HOW DOGS DOMESTICATED

spoiler alert: the eyes did it

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Abstract: The dog, *Canis familiaris*, has classical domestication attributes, possibly derived from selection for tameness, except one: the capacity to share a long gaze (30+ seconds) with a human. All dog breeds have this capacity, even puppies prior to human socialization. No other domesticate can do so. Only Great Apes, among over 5000 mammals, can. Shared gazing replaces cortisol-based fight/flight hormone response with an oxytocin governed phobia/philial response. It involves mutations in neural hormone secretion and receptors, iris visibility, periorbital muscle control, and mate selection. Humans cannot induce such complex beneficial mutations in animals. Domestication fixes adolescent behavior. Shared gazing is not adolescent behavior, but a cognitive control characteristic. Domestication amplifies and suppresses existing traits. Hence shared gazing likely evolved prior to domestication. Recent genomics evidence, comparing contemporary dogs and other canids, as well as sequencing archaeological canid remains, pushes back dog origins between 20,000 and 200,000 years BP. Evidence of dog domestication begins no earlier than 15,000 years BP. I review genetic, archaeological, and experimental evidence of dog origins, which reveal tension in a dominant explanatory paradigm. Many researchers assume dogs evolved only through artificial selection. Evidence of ancient origins requires positing a more ancient domestication activity than seems plausible, or else reframes (or dismisses) recent evidence. Neither is necessary if 1) dogs evolved prior to domestication, 2) this pre-domesticated canid had a shared-gaze capacity, and 3) during the period of hunter-gatherer population increase, social bonds between strangers became adaptive. Adopted puppies who looked people in the eye habituated humans to shared-gaze between species, which transferred to strangers. Hunter-gatherer reports suggests the shared-gaze is key to canid domestication. Others have suggested this dog capacity might be a factor in their domestication. This paper's analysis makes it central to the process.

*Did "man the hunter" wrangle a dog out of a wolf?
Or was "man's best friend" already irresistible?
How dog eyes taught our scavenging ancestors emotional intelligence.*

Introduction: I recently patented dog dental devices for veterinarians and dog owners. A patent makes you learn new things. My own training is in tropical soils and West African land tenure. Compared to software (previous patent) dogs are fun. I have to ask dog owners about their

pooch's teeth. I'm an introvert. My mom taught me to draw, so I draw dogs in exchange for a survey. I end up staring hard at dog faces, particularly eyes. I realized they're extraordinary. Dogs really look you in the eye.

Reviewing extensive genetic, paleological, and behavioral data, I found eye contact between dogs and humans fused our relationship. From recent advances in dog genomics it seemed our mutual gaze may be why dogs were domesticated.

Does this buck scientific consensus? No, it extends it. A Neil deGrasse Tyson Cosmos episode has cave people wrangling wolves into dogs to show artificial selection. Tyson explains that wolves want bones left over after a cave meal, but their high levels of cortisol ("stress hormones") prevent it. A few wolves with lower cortisol levels eat leftovers, and join the human lineage. Domestication happened. It's why dogs have floppy ears and play. But wolves eat babies, scatter prey, and other obnoxious things. It wasn't just a question them feeling less cortisol, they needed to engage humans with mutually reinforcing attachment hormones. Behavior change drives hormone response, and hormones change behavior. Domesticated canids had a trait that induced neurochemical change in humans, not just themselves.

Evidence suggests dogs looked cave people in the eyes. That's why they were domesticated. Not because they helped humans hunt. Dogs helped us develop emotional intelligence, the capacity to modify our own behavior to improve interpersonal outcomes.

Eyes see things. They can also communicate. Eyes express feelings – windows on the soul. People talk with their hands, too, sometimes as articulate as a human voice. But animals don't have hands like ours.

Dogs have eyes like ours. Many have white sclera (the “whites of our eyes”), which very few mammals have. It's not so visible. But they have distinct irises, showing where they look, the basis of eye communication.

When people gaze up in the sky, or off in the distance, it's a cue others follow. Chimpanzees, geese, ibis, wolves, and even the red-footed tortoise also follow a human's distant gaze.¹ It's almost a command, that many species, including our own, can't resist.

Eyes also communicate meaning, and not just command or submit. We start as infants, sharing long gazes with caregivers. It continues when we date, mate, work. Always look the other person in the eye, before you sign a contract. Shared gazes establish trust: a signal, not a cue.

Researchers discover that more and more animals use tools, symbols, and mirrors. But only Great Apes, dogs, and us can share a long gaze without triggering a default dominant/submit response.²

A shared gaze between people, or dogs and people, alters brain chemistry, which leads to emotionally compelling interaction. Evolution probably selected for this, for the bond a shared

gaze creates between parent and child. It's one of the first signs an infant understands.

Did dogs evolve to share a gaze, or did we breed this in when they were domesticated?

An evidence based, "Occam's razor" answer is that dogs already looked each other in the eye, and could look at people too, before they were domesticated. Especially puppies.

The genetic basis of shared-gazing needs evolution's heavy lifter, beneficial mutations. Our ancestors couldn't make something mutate. We still can't induce complex beneficial mutations. But an animal that can already do shared-gazing is worth domesticating. That animal certainly wasn't a wolf like today's. Evolution adapted a now extinct canid (the family of wolves, foxes, and all canines) into various branches, including wolves and dog-like ones. One or more of these were domesticated.

Do we prefer the notion that every dog-like feature is our doing? Perhaps there was a time when people secretly thought God created all species but dogs. They were our masterpiece. Nature drives evolution, it doesn't invent species. Humans are part of nature, so artificial selection is a form of natural selection. It's not creation. We're not gods.

Axioms: Here are 10 axioms that, with later evidence, are the basis for my hypothesis. Axioms are concepts taken to be truthful. They're basic, some may say too simple. From them we draw a conclusion.

I. Animal domestication tames an animal, for food or transport, or to participate in human domestic life. Pigs, camels, goats, and other animals adjust to pens and bridles. Dogs, cats, and also ferrets, turtles, and other animals can derive pleasure from human contact.

II. A "domestication syndrome", identified by Charles Darwin, was formalized by Wilkins et al.³ and others. Domesticated mammals have juvenile features of wild counterparts. They mature slower. Their heads are different: floppy ears, shorter jaws, etc. Experiments suggest selecting for tameness causes, almost by accident, physical changes in domesticated animals. It may be due to embryo development. Tameness “sweeps up” a suite of features *in utero*.

III. Domestication caused adolescent behavior in dogs. Yet adolescents are easily distracted. Shared gazing takes cognitive control of emotions, hard for adolescent humans, much less dogs. Cognitive control isn't a domestication trait. Shared gazing, looking in the eyes of another for >10 seconds, is not present in any of the other 41 animals domesticated by humans.

IV. All 5,000 mammal species have a fight/flight response to direct gaze, except for some primates and dogs. Only these few species have a phobia/philia response to direct gaze - either disgust (don't look) or pleasure (engage). Adrenal gland hormones govern fight/flight, pituitary gland oxytocin-serotonin balance governs phobia/philia. This “switch” involves multiple, complex genetic mutations.⁴

V. Domestication is a form of evolution: selected individuals breed successfully. According to genetic biologists, domestication mostly involved selecting existing traits wild precursors already had.⁵ Pre-domesticated dogs had capacities selected for and enhanced.

VI. People cannot make specific favorable mutations happen, particularly multiple, complex ones.⁶

VII. Autism is a human neuropathology that intersects shared-gazing and sociability. The inability to look another in the eye is only unusual among humans and dogs. The human capacity to do so may be linked to the extensive genetic material that is deleted or transposed in autism. This genetic network represents complex evolution in people, probably in dogs.⁷

VIII. Evolution can produce novel animal behavior humans only need tens or hundreds of thousands of years after it appears. Cats evolved as rodent predators a million years before farmers appreciated them.⁸ Wolves hunt diametrically differently than hunter-gatherers, their voracious calorie needs exceed what humans offer, and, to top it off, wolves eat infants. Not an animal to invite into the homestead. The wild canid domesticated as a dog had traits to engage us.

IX. Shared gazing, between people, between dogs, and between people and dogs, triggers a neurochemical feedback loop. Oxytocin is released, producing pleasure. That motivates more shared gazing. After a human and dog share a gaze, both have elevated urine oxytocin.⁹ This neurochemical cycle bonds human infants with caregivers, too. It's more than a cue (an itch), it is symbolic interaction (meaningful.) It promotes interpersonal attachment.

