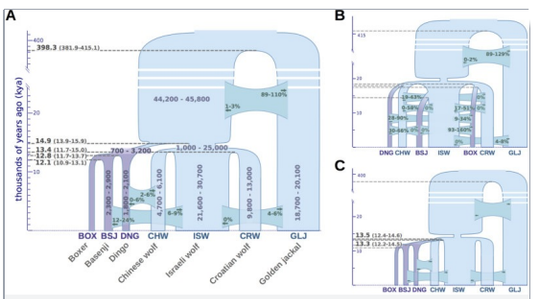
Featured Research

Genomes of modern dogs and wolves provide new insi domestication

Date: January 16, 2014

Source: University of Chicago Medical Center

Summary: Dogs and wolves evolved from a common ancestor between 9,000 and 34,000 years ago, before humans transitioned to agricultural societies, according to an analysis of modern dog and wolf genomes from areas of the world thought to be centers of dog domestication.



This chart depicts wolf and dog lineages as they diverge over time.

Credit: Freedma, et al. / PLoS Genetics [Click to enlarge image]

Dogs and wolves evolved from a common ancestor between 9,000 and 34,000 years ago, before humans transitioned to agricultural societies, according to an analysis of modern dog and wolf genomes from areas of the world thought to be centers of dog domestication.

The study, published in *PLoS Genetics* on January 16, 2014, also shows that dogs are more closely related to each other than wolves, regardless of geographic origin. This suggests that part of the genetic overlap observed between some modern dogs and wolves is the result of interbreeding after dog domestication, not a direct line of descent from one group of wolves.

This reflects a more complicated history than the popular story that early farmers adopted a few docile, friendly wolves that later became our beloved, modern-day companions. Instead, the earliest dogs may have first lived among hunter-gatherer societies and adapted to agricultural life later.

"Dog domestication is more complex than we originally thought," said John Novembre, associate professor in the Department of Human Genetics at the University of Chicago and a senior author on the study. "In this analysis we didn't see clear evidence in favor of a multi-regional model, or a single origin from one of the living wolves that we sampled. It makes the field of dog domestication very intriguing going forward."

The team generated the highest quality genome sequences to date from three gray wolves: one each from China, Croatia and Israel, representing three regions where dogs are believed to have originated. They also produced genomes for two dog breeds: a basenji, a breed which originates in central Africa, and a dingo from Australia, both areas that have been historically isolated from modern wolf populations. In addition to the wolves and dogs, they sequenced the genome of a golden jackal to serve as an "outgroup" representing earlier divergence.

Their analysis of the basenji and dingo genomes, plus a previously published boxer genome from Europe, showed that the dog breeds were most closely related to each other. Likewise, the three wolves from each geographic area were more closely related to each other than any of the dogs.

Novembre said this tells a different story than he and his colleagues anticipated. Instead of all three dogs being closely related to one of the wolf lineages, or each dog being related to its closest geographic counterpart (i.e. the basenji and Israeli wolf, or the dingo and Chinese wolf), they seem to have descended from an older, wolf-like ancestor common to both species.

"One possibility is there may have been other wolf lineages that these dogs diverged from that then went extinct," he said. "So now when you ask which wolves are dogs most closely related to, it's none of these three because these are wolves that diverged in the recent past. It's something more ancient that isn't well represented by today's wolves."

Accounting for gene flow between dogs and wolves after domestication was a crucial step in the analyses. According to Adam Freedman, a postdoctoral fellow at the University of California, Los Angeles (UCLA) and the lead author on the study, gene flow across canid species appears more pervasive than previously thought.

"If you don't explicitly consider such exchanges, these admixture events get confounded with shared ancestry," he said. "We also found evidence for genetic exchange between wolves and jackals. The picture emerging from our analyses is that these exchanges may play an important role in shaping the diversification of canid species."

Domestication apparently occurred with significant bottlenecks in the historical population sizes of both early dogs and wolves. Freedman and his colleagues were able to infer historical sizes of dog and wolf populations by analyzing genome-wide patterns of variation, and show that dogs suffered a 16-fold reduction in population size as they diverged from wolves. Wolves also experienced a sharp drop in population size soon after their divergence from dogs, implying that diversity among both animals' common ancestors was larger than represented by modern wolves.

