet others with only bonobos. Then I thought about more familiar terrain, based on an event near my house last weekend, when I was reading the bonobo genome paper.

Imagine three carloads of kids leaving a Dave Matthews concert in Saratoga Springs, New York. All three cars drive downstate to New York City on the Thruway. Once they

reach the city, one car veers off towards Brooklyn (humans). The other two enter Queens, reaching the end of their journeys in two different neighborhoods. One car stays put (bonobos), say in Forest Hills, but the other drives around a bunch of other neighborhoods (chimps)

All three cars would have gravel and other crap from the Thruway embedded in the grooves of their tires as well as from the secondary roads, markers of where they've been. But once the three dispersed, a few of the markers would have changed, the chimps' more so than the bonobos because, presumably, they would have faced different environmental conditions as they spread out in Queens.

And so the Brooklynites – the humans – could have some road residue in common with both Queens cars – the chimps and bonobos — or either. But 98% of the road rocks are shared from the original split, the Dave Matthews show.

Three Lessons

The sequencing of the bonobo genome made me think of three things.

1. Evolution makes sense. The idea of a Supreme Being creating information-dense genomes, enticing us to make comparisons and consult mutation rates to trace how species are related, seems like too much work. Why would She have bothered?

The bonobo paper also brings up the oft-missed point that we branched from a shared chimp/bonobo ancestor – we didn't descend from apes, we ARE apes. A 2009 Nova television series, Becoming Human, made this mistake repeatedly, even in the title teaser: "Six million years ago, what set our ancestors on the path from ape to human?" This prompted my friend and colleague Michael Dougherty, PhD, Director of Education at the American Society of Human Genetics, to write a heads-up guest editorial in The American Biology Teacher in February 2011.

2. Sex. To bonobos, according to de Waal, sex is "part and parcel of social relations." And the animals do it all ways (except mother-son pairings) and they do it often, albeit quickly (average act 13 seconds) and sporadically. The happy, erect and ready bonobos have face-to-face sex, once thought to be uniquely human. Females are always interested, particularly in rubbing their privates together ("genito-genital" or "GG" rubbing). Males enjoy "penis-fencing," when they hang from branches and rub their members, according to de Waal. Scrotal rubbing is also popular. Sex often precedes a meal, the opposite of human dating rituals.

Unlike the macho chimp males who compete to assure their rank on the dominance hierarchy and obtain their sex with aggression, *bonobos have apparently discovered the joys of the act, and for both genders. They use sex "to resolve conflict, show affection or excitement, and to reduce stress. Bonobos remain playful throughout their lives, show high emotional sensitivity to other individuals, and there is no evidence for lethal*

aggression between them," the researchers told me. The bonobos have sex in its eclectic guises just to have fun. And among them, females rule.

So how did the bonobos sequester a group of gene variants that led to a tranquil, XX-centric, sex-loving society? Is it that compared to chimps and us, bonobos didn't travel far from their moist forests, preserving a moment in evolution under certain conditions when males were kinder to females? And do some of the gene variants that separate bonobo from chimp perhaps explain humans with sexual predilections outside the mainstream, such as Jerry Sandusky?

I can't wait to find out the answers, and neither can the researchers. "Linking genetic features to these traits would be immensely interesting. The sequence provided by our study is the first step in providing the data needed to make these links," they said.

3. Rewinding the evolutionary tape of life.

Becoming human capped many millions of years of genetic change, as we branched from other species, losing some characteristics, gaining others. It might have happened any of a near infinite number of ways, given the information content of even the simplest of genomes.

Paleontologist and science writer Stephen Jay Gould called this idea of what might have been "rewinding the tape of life" (a tape was a device that recorded sound). I wrote his Obit, also in *The Scientist*, in June 2001.

Dr. Gould summed up the wonder of our evolutionary history better than anyone in the Academy of Achievement in 1991, and the sequencing of the bonobo genome brings it back to me:

"We want to know why we're here. To a large extent it is a grand-scale accident that we're here. Evolution has oddly contingent pathways, and we never run the same way twice. If you could go back 500 million years and run the tape of life again, you wouldn't get human beings, and you probably wouldn't get anything conscious."

Images: Max Planck Institute for Evolutionary Anthropology

About the Author: Ricki Lewis received her PhD in genetics from Indiana University. Her ninth book, The Forever Fix: Gene Therapy and the Boy Who Saved It, narrative nonfiction, was just published by St. Martin's Press. Most of her other books are college life science textbooks, including "Human Genetics: Concepts and Applications," (10th edition, 2012) from McGraw-Hill Higher Education. Routledge Press published "Human Genetics: The Basics" in 2010. Ricki has published thousands of magazine articles, from

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