X. Human social organization requires social bonding. As humans developed more complex communities, they needed to generate interpersonal attachments with strangers.⁶³ This challenges instinctive behavior of most animals, except for humans, bonobos and dogs. The ability to look another in the eyes strengthened weak ties. Religions taught people to share

emotional bonds through belief.¹⁰ Dogs taught people to develop emotional bonds, through shared gazing. A dog helps one meet strangers more easily, perhaps stimulating oxytocin cycles.

Here's how these 10 axioms fit together:

Domesticated animals are, first and foremost, tamed. Taming does more than reduce aggression. It induces a juvenile appearance in the adult animal. But shared gazing is not part of a “domestication syndrome.” Domestication changes existing traits, but doesn't introduce new ones. Beneficial mutations occur when organism populations are large, or exist for a long period of time. Dogs were domesticated during a population bottleneck.

Combinations of beneficial mutations are not made by people, but once they exist, we can select them. Looking into the eyes of another without a fight/flight response involves mutations to make the iris visible and control periorbital muscles, neurochemical mutations to supplant fight/flight with phobia/philia hormones, the propagation of neural receptors, and behavioral changes in mate selection. The dog genome has evidence of all these mutations.

Domestication and shared-gazing contradict. Staring at another person in the eyes requires cognitive control of intervening emotions. Canines display adolescent behavior selected for during domestication. They get easily distracted by emotional stimuli, i.e. squirrels. Yet they stare at a person staring at them for up to a minute, a challenge even for adolescent humans. Distractions usually trigger cortisol (fight/flight) release, unless oxytocin suppresses it.

Most dog behaviors vary between breeds and individuals. All dogs exhibit the cognitive control needed for shared-gazing. That's a hallmark of an ancient trait.

Dogs were not physically segregated from other wild canids, such as wolves. Something impeded mating. Shared gazing impedes dogs breeding with other canids, especially wolves, who respond aggressively to stares. Pre-domesticated dogs could look a lot like wolves, but behave very differently, which hunter-gatherers could detect.

Humans domesticate animals that display useful traits when wild. Cats hunt rodents. Herd animals form large groups, so corralling them makes sense. Hunter-gatherers adopt wild animal babies, but release them as they mature. A puppy that could look people in the eyes would trigger neurochemical feedback that would make them desirable to tame.

My hypothesis is that pre-domesticated dogs were canids who shared gazes, with each other, and ultimately us. This unusual complex trait likely arose in an ancestor lineage. Other canid lineages became wolves, foxes, or went extinct. Perhaps people didn't appreciate this ability until they needed emotional intelligence to navigate changing society. Durkheim wrote that aboriginal religion was developed to generate social attachments. Dogs helped us practice attachment formation with strangers, by learning to look another species in the eyes.

Evidence: Hunter-gathers probably tamed pre-domesticated dogs 10,000 to 15,000 years ago. Data from many fields suggests dogs evolved long before.

My hypothesis was stimulated by Nagasawa et al.⁹ Oxytocin, a neuropeptide that stimulates social behavior, drives the shared dog and human gaze. These researchers found the time a dog stares into their owner's eyes, which are looking at them, correlates with the oxytocin measured in the urine of dog owners and dogs afterwards.

A human parent's and child's oxytocin levels increase when they gaze into each others eyes. Dogs elicit this response, by staring into our eyes. But tamed, domesticated wolves cannot share a gaze with us.

Nagasawa et al. determined that unsocialized dogs, with limited human contact, looked at humans looking at them about as long as socialized dogs. It's not a learned trait, but hardwired.

They conclude that "Human-dog interaction by dogs' human-like gazing behavior brought on social rewarding effects due to oxytocin release in both humans and dogs and followed the deepening of mutual relationships, which led to interspecies bonding."

If we don't assume dogs are domesticated wolves, evidence difficult to explain falls in place.

Scientists who carry out research often interpret data through the lens of domestication. If results imply dogs evolved earlier than expected, they may claim people domesticated dogs that much earlier.

Prior to 1980, dog origin researchers thought wolves were domesticated as agriculture dawned 5,000 years ago. Dogs weren't the first domesticate. Much older sheep bones exist. Cave paintings of wild pigs went back 35,000 years. Over the next two decades, archaeological finds pushed the earliest dog back 10,000 years before farming. A dominant paradigm emerged: wolves were domesticated by hunter-gatherers. 21st century research revolutionized things. Recent fossils and genetic analysis show dogs diverged from other canid lineages 20,000 to 200,000 years ago.

Yet the dominant paradigm remains, and leads to contradictions. If wolves became dogs through domestication, either really ancient hominids did it, or new evidence needs reinterpretation.

Paleontological: Bones are biased. They don't last, so recent old bones are easier to find. Most skeletons of old dog bones are a few thousand years old. Half a dozen have been uncovered that are much older.

Site	Age	Location	Reference
Hohle Fels	40-35,000	Germany	(Camarós et al. 2016)
Goyet Cave	36,500	Belgium	(Germonpré et al. 2009)
Razboinichya	33,000	Russia	(Ovodov et al. 2011)
Kostenki 8	33-26,500	Russia	(Germonpré et al. 2015)
Predmosti	31,700	Czech Rep.	(Germonpré et al. 2015)

The fact that many more 10,000 to 15,000 year old dog skeletons are found doesn't mean older skeletons are questionable. Instead, they represent the current state of discovery. As with human remains, even older discoveries will be made.

Paleontologists study fossil animals and plants. One group reviewed skulls of fossil canids from across Europe. The oldest they surveyed, ~31,700 years old, resembled a dog. It was in caves with remains of many large mammals, not humans. They labeled it Paleolithic dog, and wrote it shows humans were domesticating wolves that long ago.

“One would only expect to see” such as dog “after several thousands of years” of “selective breeding during early domestication.”¹¹ The facts: a 31,700 year old dog-like skeleton was found, without human remains nearby. The claim that it represents a several thousand year

experiment in domestication are, at best, guesses. Most likely this reflects an unconscious assumption: dog evolution means domestication.

Archaeological: Archaeologists recovered an ancient dog from a Siberian cave. Radiocarbon dating of its mandible averaged 33,000 years.

Its skull shape is in the range of other ancient dogs, but its teeth are not as crowded. Its snout is dog-like, its carnassial tooth more wolf-like. They conclude it may be an “intermediate” specimen.¹² But is it a partly evolved dog, or a partly domesticated one?

The archaeologists admit that the idea that all dog traits are products of domestication “has been challenged in recent years by the hypothesis that animals colonized anthropogenic environments of their own volition, and evolved into new (“domestic”) species via natural evolutionary processes.” This new hypothesis “better fits a number of associated observations.” But they nevertheless conclude their dog must be an early domestication attempt.

Other archaeologists have a hard time believing such old dogs existed. “In our opinion,” wrote a French team, “these original canids were representatives of local divergent populations of wild wolves, and, though interesting and plausible, the proposal of so early dog domestication still needs to be confirmed by further discoveries.”¹³

Q: Why would paleolithic humans devote so much effort, over so many generations, to domesticate a wolf?

A: They didn’t, if dogs evolved before domestication.

Genetic Analysis: Most mutations are neutral, or worse. Beneficial mutations are rare. Most are minor. Digesting a new plant may let you have a slightly higher weight baby. In terms of overall fecundity, it's one of a thousand things, among all dietary, disease, and physical aspects, mental and emotional abilities.

Major beneficial mutations are extremely rare. They begin with one individual. They must be passed on through reproducing individuals, and then spread through an entire population. Rare or not, evolution needs beneficial mutations. All of today's 5,000 plus mammal species share an ancestor from 100 million years ago. So 50 species evolved every million years, on average. The number started smaller, then as a branching tree grew exponentially. Several great extinctions pruned it severely.

Canids have a common ancestor that lived over 60 million years ago. But they hit a little extinction, and today's canids all diverged from one species who survived, 16 million years ago. Since then 32 to 36 species evolved: a new species every half million years.¹⁴

Several canid species arose in the last million years, and went extinct. So the speciation rate is faster than 1 per ½ million years. Two or three times faster would mean a new species appeared every 125,000 to 250,000 years.