The researchers also found differences across dog breeds and wolves in the number of amylase (AMY2B) genes that help digest starch. Recent studies have suggested that this gene was critical to domestication, allowing early dogs living near humans to adapt to an agricultural diet. But the research team surveyed genetic data from 12 additional dog breeds and saw that while most dog breeds had high numbers of amylase genes, those not associated with agrarian societies, like the Siberian husky and dingo, did not. They also saw evidence of this gene family in wolves, meaning that it didn't develop exclusively in dogs after the two species diverged, and may have expanded more recently after domestication.

Novembre said that overall, the study paints a complex picture of early domestication.

"We're trying to get every thread of evidence we can to reconstruct the past," he said. "We use genetics to reconstruct the history of population sizes, relationships among populations and the gene flow that occurred. So now we have a much more detailed picture than existed before, and it's a somewhat surprising picture."

Story Source:

Article 2 ← Talks about how people breeding for looks caused them to be less resistant to diseases

did they help from hunter were they bred to care for and make getting food harder?

Possibly ← Due to corruption for food.

→ Article 3

The above story is based on materials provided by **University of Chicago Medical Center**. *Note: Materials may be edited for content and length.*

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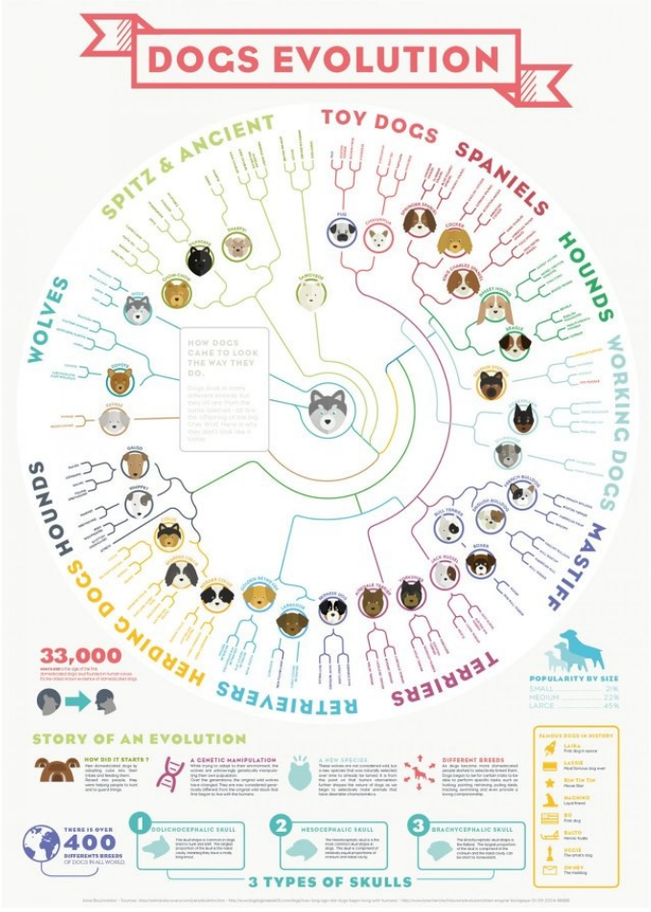
INFOGRAPHIC OF THE DAY

Infographic: How Dogs Evolved

THIS INFOGRAPHIC ON THE HISTORY OF MAN'S BEST FRIEND MAY BE CUTE, BUT IT HIDES THE DARK SIDE OF DOG BREEDING.

Some 40,000 years ago, dogs were wolves: silver-eyed stalkers who hunted man with blood-smeared lips in the deserts of Paleolithic Persia. Today, though, millennia of domestication have turned those limber predators into an assorted motley of breeds like the Pomeranian, a pocketbook-sized canine idiot so unwolf-like that it would only be recognized by its primordial ancestors as an *amuse-bouche*, not a peer.

How the heck did we take a wolf and come up with bulldogs, Yorkshires, collies, golden retrievers, whippets, goldendoodles, and otterhounds? Designed by Parisian artist Alice Bouchardon, the "Evolution of Dogs" tries to make sense of the complicated Darwinian (and not-so-Darwinian) machinations that have led us to the kinds of dog breeds that can be toted in Paris Hilton's handbag.



