Wolf evolution and 'settled science'

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A coyote (Canis latrans)

Are the red and eastern wolves separate species, or hybrids with coyotes? And what has that got to do with climate change? Actually a lot, in illustrating what scientific inquiry is and what it isn't.

Comparing canid genomes

A report in this week's *Science Advances* questions conclusions of a 2016 comparison of genome sequences from 28 canids. The distinction between "species" and "hybrid" is of practical importance, because the Endangered Species Act circa 1973 doesn't recognize hybrids. But DNA information can refine species designations—or muddy the waters.

At first, genetic marker (SNP) studies hinted at a mixing and matching of genome segments among coyotes, wolves, and dogs. Then came full-fledged genome sequencing.

Last year Bridgett M. vonHoldt, head of Evolutionary Genomics and Ecological Epigenomics at Princeton and colleagues, scrutinized the 28 full genome sequences for signs of "lack of unique ancestry." They compared the genomes of 3 domestic dog breeds (boxer, German shepherd, and Basenji), 6 coyotes, a golden jackal from Kenya, and various wolves to 7 "reference" genomes from 4 Eurasian gray wolves (to minimize recent mutations) and 3 coyotes. The conclusion: lots of genes have flowed from coyotes and gray wolves into the genomes of the animals that became what we call red and eastern wolves, in different proportions.

A bit of background.

- **Red wolves were declared endangered in 1973. A dozen**

animals, selected by appearance and absence of coyote traits in their young, were "captively" bred to establish a population in North Carolina that is now several hundred strong. The 3 red wolf genomes evaluated in the 2016 study came from NC. Historically the animals are from the southeastern US.

- **Gray wolves and coyotes, according to the 2016 study, are "very close relatives with a recent common ancestry," although there's about as much genetic variability between the two species as within each.**
- **Eastern wolves are from the Great Lakes and the Algonquin Park region of Ontario, moving eastward.**

Classifying these animals based on geography and visible traits gets confusing, with all the overlaps and shared DNA sequences. Apparently various pairings can successfully mate but probably don't do so very much in the wild when populations are large. Tracking genomes reveals a classic cline, in the parlance of population genetics, with coyote gene introgression into wolf genomes rising from Alaska and Yellowstone (8-8.5%), to the Great Lakes (21.7-23.9%), to Ontario (32.5%-35.5%), and to Quebec (>50%). (BTW the Basenji, the barkless dog, is 61% gray wolf.)

Paul A. Hohenlohe of the University of Idaho and colleagues maintain that the 2016 findings actually support 2 hypotheses: recent admixture (hybridization) or that red and eastern wolves are distinct species. Actually it's 3: hybridization might have happened a long time ago, something that following genes with known mutation rates might reveal.

Eastern wolf (Canis lycaon). Credit: Michael Runtz

The new paper challenges the 28-genome comparison:

- **The 7 reference genomes were chosen based on the animals' physical characteristics and home turf – not on some standard "coyote" or "gray wolf" genome. So the genomes to which the 28 were compared might not have been "pure" anything.**
- **Two reference coyote genomes were pooled from animals from Alabama and Quebec – which might have had some gray wolf genes. Gene flow when animals mate is, after all, a two-way street, sending wolf genes back into coyotes as well as the other way around.**
- **The 2016 paper hypothesizes that red wolves are distinct due**

to genetic drift – chance sampling from an ancestral genome – but unique ancestry is an alternate explanation.

- **The "lack of unique ancestry" from the 2016 study doesn't mean it isn't there.**

Dr. vonHoldt's team responded to Dr. Hohenlohe's team's comments, reiterating that the results show red wolf and eastern wolves are "genetically very similar to coyotes or gray wolves," reflecting recent hybridization.

Discussion of wolf classification goes back a quarter century, and this trio of papers is only a recent glimpse of the debate. But I love the respectful back-and-forth of the efforts to extract a compelling narrative from the data that might be what actually happened. Multiple interpretations of the same data and amending interpretations as new data accumulate is the very essence of the scientific process.

Anti-science rhetoric

Let's reframe the wolf papers using the language of the popular climate change discussion.

Are Hohenlohe and his co-workers "coyote deniers?"

Do vonHoldt and her colleagues "believe in" wolf-coyote couplings and Hohenlohe et al don't?

The science of wolf origins is clearly not "settled" – for science is NEVER settled. Facts aren't proven, but instead evidence demonstrated and assessed, from both experimentation and observation. The information from tested hypotheses may be so consistent and compelling that it eventually builds to gestate a

theory, or even a law, that then explains further observations. But to get there, science is all about asking questions. As I've written in all 35 or so editions of my various textbooks, science is a cycle of inquiry.

Climate change “deniers” aren’t as dangerous to our children as is science illiteracy.

In fact the history of genetics is a chronicle of once-entrenched dogma changing with new experiments and observations. I was in grad school when Walter Gilbert's famed "Why Genes in Pieces?" was published. The classic paper introduced introns, the parts of genes that aren't represented in the encoded protein. It was an astonishing idea circa 1978, but with compelling evidence. Yet even Mendel's pea crosses sought an alternate explanation for the prevailing notion that traits simply disappear between generations.

Before I'm hurled insults, let me assert that although my expertise isn't in climate science, I think that the evidence very strongly supports the hypothesis that the planet is warming at an accelerated rate compared to some other times. And fossil fuel use is likely a partial cause, not just a correlation or association, because the relationship is linear and a mechanism plausible. But I don't "believe" in global warming as if it is the tooth fairy or a deity.

I cringe when politicians and celebrities appoint and anoint themselves experts on climate change, then use language that illustrates profound unfamiliarity with the ways of science.

Why did Eddie Vedder begin his speech at the Rock and Roll Hall of Fame induction ceremony for Pearl Jam with "climate change is real?" He's a musician, not a meteorologist. Why not, "semi-conservative DNA replication is real?" Or "hydrogen bonds are real?" "Noble gases are real?"

I've long had a problem with the term "climate change," because of course climate changes! Why would it ever be static, given weather ups and downs?

Climate dynamics are a little like the composition of blood, or any other manifestation of biological homeostasis. Have a complete blood count at various times and, if you're healthy, results are likely to be within a narrow normal range. Ditto blood sugar, liver enzymes, serum cholesterol level. But steady blood counts don't mean that the same blood cells hang out forever. Bone marrow stem cells continually pump out blood cell progenitors as the older specialized cells die off. Natural systems change over time, with fluctuations large and small.

Climate always has and always will change.

We can learn about normal blood circulation by studying off-kilter situations—leukemia, infection, anemia—without fear of being labeled a "denier." It's not only a scientifically inappropriate term, but one that is offensive to some, with its echoes of the Holocaust.

I'm interested in other times – deep, geologic time, not the president's simplistic reference to the next century – when the climate warmed at the rate that it is doing so now. How long did the warming escalate and persist? What forces or events might have precipitated warming? What factors accompanied its ultimate reversal as ice ages neared? By asking questions we can learn what we can expect from nature, so that perhaps we can better understand what we can do to counter the warming trend.

And so those who claim to believe in climate change and vilify those who ask questions might learn a lesson in what science actually is from the elegant discussion of wolf origins.

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