In 1997, Science published a paper that purported to determine, genetically, the origin of dogs. It stated they were domesticated about 135,000 years ago.¹⁵ This became major news.¹⁶

Vila et al., the Science authors, used mitochondria DNA that only changes because of mutations. The dog genome is similar in scale to humans, 2.5 billion DNA base pairs. Until a

few years ago, too big to swallow whole. Mitochondria genes, a narrow group inherited from only the mother, were more tractable. Dogs and wolves have very different mitochondria genes. They compared certain gene sequences of wolves, jackals, dogs, and other canids. They assumed that beneficial mutations accumulate in mitochondrial genes at a rate of 1% of the whole, per million years. That's also considered sufficient mutation to evolve a new species.

Vila et al. note that coyotes and wolves diverged one million years ago, according to the fossil record. They found their mitochondria divergence was 0.75% (not 75%.) This implies coyotes and wolves are less than completely separated species. They can still mate.

The mitochondrial genetic divergence of dogs and wolves, though substantial, was 0.1%. That's 1/7 of the coyote-wolf difference. If it took one million years for 0.75% divergence to evolve, then 1/7 of that divergence may have taken one million divided by 7, around 135,000 years.

The authors appreciated the dilemma they put most paleontologists in, given the assumption that domestication occurred 10,000 to 15,000 years ago.

Vila et al. argued genetically distinct dogs may have still looked like wolves.

A similar mitochondrial genetic analysis was published in Science five years later, by Savolainen et al.¹⁷ They posited dogs and wolves diverged in as short as 1/15 the time of usual species separation. Also, their samples revealed a split between Asia and Europe. Asia dogs had more unique mitochondrial genes, which suggest it was where dogs originated.

Savolainen et al.'s data showed dogs became a separate lineage around 40,000 years ago. European dog data show a more recent origin, 15,000 years ago. The reason: Asian dog mitochondrial gene mutations were more abundant and randomly distributed.

But if several Asian wolves were domesticated at the same time, and each sent an independent lineage migrating to Europe, it might produce this picture.

The Asian dogs could mix together, and genetic diversity made their genomes look farther removed from wolves. If each European lineage kept apart, they reflect the real age better.

Since the dominant paradigm states that wolves were domesticated into dogs around 10,000 years ago, the researchers liked this story. Within a decade these scientists and colleagues whittled Asian dog origins as low as 5,400.¹⁸

If many wolves are domesticated at the same time, in the same area, dogs begin with a wide genetic variety. It can be mathematically modeled. Then dial the number of “founders” needed to match a desired date of origin.

But why would many wolves get domesticated simultaneously? Perhaps “taming of wolves was an important custom of the related human culture”. This is the tail taming the dog. An Asian culture that engaged in widespread wolf domestication would be an anthropological find of first order.

Wolves are dangerous. As Koler-Matznic points out, circus acts avoid them, even though wolves can be trained.¹⁹ Unlike tigers, 90% of wolf victims are small children, a non-starter given

the usual circus audience. Why would Asian hunter-gatherers tame animals that still “steal” babies in rural India?

Without simultaneous wolf domestications, the geneticists admit dogs must have an “ancient origin” from “a single female wolf at a singular chance event,” over 100,000 years ago, which contradicts the dominant paradigm.

Are they trying to explain away anomalous results? If dogs are domesticated wolves, then a single group domesticated them 100,000 years ago, or many domesticated many wolves 10,000 years ago. Instead of “*deus ex machina*,” dilemmas resolved inexplicably by god, it's “*vir antiqui ex machina*,” inexplicably resolved by ancient people.

A shared-gaze capacity didn't appear simultaneously in many wolves. If many species have a similar trait, then it likely does have many genetic ways to happen. If very few species share a trait, not so. If a trait has many genetic ways to happen, it can have many ancestors. If a trait occurs one way, it has one ancestor.

Convergent evolution describes how different genetic instructions can achieve similar outcomes. Both humans and lemurs have blue eyes. The genetic cause is different.

Only humans, other Great Apes, and dogs, among 5,000 mammals, share a long gaze (mutual stare >10 seconds). This may be convergent evolution. The genetic cause may be different in each species.

But when so few species have a trait, then within each species, that trait probably has a single ancestor. Very few animals have blue eyes. Blue eyes among humans derive from a single ancestor. Why would more variety be found in a single species than among many different ones?

Humans domesticated 42 species. Only one, dogs, shares a long gaze with us. Within dogs, that trait probably derives from a single ancestor.

Different instructions, similar knots, each with its own ancestry.

There are several ways to knot a tie, each with their own ancestry. But they produce the same effect: convergent evolution.

There's one way to knot a bow tie. They have a single ancestor: the knotted cravat.

One set of instructions, single ancestry

One canid lineage, 100,000 years ago, may be the ancestor of dogs, passing down a unique trait that distinguished them from other canids, especially wolves: the shared-gaze.

Darwin recognized dog breeding was an illustration of evolution, with breeders instead of wild mates as match makers. Seeing tremendous diversity among dog breeds, he doubted “all our dogs have descended from any one wild species.” But Darwin was excited if they were. “Then such facts would have great weight in making us doubt about the immutability of the many very closely allied and natural species.”²⁰

The variety of dogs masks their single origin. Variety suggests to us dogs may have many

ancestors, though these may all be the same kind of wolf. But as Darwin suspected, this is probably a mirage. The traits that dramatically distinguish dog breeds are expressions of very limited genetic differences.²¹

Larson reviewed the genetic research on dogs critically. He pointed out that the first domestic populations of dogs must have shared 100% of their distinct mitochondrial gene groups with their wild counterparts. But contemporary dogs and wolves share almost none. Mitochondrial genes may mutate faster than the rest of DNA, but could so much difference between wolves and dogs develop in ten thousand years?

Larson wrote it first appears dogs and wolves diverged “long before domestication.” But he wants to rescue the dominant paradigm. Instead of using the “many founders” plot twist, he points out that genetic differences mainly reflect non-beneficial mutations, which are so numerous they could overwhelm the statistics. Instead of many founders, many neutral and “slightly deleterious” mitochondrial gene mutations disguise the recent origin of dogs.²²

Harmful and neutral mutations are much more common than beneficial ones. Harmful mutations that result in severe disability aren’t reproduced, while beneficial mutations are rare.

Neutral or slightly negative mutations accumulate for tens of thousands of years. Mitochondrial gene mutations that distinguish dogs are neutral to slightly harmful. Larsen proposed they accumulate in the genome much more quickly than expected. Then after a shorter period than expected, such mutations completely distinguish dogs from wolves.

Mutations aren't just good or bad. Some have no visible impact. Geneticists call these synonymous: the DNA letters get shuffled but no change results. If mutations cause visible change, they're called nonsynonymous.

Subramanian and Lambert found:

1. Mitochondria nonsynonymous (with impact) mutations accumulate 9 to 15 times faster than the baseline rate.

2. Mitochondria synonymous mutations do not accumulate faster.²³

3. Synonymous mutations are ~20 times more common than nonsynonymous.

Alternate spellings,
same sound:
synonymous
mutations

whitman	yeatman
wittman	yetman
woodman	yateman
wightman	yatman
weidman	yeatmen

Synonymous
mutations are like
new spellings of old
words.

Alternate spellings,
different sound:
nonsynonymous
mutation

John	Jean
Juan	Johann

Nonsynonymous
mutations are like
words in a new
language.

If all Larson's mitochondria mutations were nonsynonymous, and a new canid evolved 15 times faster than baseline, it would be over 30,000 years old. But synonymous mutations are much more common than nonsynonymous ones, perhaps 20 times more frequent. The change rate was at most 2, 3, or 4 times baseline. That pushes divergence back to 83,000 to 250,000 years ago.

The old picture

Revised picture

The new picture

In 2015, genetic historians started analyzing the whole genome.

They found dogs became dogs before modern wolves were wolves.

Freedman et al. identified population bottlenecks in both dog and wolf genomes. Bottlenecks are evolutionary hot zones, when unusual

selection occurs. An individual's rare traits are usually diluted through mating. If large populations get squeezed in a bottleneck, individuals mate relatives, promoting rare mutations. Bottlenecks are when dogs became dogs, and wolves became wolves. The dog bottleneck came first.²⁴

Skoglund et al. agreed that dogs diverged from their ancestor before wolves did. But they found Freedman et al.'s evolutionary time frame too fast. It's hard to wrap one's head around, but Freedman et al. assume the chance of mutation is one in 10 million, each generation. That's fast. Skoglund et al.'s genome shows it's more like one in 40 million.