According to a genetic analysis by UCLA in 2010, what we call dogs today likely originated as gray wolves about 33,000 years ago in the Middle East, the same area where both domestic cats and many livestock animals originated. But exactly how is a creature like a pug, a bull terrier, or even a coyote related to those wolves? In Bouchardon's infographic, the gray wolf's heritage is broken down into 11 different families of dogs, ranging from hounds and herding dogs to toy dogs and mastiffs.

"HOW THE HECK DID WE TAKE A WOLF AND COME UP WITH A GOLDENDOODLE?"

There are now over 400 breeds and they can all roughly be characterized by the shapes of their skull. The most wolf-like dogs, such as Siberian Huskies, have dolichocephalic skulls, which dedicates the largest proportion of the skull to the nasal cavity for smelling and hunting. Mesocephalic skulls are the most common, and dedicate equal portions of the skull to cranium and nasal cavity, while brachycephalic skulls are ones like in the pug and bulldog, where the snout is either flat or nonexistent.

Although this infographic is light in tone, it's important to keep in mind while looking at it that over-breeding has largely ruined many of these breeds over the course of the last century. Consider, for example, what some of the most popular dogs today looked like just a hundred years ago, and it becomes clear that humans have aggressively bred many dogs to actually increase their likelihood of having genetic diseases.

The result? Breeds which are more likely to win blue ribbons at dog shows, but which live lives full of illness and suffering.

As cute as the Bouchardon's "Evolution of Dogs" chart is, we should try remember that many breeds of dogs would be better off trying to recombine with other breeds back *into* the gray wolf, not further diverge down a path of genetic mutation from its ancestry.

[Image: Golden Retriever via Shutterstock]

JOHN BROWNLEE

John Brownlee is a writer who lives in Boston with two irate parakeets and a fiancée of more exquisite pluma... Continued

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John, Brownlee. "Infographic: How Dogs Evolved." Co.Design. 17 Jan. 2014. Web. 19 May 2014.

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Prehistoric Dogs

40 Million Years of Dog Evolution, from Amphicyon to the Labradoodle

By Bob Strauss

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In many ways, the story of dog evolution follows the same plot line as the evolution of horses and elephants: a small, inoffensive, ancestral species gives rise, over the course of tens of millions of years, to the respectably sized descendants we know and love today. But there are two big differences in this case: first, dogs are carnivores, and the evolution of carnivores is a twisty, serpentine affair involving not only dogs, but prehistoric hyenas, bears, cats, and now-extinct mammals like creodonts and mesonychids. And second, of course, dog evolution took a sharp right turn about 15,000 years ago, when the first wolves were domesticated by early humans.

It has been a long road from the earliest dog ancestors to the modern Grey Wolf (Wikimedia Commons)

As far as paleontologists can tell, the very first carnivorous mammals evolved during the late Cretaceous period, about 75 million years ago (the half-pound Cimolestes, which lived high up in trees, being the most likely candidate). However, it's more likely that every carnivorous animal alive today can trace its ancestry back to Miacis, a slightly bigger, weasel-like creature that lived about 55 million years ago, or 10 million years after the dinosaurs went extinct. Miacis was far from a fearsome killer, though: this tiny furball was also arboreal, and feasted on insects and eggs as well as small animals.

Borophagus, the "voracious eater," weighed up to 100 pounds fully grown (Getty Images)

Before the Canids - Creodonts, Mesonychids & Friends

Modern dogs evolved from a line of carnivorous mammals called "canids," after the characteristic shape of their teeth. Before (and alongside) the canids, though, there were such diverse families of predators as amphicyonids (the "bear dogs," typified by Amphicyon, which seem to have been more closely related to bears than dogs), prehistoric hyenas (Ictitherium was the first of this group to live on the ground rather than in trees), and the "marsupial dogs" of South America and Australia. Although vaguely dog-like in appearance and behavior, these predators weren't directly ancestral to modern canines.

The Pleistocene Dire Wolf was the largest canine ancestor that ever lived (Daniel Reed)

Even more fearsome than bear dogs and marsupial dogs were mesonychids and creodonts. The most famous mesonychids were the one-ton Andrewsarchus, the largest ground-dwelling carnivorous mammal that ever lived, and the smaller and more wolflike Mesonyx; oddly enough, mesonychids were ancestral not to modern dogs or cats, but to prehistoric whales. The creodonts, on the other hand, left no living descendants; the most noteworthy members of this breed were Hyaenodon and the strikingly named Sarkastodon, the former of which looked (and behaved) like a wolf and the latter of which looked (and behaved) like a grizzly bear.

The First Canids - Hesperocyon and the "Bone-Crushing Dogs"

Paleontologists agree that the late Eocene (about 40 to 35 million years ago) Hesperocyon was directly ancestral to all later canids--and thus to the genus Canis, which branched off from a subfamily of canids about six million years ago. This "western dog" was only about the size of a small fox, but its inner-ear structure was characteristic of later dogs, and there's some evidence that it may have lived in communities, either high up in trees or in underground burrows. Hesperocyon is very well-represented in the fossil record; in fact, this was one of the most common mammals of prehistoric North America.

Another group of early canids were the borophagines, or "bone-crushing dogs," equipped with powerful jaws and teeth suitable for scavenging the carcasses of mammalian megafauna. The largest, most dangerous borophagines were the 100-pound Borophagus and the even bigger Epicyon; other genera included the earlier Tomarctus and Aelurodon, which were more reasonably sized. We can't say for sure, but there's some evidence that these bone-crushing dogs (which were also restricted to North America) hunted or scavenged in packs, like modern hyenas.

The First True Dogs - Leptocyon, Eucyon and the Dire Wolf

Here's where things get a bit confusing. Shortly after the appearance of Hesperocyon 40 million years ago, Leptocyon arrived on the scene--not a brother, but more like a second cousin once removed. Leptocyon was the first true canine (that is, it belonged to the caninae subfamily of the canidae family), but a small and unobtrusive one, not much bigger than Hesperocyon itself. The immediate descendant of Leptocyon, Eucyon, had the good fortune to live at a time when both Eurasia and South America were accessible from North America--the first via the Bering land bridge, and the second thanks to the uncovering of central America. In North America, about six million years ago, populations of Eucyon evolved into the first members of the modern dog genus Canis, which spread to these other continents.

But the tale doesn't end there. Although canines (including the first coyotes) continued to live in North America during the Pliocene epoch, the first plus-sized wolves evolved elsewhere, and "re-invaded" North America shortly before the ensuing Pleistocene (via that same Bering land bridge). The most famous of these canines was the Dire Wolf, *Canis diris*, which evolved from an "old world" wolf that colonized both North and South America (by the way, the Dire Wolf competed directly for prey with Smilodon, the "saber-toothed tiger.")

The end of the Pleistocene epoch witnessed the rise of human civilization around the world. As far as we can tell, the first domestication of the Gray Wolf occurred somewhere in Europe or Asia anywhere from 30,000 to 15,000 years ago. After 40 million years of evolution, the modern dog had finally made its debut!

Here's a list of the most notable prehistoric dogs and dog ancestors; just click on the links for more information.

Aelurodon This "cat-toothed" dog behaved more like a hyena.

Amphicyon Otherwise known as the "bear dog."

Borophagus One of the biggest of the bone-crushing canids.

Cynodictis This was once thought to be the first true dog.

Dire Wolf A giant wolf of the Pleistocene epoch.

Dusicyon This "foolish dog" went extinct in the 19th century.

Epicyon This prehistoric dog was built more like a big cat.

Eucyon The immediate predecessor of modern canines.

Hesperocyon An early ancestor of the modern dog.

Ictitherium One of the first ground-dwelling hyenas.

Leptocyon A tiny, foxlike ancestor of the modern dog.

Tomarctus A bone-crushing dog of the Miocene epoch.

"Strauss, Bob. "Why Your Dog's Pedigree Goes Back 40 Million Years." About.com Dinosaurs. About.com, 2014. Web. 20 May 2014.
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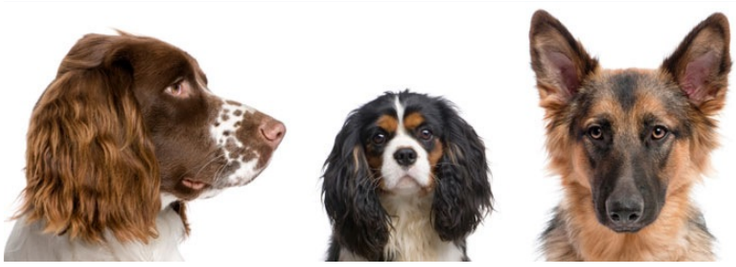

How Did Wolves Become Dogs?

by Brian Thomas, M.S. *

From the tiny Chihuahua to the massive mastiff, the over 200 breeds of domesticated dogs come in a wide variety of different body sizes and proportions, hair lengths and textures, and demeanors.[1] Evolution asserts that animals change through a gradual accumulation of mutations. But evidence shows that the wolf-to-dog transition occurred rapidly, according to pre-designed genetic potential and not mutations.