Instead of an ancestor becoming a pre-domesticated dog 12,000 years ago, that pushes it back to 48,000. Conservatively, Skoglund et al. propose a divergence age of 27,000 to 40,000.²⁵

This is the usual evolutionary sequence given for canids. The dog is last to have been derived.

This is the accurate evolutionary sequence. The wolf is the last to have been derived, after dog.

Genetic evidence pushes dog origins back well before domestication likely occurred, and before modern wolves evolved. Does it feel wrong that wolves evolved after dogs became dogs? When Darwin and others claimed Great Apes and humans had a shared ancestor, many rejected the evidence. Descent from a common ancestor fits the evidence for dogs and gray wolves, too. Teleological temptation goads us to believe “dogs were designed to be our friends.” But mutations are not designed, only selected. Dogs result from "selection of the friendliest," in the words of evolutionary biologist Brian Hare.²⁶ A shared-gaze capacity may be the trait selected.

Mechanism: Earlier, ten axioms were proposed to deduce why dogs were domesticated. The path to uncovering genetic mechanisms that led to a dog shared-gaze capacity is less clear. Abduction is a form of reasoning one can use in this case. Make observations, develop a likely explanation, make more observations, and iterate the explanation.

Animal species often exhibit repetitive, easily distracted, asocial behaviors, similar to that found in autism spectrum disorder, ASD. Even Great Apes share gazes infrequently. Chimps share them with infants, but rarely peers.²⁷ Bonobo adults mainly share gazes after resolving conflict, as if to establish trust.

Animals aren't autistic. ASD is a disorder specific to humans, which marks their distinction from other animals. A surprising number of genes that distinguish humans from chimpanzees are linked to ASD. In ASD those genes are disordered, most often deleted.²⁸

ASD-related genes, when properly configured, are mutations that led to human emotional intelligence, including shared-gaze capacity. If ancient people lacked the capacity to share egalitarian gazes, they weren't autistic, but more animal-like.

One scholar compared 30,000 year old Chauvet cave paintings with the artwork of a talented autistic girl, and found similar constructions. Neither presented imagery of people, only animals, drawn in bold curves, with the same not-quite-3D perspective.²⁹ Since gaze and visual art are related, perhaps cave dwellers didn't look at each other the way contemporary people do.

But as human populations increased, and the need to establish social links developed, ancient people evolved attachment skills: emotional intelligence. Instead of shared gazing limited

to infant-parent bonding, it was used in politics and diplomacy, religion and justice. As human emotional intelligence increased, prior animal-like behavior stood in contrast, and eventually became a pathology: ASD.

Dogs were domesticated at this time, probably to assisted attachment formation in many ways. The most profound may have been to enable humans to share gaze more competently.

Could ASD-related genes in dogs be the mechanism by which they evolved their shared-gaze capacity? Serendipity. A genetic research team looked into a closely related phenomena. In fact, they provide a tidy, mechanistic cause for dog shared-gazing. Like most things that seem too good to be true, it is. But it remains promising.

The research group, led by Brigitte vonHoldt, a Princeton geneticist, published a first paper in 2010.³⁰ They detected some unusual “single nucleotide polymorphisms” (SNPs) in the dog genome. SNPs are inverted, inserted, or missing amino acid base pairs. Instead of a guanine-cytosine pair, it's cytosine-guanine, adenine-thymine, or not there.

Of perhaps 10 million SNPs in typical canids, vonHoldt et al. surveyed 48,000, or 0.05%. They were looking for SNPs in genes of either dogs or wolves that weren't shared by both. Either these SNPs appeared after dogs and wolves diverged, or they were lost in one or the other canid. The dog gene with SNPs that differed most, in their sample, sends new neurons through the brain, and generates opioid receptors.

Opioid receptors can serve as oxytocin receptors. Oxytocin production is constrained in all animals. It's availability may be increased by receptor structure or receptor quantity. A few

species, mainly primates, have more elaborately structured oxytocin receptors.³¹ Oxytocin plays a constant role in their social life. Among many other species, oxytocin plays a mating role. A few individuals may pair off more quickly, because they have a greater quantity of oxytocin receptors.³² An SNP in a gene governing receptors for oxytocin could be relevant, given oxytocin's import in shared-gaze capacities.

A different distinctly dog gene has 12 SNPs, a potential mutation. It regulates olfactory neurons, governs hair and eye color, and controls the periorbital area around eyes, such as eye muscles and ligaments. These direct eye movement.

Dogs' capacity to share a long gaze with another dog or human has three causal layers. The outer layer involves periorbital tissue, nerves, and muscles surrounding the eyes, which physically control gazes. The middle layer integrates the external world with an individual's response, produced by neurochemical signals (hormones) and expectation. The inner layer is molecular information (DNA) and experience. The strongest statistical signals vonHoldt et al. detected relate to mechanisms in all three levels.

Yet vonHoldt et al. were more interested in a weaker signal, a few SNPs on dog and wolf genes that, if deleted in humans, cause Williams Syndrome (WMS). I understand why. Although this rare form of autism (it affects 1 in 10,000 to 20,000 births) has attributes similar to other autism conditions, such as mental deficiency, skeletal, dental, and heart abnormalities, it also causes "hypersocial behavior." The researchers consider hypersociability a defining characteristic of dog behavior.

Although the vonHoldt et al. papers do not define it, WMS hypersociability is behavior that involves shared-gazes. WMS persons approach others, whether familiar or strangers, and stare them in the eyes. They often launch into a dialogue. Even if one-sided, they may not move their eyes from the other person's.³³

Could this mechanism control the unique shared-gaze capacity of dogs? In 2017 vonHoldt et al. followed up with research on just the WMS-related genes in dogs and wolves. They found evidence that the dogs have been selected in ways that may alter these particular genes.³⁴ But three issues limit their potential to shape shared-gazing.

First, human WMS shared-gazing is caused, in part, by a microsaccade disorder. Animal eyes constantly move a tiny amount, very quickly. This microsaccade function is necessary for larger eye movements. It's disrupted in WMS, leading to 'sticky gazes' as the individual is unable to move their eyes away from what they're looking at. They anchor gaze on another's eyes, and stick there.³⁵ Dogs have no such disorder; their microsaccade function is fine.

Second, dog WMS-related genes result from breed selection over the past few hundred years. vonHoldt et al. found some WMS-related genes have significant structural variants, and not all dogs had them. Variants correlate with stereotypical dog breed sociability. Breeds more human oriented may have them, breeds less human oriented may not, and so forth. The genetic structural variants emerged during dog breeding, and may still be a factor in our dog preferences. This is far too recent to be a factor in dog domestication, much less dog evolution.

Related to this, dogs all had significantly less heterozygosity than wolves, in WMS-

related genes. Each offspring has two sets of chromosomes, one from mother, one from father. If the corresponding segments of both chromosomes have somewhat different alleles, they're heterozygous. If the segments have identical alleles, they're homozygous.

vonHoldt et al. imply that dog WMS-related gene homozygosity may be a residue from domestication. More likely, it results from breed selection. Genetic homozygosity represents fairly recent selection activity. The stretch of homozygosity in dogs, with 30 to 50 homozygous SNPs, corresponds to genetic material 50 to 200 generations from a common ancestor.³⁶ If dogs have roughly 3 year generations, that's 150 to 600 years ago, corresponding to the era of breed development.

Finally, human WMS shared-gazing is a permanent state. Most humans, other primates, and dogs will share long gazes with others, but also avoid looking at certain people, primates, and dogs, especially strangers. WMS persons make no distinction, looking everyone in the eye. It's disregulated gazing, not simply shared-gazing. This is profoundly different.

Human WMS is caused by the deletion of 27 contiguous genes. Most of the resulting symptoms are developmental failures. "Hypersociability" may reflect a disabled governing system. Instead of balancing interest and caution, phobia and philia, it's only interest, philia. To the extent balance involves anxiety-producing serotonin and social-pleasure inducing oxytocin, the WMS condition lacks equilibrium.

Dogs are not "hypersocial" in the WMS sense, because they balance caution and focus, phobia and philia. They avoid the gaze of strangers, while seeking the gaze of their masters.

In summary, dogs have no microsaccade problems, the WMS-related genetic variants in dogs correlate with breed development, and human WMS involves only philia, with WMS persons staring at strangers and friends both, unlike dogs. The genetic data vonHoldt et al. detected may have indirect connection to dog shared-gaze capacity, rather than a direct one.

Two mechanisms direct eye gazing: inhibition or compulsion. In most primate societies, including humans, individuals avoid looking at those with very low status. A set of primate amygdala neurons encodes submissive, low-status monkeys and disgusting things, which monkeys avoid looking at. On the other hand, most motorists who pass a car accident feel compelled to look at it. Rubbernecking is compulsive gazing. Another set of primate neurons encodes desirous food and high status monkeys, the things monkeys look at.³⁷

Most animals, like wolves, have a fight/flight response to direct gazes. Primates, dogs, and people also have an inhibit/compulsive, or phobia/philia response. The phobia response can be disgust, the philia, pleasure. Fight/flight is governed by the hormones norepinephrine and epinephrine. Philia produces oxytocin, phobia serotonin; oxytocin inhibits serotonin signals.³⁸

Shared-gaze is intimately correlated with phobia/philia response, and only occurs in a few species. At some point a Great Ape ancestor did not engage in shared-gaze, and presumably lacked phobia/philia response. This capacity evolved across primates, including humans. Canids also developed it, through natural and/or artificial selection.

The genome area vonHoldt et al. focused on may include genes that participate in a genetic network that enables the shift from fight/flight to phobia/philia. Genes that code oxytocin

receptors reside on chromosome 1, not chromosome 6, where the WMS-related genes are.

Oxytocin genes are highly conserved, meaning they rarely change. Any modification in the oxytocin system will occur over a very long time, since mutations are rare and constrained.

Oxytocin is intimately related to reproduction. Any modification that increases reproduction becomes dominant in the species. Oxytocin should remain near an optimal adaptive level.

The modification of a genetic network that replaces adrenal gland fight/flight hormones with pituitary gland oxytocin is complex. Domesticated chickens³⁹ have reduced levels of adrenal hormones, but no reported evidence of elevated oxytocin. Tame foxes have higher levels of serotonin, which is known to diminish aggression, but not higher oxytocin.⁴⁰ The evolution of oxytocin secreting neurons is slow. Around half, in dogs and primates, are rods like those in fish and frogs. The rest have dendrites, tree-like, but with only a tenth of the branches of other neurons. During lactation, these dendrites swell and release more oxytocin. Otherwise production is conserved.⁴¹

Oxytocin receptor sites are also slow to change. The fact that vonHoldt et al. found dogs have a distinctive genetic profile for opioid receptors is interesting, since these also bind oxytocin. Some combination of genetic changes and behavioral modifications led to the shared gaze capacity. The most likely scenario is that this complex change occurred over a longer period than domestication, and the 10,000 years of dog-human relationships. It made pre-domesticated dogs attractive targets to domesticate.

Domestication: Domestication is invoked in nearly all dog origin research. It's not often explained. Three types of domestication are generally advanced, all based on reasons to tame wolves. They either aided hunters, were adopted as cute cubs, or like human waste.

The first, most common explanation is that dogs helped "man the hunter" hunt. Humans certainly hunted, but they were not just predators. Humans lack running speed to effectively capture most game, they lack visual acuity or night vision to detect game from great distances or in darkness. They lack arm or tooth strength to strangle or cut most animals. Instead, humans make tools, like spears. They can run great distances, more than any other ground animal, due to bipedal stature and lack of fur. Humans turned hunting into scavenging: they'd wound a large beast, then track it for great distances, until it collapsed. They didn't have to risk an attack, like a predator. The animal couldn't fight back. It was like meat found by scavengers.

Dogs are scavengers, but wolves much less so. Wolves hunt in a classic predatory style: they approach a herd and cause panic. An outside herd member, perhaps very young or old, bolts and founders. Wolves attack, kill fast, and do not let other species eat.

There's nothing similar between wolf and human hunting styles. Wolves cause panic. Humans avoid notice. These contradict. People wouldn't want wolf assistance. Humans might try to steal meat wolves bring down. That's no basis for symbiosis, and not a successful strategy.

The second method of domestication is "man the pup breeder." Prehistoric hunter-gathers may have found wolf pups, raised and bred them, to tame and domesticate. Yet existing hunter-gathers have been observed for a century. They adopt wild pets sometimes. They have

never been observed selecting offspring or breeding. Nor do they adopt canids in particular.

There's nothing about those they encounter to distinguish them as useful.

The third model of domestication borrows from the cat. Wolves began to notice human waste sites, the way cats noticed seed storage facilities. Most wolves were too fearful to approach close to people. Presumably a few outliers, with lower stress levels, approached and scavenged some of the waste. Perhaps these wolves were spared human hunting, or somehow survived better. They grew fond of people, and we of them. This model was first proposed by Brian Hare, who developed the hypothesis as “survival of the friendliest.” The friendlier wolves gained benefits from participating in human society. Hare also proposes that “survival of the friendliest” explains why *Homo sapiens* survived, while Neandertals, Denisovans, and other hominids did not. Humans were able to coordinate better, because they were not hostile to people they didn't know, but could work with.⁴²

Contemporary wolves, whose caloric needs are extravagant, would not find hunter-gatherer scraps adequate. Where's the beef, with an animal that consumes so much more meat than it carries on its paws? Cats hunt rodents, which made farmers very happy. Dogs were domesticated before agriculture. What made hunter-gatherers happy?

A comparison of human and wolf teeth is abundant evidence that diets were completely different. Wolf pups are cute, but so are many young animals adopted by hunter-gatherers. But the “selection of the friendliest” scenario doesn't depend on material value. If people coordinated better, they developed emotional attachments with others more easily. A shared-gaze capacity would be a key attribute that supported Hare's hypothesis. The pre-domesticated dog's shared-

gaze talent may have been appealing because it promoted this novel human behavior. No other primate can share a long gaze with species members from outside their territory and social groups. Humans could not do so either, presumably, until it was necessary.

Once pre-domesticated dogs entered human lineages, people selected them for tameness. Those pups sired from friendly canids were preferred. Which came first, the mature dog or the puppy? Probably the pup, raised by curious people. They shared long gazes with these strangers, generating oxytocin-mediated good feelings. Domestication was almost inevitable.

My hypothesis is that dogs were already distinct from wolves, before they were domesticated. Pre-domesticated dogs had the capacity to look at each other, and at humans, in the eye. Not just glance. Exchange gazes.

This was profound, more compelling than rodent control, because it triggers a cascade of neurochemistry humans learn when young. Infants discover meaning when they look at their mother or caregiver in the eyes. A hormone, oxytocin, is released in the infant's brain, as well as the caregiver's. It's the most pleasurable brain state, and bonds the infant and caregiver.

If pre-domesticated dogs could engage the type of interaction seen between infants and mothers, their domestication became a foregone conclusion.

Domestication Siberian Style: Charles Darwin was inspired by dog breeders, who demonstrated what selection could accomplish.

A number of studies have tamed wild animals, including wolves, dingoes, and foxes. The most important was performed in Siberia, by Russian geneticist Belyayev.

Starting in the 1950s, continuing for more than 50 years and 20 generations of animals, his team bred silver foxes solely for tameness. This was achieved, along with changes in face shape and coat colors. Hence, Belyayev and others conclude that a “domestication syndrome” is driven by tameness. Tamer animals mature more slowly, with more juvenile facial features, more fat, and less camouflaged coats.⁴⁰

All tame fox characteristics were found in wild foxes, but at much lower frequency.

Several fox neurohormones changed levels. After 12 generations of selective breeding, corticosterol levels almost halved. After 28 to 30 generations, they halved again. The tame foxes' brains had increased levels of serotonin. These neurohormones may be important for non-aggressive responses to humans.

But one hormone is not mentioned in the fox research: oxytocin.

The silver fox studies are the basis for Wilkins et al.'s embryological “domestication syndrome”. Selecting for tameness “sweeps up” neural crest genes that transform embryological development.⁴³

One thing Wilkins et al. don't include in the syndrome: domestication does not induce gazing at human eyes. The tame foxes follow human eye

directions, looking in the distance if a person they watch does. But they don't look at a person looking at them for any length of time.