Mark Derr, author of a new book titled *How the Dog Became the Dog: From Wolves to Our Best Friends*, discussed on National Public Radio's program *Fresh Air* how human interaction may have domesticated wolves beginning in the Ice Age. Since dogs are smaller than wolves and have more varying proportions, coat colors, and other features, interviewer Dave Davies asked Derr, "So how could this association of wolves with humans lead to these physical changes?"

Derr replied:

> Well, what happened was that you had populations of dog-wolves that became isolated from the greater wolf population and in doing so, they began to breed more closely—to inbreed as it were. And when you inbreed, you get genetic peculiarities that arise, and those peculiarities then begin to become part of the population.... In other words, a mutation will appear in a small population. If I don't want it, what I do is kill the animals so that they don't reproduce. If I do want it, I try to get them to reproduce.[2]

So, according to Derr, a certain "peculiarity"—for example, a curly tail—first arises by mutation. This mutation and its resulting trait are supposedly then concentrated into a distinct dog lineage by breeding the dogs that have it.

At first, this might sound reasonable, but a landmark study published in the journal *Bioessays* in 2009 told an entirely different story. Researchers artificially selected foxes for "tameability." Foxes were certainly part of the originally created dog kind, having been known to interbreed with coyotes, for instance. The experiment, which utilized Russian fox fur farms, began "about 50 years ago" and has produced scores of fox generations thus far.[3]

The researchers chose foxes that were the least aggressive and bred them. They chose 100 females and 30 males "as the initial parental generation for selection for tolerance of human or docility, then for tameability."[3] Then, they used approximately the top 10 percent of the tamest offspring as parents for each next generation for dozens of generations.

"As a result of such a rigorous selection, the offspring exhibiting the aggressive and fear avoidance responses were eliminated from the experimental population in just two-three generations of selection," the study authors wrote.[3]

They didn't need thousands of years, just three generations. And at just the sixth generation, fox pups eagerly sought human contact, complete with wagging tails, "whining, whimpering, and licking in a dog-like manner."[3]

And amazingly, the tame foxes quickly acquired an array of traits shared by many domesticated mammals, showing that mutations were not involved. To show this, the authors compared the wild and domesticated horse, cow, sheep, pig, dog, and rabbit. The wild animals have similar and stable traits, including erect ears, straight tails, restricted breeding seasons, and uniform coat colors and body sizes. But the domesticated ones had such features as floppy ears, curled tails, spotted coat colors, variations in coat textures and lengths, variations in breeding time, and marked differences in skeletal size and proportion.

Surely, chance-based genetic mutations could never produce identical variations in so many different kinds of mammals. For this reason, the authors wrote, "Finally, it is difficult to interpret the changes in the domesticated foxes as a result of randomly arisen new mutations."[3]

Instead, changes in gene regulation must have caused these trait variations. That's not evolution by mutation, but variation by design. Thus, according to this research, dogs could have become "man's best friend" in three dog generations from a wolf ancestor simply by selective breeding in the recent past.

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Mr. Thomas is Science Writer for the Institute for Creation Research.

Article posted on November 18, 2011.

Thomas, Brian. "How Did Wolves Become Dogs?" How Did Wolves Become Dogs? N.p., 18 Nov. 2011. Web. 21 May 2014.

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Dogs Adapted to Agriculture

As wolves became domesticated, their genes adapted to a starch-rich diet of human leftovers.

By Ed Yong | January 23, 2013

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Tamaskan dog
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A comparison of the full genomes of dogs and wolves revealed many changes that accrued as wild canines evolved into man's best friend. Unsurprisingly, many of these differing regions regions affect the brain, and may explain the different temperaments of wolves and dogs. But the comparison, published today in *Nature* also pinpointed several regions that are involved in digestion, including genes that help to break down starch.