If Belyayev's experimental data justifies a hypothesis like Wilkins et al.'s "domestication syndrome," the data that isn't there justifies a hypothesis that shared gazes are a more complex genetic innovation.

"The dog that didn't bark" is, in this case, "the fox that didn't look you in the eye.

Domestic Resolution: One alternative to the dominant paradigm uses the model of dingoes in Australia, wild dogs that trail Australian aborigines, but don't cohabit.

Maybe dogs were domesticated a bit, then went feral, until humans settled around agriculture. Tame dingoes share gazes with human handlers of three seconds.⁴⁴ That's longer than tame foxes or wolves, yet a fraction of what dogs do. This may represent a pre-domesticated dog. It more likely explains why dingoes have remained undomesticated by aborigines, even after 5,000 years of close contact. They lack the capacity to trigger the oxytocin reinforcement cycle.

If the shared-gaze capacity of dogs was recognized by humans as a resource, it resolves the dominant paradigm's contradiction. Dogs may have attracted domestication attempts multiple times. They were domesticated 10,000 to 15,000 years ago. But they were already dog-like, because they had a unique, key trait: the shared-gaze.

Domestic Coevolution: Coevolution happens when at least two organisms mutually adapt. Some think dogs and humans have both become less aggressive, perhaps in concert with each other. Humans, however, drive co-evolution at accelerated rates. Domestication may be such a process.

Once humans notice beneficial traits, coevolution accelerates. Cannabis (marijuana) evolved prior to domestication. Its compounds affect the endocannabinoid neuro-transmitter system, which all animals have, including humans. Cannabis flowers contain cannabinoid oil. Their odor signals attract animals, including humans, to disperse their seeds. This took millions of years to evolve. Once people realized flowers altered perception, affecting neurotransmitters, they quickly bred cannabis for enhanced use in very short time.

As they modified cannabis, it modified culture. People felt fearful, enacted laws, imprisoned millions. They continue to modify cannabis. Cannabis modifies them.

Dogs gazed into each other's eyes, and into other species eyes. This required extensive evolutionary time. Then humans and dogs interacted. Dogs who could gaze at people were protected, for the same reason as cannabis: the gaze produced pleasurable neurotransmitters.

Dogs themselves experience neurochemical changes, a reinforcing cycle. Dogs and people bonded, sharing benefits. All traits vary, so that dogs who looked longer were preferred.

Dogs themselves may like humans who can look them in the eye. Did ancient people? Some cultures don't embrace shared gazing, at least in public. Individuals vary. If some paleolithic people avoided each other's direct gaze, they may have used dogs to learn how to look something in the eye.

The neurochemical feedback loop caused by the shared gaze was a basis for coevolution between dogs and humans. The bond motivated people to domesticate them, to change dog morphology and behavior. Dogs prepared us for more complex societies.

According to the Netherlands Historical Database of the Global Environment, the world's population may have doubled between 12,000 and 11,000 years ago, around the time of dog

domestication.⁴⁵ This increase had dramatic impact on hunter-gatherer societies, bringing small groups into frequent contact. It was the beginning of the Holocene, the present geological era defined by human dominance. Population growth created a need for more consistent protein and cereal production. People collected seeds to plant them, and selected young animals to raise.

Long before settled agriculture, humans explored ways to boost food output. Long before groups formed clans, and clans tribes, humans explored ways to navigate new social attachments. People began to tame and domesticate dogs, attachment specialists.

Hypothesis Test: Humans fear wolves and big cats, like lions and tigers. In the African savanna, European steppes, and Siberian far east, big cats and wild canids both have a presence. These and similar areas were inhabited by human groups for at least the past 40,000 years. Cats and canids compete, but usually in different niches. Still, the presence of one can make the area unpalatable to the other. If they cross paths, either may attack the other.⁴⁶

Only in south-east Asia, especially India, have tigers regularly attacked people. Wolves also attack people in this region, killing around the same number of people annually as do tigers.⁴⁷ Wolves eat small children, while tigers attack all kinds of people. Yet people have domesticated a relative of each. The domestic cat derives from the African Wildcat, *Felis lybica*, first tamed 10,000 years ago in some of the earliest Mideast agricultural settlements. Even today, hand-reared African wildcats behave like domestic cats.

In southern Africa, where people have continuously lived for over 80,000 years, the big cat and wild canid species are the most social and gregarious of their types. Their interactions with hunter-gatherers are extremely interesting, because these people assess inter-species sociability very perceptively. Both wild species do things wolves do, engaging in territorial protection and group hunting. At least one of them offered people a domestication opportunity since the middle Pleistocene, almost 100,000 years ago.

The Ju/hoansi of southern Africa lived in the Kalahari desert area. In the 1950s, and probably long before, each group numbered 30 to 70. A group associated with a particular watering hole. Usually a lion pride (20+ animals) also used the watering hole. Both people and lions hunted similar large game. Lions kill a victim immediately, hunters track it for several days. Their poison arrows take that long to prove fatal. They're no use as a defense against an attacking lion. But census surveys of Ju/hoansi found that only one of 1,500 deaths between 1910 and 1969 was caused by a lion, and that was questionable.⁴⁸

Here's a description of the Ju/hoansi, made by Elizabeth Thomas between 1951 and 1956. "The people slept on the ground, without fences or walls or large, intimidating fires, surely as our

ancestors had slept every since they moved from the forests to the savanna. If lions came to the Bushman camps at night, the people would stand up and would sometimes shake burning branches at the lions. Also they would speak to them loudly in steady, commanding tones, telling them to leave. On most occasion that we observed nocturnal visits by lions, the lions stayed around for a short time, but soon enough they faded into the darkness beyond firelight and then left, as requested."⁴⁹

This represents a relationship between the hunter-gathers and lions. African villagers who were settled farmers at that time suffered lion depredation. (Incidentally, 40 years later Ms. Thomas wrote ethological studies on dogs that became best-sellers.)

Although the outside world made inroads into Ju/hoansi culture long before 1950, their relationship with lions would remain emblematic of how earlier humans approached wild animals, for a decade or two more. The Ju/hoansi understood and manipulated social dynamics of neighbor species. They, and any ancestral peoples of this area, also encountered a remarkable wild canid, the African wild dog, which has never been domesticated. The wild dog (which diverged from domestic dogs over a million years ago) is far less dangerous to people than wolves. There are no recorded attacks of wild dogs on people.⁵⁰

African Hunting Dog *Lycaon pictus*

African wild dogs do not compete with humans for water. Since spotted hyenas can steal their food, desperate

humans could as well. Yet hunter-gatherers didn't domesticate them, despite cohabiting the same area, and their extensive inter-species knowledge.

Although only dogs extensively look at people, dogs and wolves have eyes with easy-to-see irises. A prerequisite to shared gazing is the ability to see the eyes of the animal.⁵¹ Wild dog eyes are camouflaged, almost invisible. They may glance at each other in play, but not when hunting. It's too difficult to see the other's eyes. They do not look into human eyes when tamed.

African wild dogs are tailored for domestication. They are "the most social of all canids."⁵² They sleep in groups, piled next to each other. Wild dogs from different packs meet without conflict. Although they have an alpha "couple" who dominate mating, it isn't enforced by violence. It's based on attitude, and others mate. African wild dogs are a bit like bonobos, semi-self domesticated. They once ranged as far north as Egypt, where in pre-dynastic times hunter-gathers may have worn wild dog tails on their belts. People have raised their pups until maturity. They're ideal for domestication. Yet African wild dogs were not domesticated.

10,000 or more years ago, hunter-gatherers domesticated a wild canid that's now dog. It's hard to imagine this wild relative was any more suited to domestication than the African wild dog. The only domesticating attribute African wild dogs lack completely is the capacity of shared-gazing. This natural test supports the hypothesis that shared-gazing is key to human interest in canid domestication.

Ju/hoansi are among the most anthropologically surveyed people on earth, so any representation of their culture will violate some scholar's interpretation. The hypothesis test isn't

about the Ju/hoansi, however. It's about the wild canid in their midst, and the fact that it wasn't domesticated. Hunter-gatherers like the Ju/hoansi domesticated dogs. Ancient burial sites where dogs and people are interred together are concentrated near the end of hunter-gatherer epochs. They disappear once agriculture and pastoralism take over. In eastern Siberia around Lake Baikal, dog burials are almost all from 7,000 to 8,000 years ago, and only in hunter-gatherer habitations, not the pastoralist ones that emerged in this period.⁵³ In California hunter-gatherer groups dominated until the Spanish arrival in the 16th century. Dog burials began at least 3,500 years earlier, and continued through the 17th century. These hunter-gatherers kept dogs as pets, guards, and for work.⁵⁴ Two burials of humans and dogs together were discovered in the upper Jordan valley in Israel, dated 12,000 years ago. The earliest undisputed dog remains in the near east, they're from the last era of Natufian hunter-gatherers.⁵⁵ This is some of the evidence that wild canids were domesticated by hunter-gatherers during periods of population increase.

1,500 years ago farming and pastoral Bantu peoples migrated into the Ju/Hoansi region, forcing the hunter-gatherers into drier domains where scarce water pushed groups into closer contact than before.⁵⁶ This was a moment for potential attachment-based domestication. But the Africa wild dog lacked the shared-gaze attribute. Dogs that do share gazes invaded the area in the 20th and 21st centuries, as part of a foreign colonization force. James Suzman observed semi-sedentary Ju/hoansi in 1995.⁵⁷ Now farm laborers, they suffered endemic hunger and mistreatment. Ju/hoansi laborers sat in the bed of trucks, while farmers' dogs sat in the cab; laborers ate gruel, dogs got meat. This deeply offended Ju/hoansi egalitarian norms. "Dogs are treated as people, and people are treated as dogs" they told Suzman. Not surprisingly, these Ju/hoansi did not much like dogs.

So even to recent hunter-gatherers, dogs are symbols. The expression “running dog,” meaning a local helper of a distant oppressor, was coined during China's Qing dynasty, when dogs were better fed in the emperor's palace than ordinary people. There's a roaring controversy in contemporary China, between traditional rural culture that eats dogs and modern urban culture, where dogs are pets. In the U.S., 20th century “yellow dog Democrats” became “blue dogs” in the 21st. Even discussions of dog origins include platitudes about human identity.

When hunter-gatherer populations concentrated 10,000 years ago, they lacked this cultural baggage, but needed emotional grace. Certain wild canids expressed meaning through shared gazes, which generated neurochemical bonding between our species.

Until agricultural systems introduced social hierarchy, and societies grew oppressive and unequal, dogs were basically friends. Once people developed social structures to entrap us, dogs became pawns and pariahs. As modern societies try to unwind from these systems, dogs can once again be seen for what they are, just really good friends.

Conclusion:

“The past is never dead. It's not even past.”

William Faulkner

We're at a watershed moment in understanding dog origins. Once we believed that somewhere in our distant past, people braver than us dared to tame wolves ... archaeology, paleontology, and genetics have punctured this view.

Dogs diverged from their now-extinct ancestor between 20,000 and 200,000 years ago, before modern wolves had even appeared. We now know that dogs have a remarkable capacity no other animal, save Great Apes, shares: the capacity to look you in the eye for about 40 seconds, on average. It's out of character for dogs, until you realize by character we mean the juvenile aspects that domestication bred into them. Shared-gazing probably evolved before domestication.

The logical hypothesis for why dogs were domesticated is they could look you in the eye.

It's an idea whose time has come. Other trends in culture have pushed back against the dog as tame wolf concept. Animal biologists recently felt compelled to argue against the claims of dog trainers that an owner must be an “alpha” dog. It's wolves, not dogs, that have “alphas.” A dominant male and female wolf in a pack mate after violent internal status competition. From this comes the term “alpha” wolf. Dogs share plentiful game, while wolves go solitary. Most importantly, dogs breed freely with each other. There are no “alpha” dogs in the wolf sense.⁵⁸

"Emotional intelligence" has become increasingly significant. So has "cognitive control", whose complex genetic basis demonstrates why it isn't something domestication causes.⁵⁹ Shared gazing intersects both.

Scientists themselves may hesitate to break with a long-held assumption that dog evolution is domestication. But it's not a radical change. The capacity to share a long gaze is behavior, if grounded in anatomy and neurobiology. Domestication selects “tamer”, better

behaved wild canids. Puppies would have been easiest. As they stared at humans, just as they do now, it started the neurochemical bonding process.

As Faulkner wrote, the past is viewed through the lens of the present. Our present grants animals more capacity than before. That gives us new tools to conceive the past.

Someone else said it first: In 1983, Manwell and Baker wrote that dog origin research was constrained by a “disciplinary dogmatism” that insisted humans domesticated the dog from a gray wolf. Most evidence, even then, suggested the likely ancestor of dogs was a “currently unpopular idea . . . a wild *Canis familiaris*,” a pre-domesticated dog-like animal.⁶⁰ Manwell and Baker believed it was a romantic notion that humans tamed wolves, based on an unexamined assumption that dogs must only be products of artificial selection.

Janice Koler-Matznick, in 2002, reviewed the evidence for the wolf domestication hypothesis, and found many conceptual gaps.⁶¹ She hypothesized that the most likely ancestor of the domestic dog was a medium-sized, generalist canid. Her argument focused on a realistic assessment of wolves, which many scientists overlook. Wolves are immensely difficult to domesticate. They “instinctively chase large prey, and thus would hinder humans hunting.” If wolves secured prey, “humans would have to fight them for it.”

Wolves abandon their offspring if their own survival is at risk. Why would they adopt more loyalty to another species? In contemporary India, wolves prey upon children. Why would they be introduced into families? Wolf packs have very high nutrient needs. Feeding them would be unsustainable. Wolves would not have found hunter-gather trash sufficient. Wolves are

specialists, whereas most wild animals that have adapted to humans are generalists: the raccoon, rat, and canids such as the coyote and red fox. These have more genetic distance from the wolf, but show how a pre-domesticated canid could be very different from today's wolves.

Koler-Matznick concluded "if the inertia created by the wolf-origin dogma can be overcome, and the problem considered without preconceptions, perhaps investigation of possible functional origins of the morphological differences between dogs and wolves, expanded nuclear DNA studies and re-evaluation of the canid archaeological and fossil record will answer some of the unresolved questions concerning our most ancient domesticate."

In "Dawn of the Dog: The Genesis of a Natural Species," published in 2016, Koler-Matznick develops her ideas with special attention to the dingo, the indigenous wild, or perhaps feral, dog of Australia. In her experience with dingoes, she notes their limited capacity to look you in the eye, compared to a dog. She writes "Perhaps the dogs' greater propensity for looking directly into faces in a non-threatening manner is an ancestral trait, one that made it easier for dogs to associate with humans. People could relate to them through mutual eye contact, as they do with other people."⁶²

That's the hypothesis. Hunter-gatherers evolved social structures⁶³ with dog help.

Final Thoughts

Along with cats, dogs selected humans as partners. Unlike cats, who were kept because of their useful service, dogs probably did so by exploiting our emotions. Ironically, that's the

opposite of how they're perceived today. Cats are the lazy ingrates, while dogs provide services.

But their primary service is to be a best friend.

The assumption that human ancestors wrangled wolves into dogs appeals to a macho, chest-thumping view of human nature. It's like the "man the hunter" myth, which can be disposed of by looking at human teeth. They're unsuited to raw meat, and customized for grinding carbohydrates. But "man the scavenger" grates on patriarchal myth. Perhaps "selection of the friendliest" does as well.

You can't make anything or anyone love you. You can love them, and hope. Dogs, through shared gaze, express something like love. For people to have hardwired this into dogs would grant us the power of making an animal that loves us. That suggests humans have god-like power, a sure exaggeration.