"This supports the idea that proto-dogs evolved new digestive adaptations to rely on the edible by-product of the agricultural revolution – garbage," said Brian Hare from Duke University, who studies animal domestication and was not involved in the study.

Israeli fossils and genetic studies date dog domestication to around 10,000 years ago, coinciding with the Agricultural Revolution, when humans went from nomadic hunter-gatherers to farming and living in settlements. Some scientists have suggested that wolves were attracted to dump sites near these early settlements and scavenged on leftovers from vegetables and cereal plants. "Dogs may have domesticated themselves by seeking out humans, to eat from their scrap-heaps," said Kerstin Lindblad-Toh from Uppsala University, who led the new research.

Lindblad-Toh led the team that published the full domestic dog genome back in 2005. With that project completed, she turned to the evolutionary history of our canine companions. "While a lot of studies have looked at the when and where of dog domestication, little has been done to understand how this happened on a genomic level," she said.

Together with Erik Axelsson, Lindblad-Toh sequenced the full genomes of 12 wolves from around the world, as well as 60 dogs representing 14 diverse breeds. They searched for signatures of domestication by looking for sequences that that showed the greatest differences between dogs and wolves, or for sequences that were consistent across dog breeds but varied in wolves.

The team eventually came up with a list of 36 regions, containing a total of 122 genes. Half of these regions contained brain genes. "This is not surprising," said Lindblad-Toh. Compared to wolves, dogs are less aggressive, more sociable, less afraid of humans, and better able to read our behavioral cues.

Six other regions, containing 10 genes, were involved in digesting fat and starch. Specifically, dogs carry extra copies of the gene for amylase—an intestinal enzyme that cuts starch into maltose—and now produce 28 times more of the protein than their wolf counterparts. Dogs also produce 12 times more maltase-glucoamylase, which converts maltose into sugar, thanks to several mutations in the gene for this enzyme. Mutations in a third gene—*SGLT1*—improved the function of a protein that absorbs the sugar through the gut.

"They have made a very convincing case for the involvement of starch digestion in the evolution of the dog," said Ben Sacks from the University of California, Davis, who was not involved in the study. (Interestingly, some of the changes observed in dog digestion have parallels in humans. As we moved from hunting meat and gathering berries to farming grains and vegetables, we, too, duplicated our amylase gene, which some have seen as an adaptation to a starch-rich diet.)

Rodney Honeycutt, an evolutionary geneticist from Pepperdine University, was also impressed by the data, but noted that it is unclear when these changes took place. "The ability to digest starch effectively would not necessarily make an animal docile, and may have occurred subsequent to domestication," he said.

But Lindblad-Toh argued that mental and digestive changes are likely to go hand in hand. "Dogs that were not afraid of people and that could adapt to a more omnivorous diet may have been the ones that stayed and were domesticated," she said.

E. Axelsson et al., "The genomic signature of dog domestication reveals adaptation to a starch-rich diet," ***Nature*****, 2013: doi:10.1038/nature11837, 2013.**

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genetics & genomics, evolution, domestication and dog

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January 24, 2013

Rudyard Kipling's Just So Stories talked about Wild Dog taking food from the First Woman - perhaps he knew more about DNA, evolution and domestication than we thought. We've written about the DNA changes in the dog and the wolf at http://www.genome-engineering.com/how-the-dog-and-its-genes-came-out-of-the-wild-woods%E2%80%A6.html

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January 24, 2013

"As we moved from hunting meat and gathering berries to farming grains and vegetables, we, too, duplicated our amylase gene, which some have seen as an adaptation to a starch-rich diet.)"

I hope the impractical paleo-diet proponents are reading this. But then again why would they be on a science website? They have Robb Wolf feeding them the pseudo version.

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James V. Kohl
Posts: 121

January 24, 2013

The difference in the epigenetically-effected genetically predisposed development of the brain and behavior of adult wolves and dogs can be attributed to exploration using only olfaction (sans vision and hearing) during the first two weeks of life in wolf pups. The downstream effects of acquired nutrients and pheromones on subsequent brain development and behavior are hormone-organized and hormone-activated by the epigenetic effects of nutrients and pheromones, as they are in all vertebrates and invertebrates. Moreover, "Olfaction and odor receptors provide a clear evolutionary trail that can be followed from unicellular organisms to insects to humans."

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