References

- 1 Gabrielle Davidson et al., Gaze sensitivity: function and mechanisms from sensory and cognitive perspectives, *Animal Behaviour* 87 (2104), 3-15
- 2 Bernard Baars and Nicole Gage, *Cognition, Brain, and Consciousness*, Academic Press, 2007
- 3 Adam Wilkins et al., The "Domestication Syndrome" in Mammals: A Unified Explanation Based on Neural Crest Cell Behavior and Genetics, *GENETICS* (197)3, (5/1/2014), 795-808
- 4 Golijeh Golarai et al., Autism and the development of face processing, *Clinical Neuroscience Research* 6 (2006), 145-160
- 5 John Doebley et al., The Molecular Genetics of Crop Domestication, *Cell*, 2006, (127)7, 1309-1321
- 6 Ali Vahdati et al., Effect of Population Size and Mutation Rate on the Evolution of RNA Sequences on an Adaptive Landscape Determined by RNA Folding, *International Journal of Biological Science*, (2017), 13(9), 1138-1151
- 7 Wendy Jones et al., Hypersociability in Williams Syndrome, in *Linking Cognitive Neuroscience and Molecular Genetics*, ed by Ursula Bellugi and Marie St. George
- 8 Kim et al., Comparison of carnivore, omnivore, and herbivore mammalian genomes with a new leopard assembly, *Genome Biology* 2016(17), 211-220

- 9 Miho Nagasawa et al., Oxytocin-gaze positive loop and the coevolution of human-dog bonds”, *Science*, 4/17/2015), (348)6232, 333-336
- 10 Emile Durkheim, *The Elementary Forms of the Religious Life*, Oxford University Press, (2008) (originally 1912)
- 11 Germonpre et al., Fossil dogs and wolves from Palaeolithic sites in Belgium, the Ukraine and Russia, *Journal of Archaeological Science*, (2009), 36, 473–490
- 12 N.D. Ovodov et al., A 33,000-Year-Old Incipient Dog from the Altai Mountains of Siberia: Evidence of the Earliest Domestication Disrupted by the Last Glacial Maximum. *PLoS ONE*, (2011), 6(7) e22821
- 13 Maud Pionnier-Capitan et al., New evidence for Upper Palaeolithic small domestic dogs in South-Western Europe, *Journal of Archaeological Science*, (2011), 38, 2123-2140
- 14 Xiaoming Wang and R.H. Tedford, Evolutionary history of canids, chapter in *The Behavioural Biology of Dog*, Edited by Per Jensen, CABI, (2007)
- 15 C. Vila et al., Multiple and ancient origins of the domestic dog, *Science* (1997) 276, 1687-1689
- 16 Robert Lee Hotz, Dogs' Days Date Back 100,000 Years, *Los Angeles Times*, June 13, 1997
- 17 Savolainen et al., Genetic evidence for an East Asian origin of domestic dogs, *Science*. (2002), (298)5598, 1610-3
- 18 Jun-Feng Pang et al., mtDNA Data Indicate a Single Origin for Dogs South of Yangtze River, Less Than 16,300 Years Ago, from Numerous Wolves, *Molecular Biology Evolution*, (2009), 26(12): 2849–2864
- 19 Janice Koler-Matznick, The Origin of the Dog Revisited, *Anthrozoös* (2002), 15(2), 98-118
- 20 Charles Darwin, *On the Origin of Species*, Dover, (2006) originally published (1859)
- 21 R.K. Wayne and B.M. vonHoldt, Evolutionary genomics of dog domestication, *Mammalian Genome*, (2012), (23)1-2, 3-18
- 22 G. Larson, Genetics and Domestication: Important Questions for New Answers, *Current Anthropology*, (2011), 52(S4), S485-S495
- 23 Sankar Subramanian and David Lambert, Time Dependency of Molecular Evolutionary Rates? Yes and No, *Genome Biological Evolution*, (2011), 3 1324–1328
- 24 Freedman et al., Genome sequencing highlights the dynamic early history of dogs, *PLoS Genetics*, (2014), (10)1, e1004016
- 25 Skoglund et al., Ancient Wolf Genome Reveals an Early Divergence of Domestic Dog Ancestors and Admixture into High-Latitude Breeds, *Current Biology*, (2015), (25)11, 1515-1519
- 26 Brian Hare, Survival of the Friendliest, *Annual Review of Psychology*, (2017), Volume 68: 155-186
- 27 William D. Hopkins et al., Genetic Influences on Receptive Joint Attention in Chimpanzees, *Scientific Reports*, (2014), Volume 4, Article number: 3774
- 28 Ryan Doan, Mutations in Human Accelerated Regions Disrupt Cognition and Social Behavior, *CELL*, (2016), (167)2: 341-354
- 29 Nicholas Humphrey, Cave Art, Autism, and the Evolution of the Human Mind, *Cambridge Archaeological Journal*, (1998), (8)2: 165-91
- 30 Bridgett vonHoldt et al., Genome-wide SNP and haplotype analyses reveal a rich history underlying dog domestication, *Nature*, (2010), (464)7290: 898–902

- 31 Danielle Baribeau and Evdokia Anagnostou, Oxytocin and vasopressin: linking pituitary neuropeptides and their receptors to social neurocircuits, *Frontiers in Neuroscience*, (2015) 9: 335 doi: 10.3389/fnins.2015.00335
- 32 Ross, H., et al., Variation in oxytocin receptor density in the nucleus accumbens has differential effects on affiliative behaviors in monogamous and polygamous voles, *Journal of Neuroscience*, (2009), (29)5: 1312-8
- 33 Ursula Bellugi et al., Affect, Social Behavior, and the Brain in Williams Syndrome, *Current Directions in Psychological Science*, (2007), (16)2: 99-104
- 34 Bridgett vonHoldt et al., Structural variants in genes associated with human Williams-Beuren syndrome underlie stereotypical hypersociability in domestic dogs, *Science Advances*, (2017), (3)7: www.ncbi.nlm.nih.gov/pmc/articles/PMC5517105/
- 35 Jo Van Herwegen, Williams syndrome and its cognitive profile: The importance of eye movements, *Psychology Research and Behavior Management*, (2015), (8)8:143–151
- 36 Eui-Soo Kim et al, The Relationship between Runs of Homozygosity and Inbreeding in Jersey Cattle under Selection, *PLoS One*, (2015), (10)7: e0129967
- 37 Jérôme Munuera, Social Hierarchy Representation in the Primate Amygdala Reflects the Emotional Ambiguity of Our Social Interactions, *Journal of Experimental Neuroscience*, (2018), 12: 1179069518782459
- 38 R. Mottotese, Switching brain serotonin with oxytocin, *Proceedings of the National Academy of Sciences*, (2014), (111)23: 8637-42
- 39 Pia Løtvedt et al., Chicken domestication changes expression of stress-related genes in brain, pituitary and adrenals, *Neurobiology of Stress*, (2017), 7: 113–121
- 40 Lyudmila Trut et al., Animal evolution during domestication: the domesticated fox as a model, *Bioessays*, (2009), (31)3, 349–360
- 41 H. Sophie Knobloch and Valery Grinevich, Evolution of oxytocin pathways in the brain of vertebrates, *Frontiers of Behavioral Neuroscience*, (2014), (8)31 doi: 10.3389/fnbeh
- 42 Brian Hare and M. Tomasello, Human-like social skills in dogs?, *Trends in Cognitive Science*, (2005) (9)9:439-44
- 43 Adam Wilkins et al., The “Domestication Syndrome” in Mammals: A Unified Explanation Based on Neural Crest Cell Behavior and Genetics, *Genetics*, (2014), (197)3, 795-808
- 44 Angie Johnston et al., Uncovering the origins of dog–human eye contact: dingoes establish eye contact more than wolves, but less than dogs, *Animal Behaviour*, November 2017, (133), 123-129
- 45 Netherlands Environmental Assessment Agency, History Database of the Global Environment, themasites.pbl.nl/tridion/en/themasites/hyde/basicdrivingfactors/population/, (2010)
- 46 Dale Miquelle et al., Tigers and Wolves in the Russian Far East, Chapter 10 in *Large Carnivores and the Conservation of Biodiversity*, edited by Justina Ray et al., Island Press, (2005)
- 47 J.D.C. Linnell et al., The fear of wolves: a review of wolf attacks on humans, *NINA Oppdragsmelding*, (2002), 731:1-65
- 48 Marcus Baynes-Rock and Elizabeth Marshall Thomas, We Are Not Equals: Socio-Cognitive Dimensions of Lion/Human Relationships, *Animal Studies Journal*, (2017), (6)1, 104-127
- 49 Elizabeth Marshall Thomas, The Lion/Bushman Relationship in Nyae Nyae in the 1950s, *Anthropologica*, (2003), (45)1, 73-78

- 50 Bradley Smith, Cognition and behaviour in captive dingoes (*Canis dingo*), A thesis submitted for the degree of Doctor of Philosophy (Psychology) UNIVERSITY OF SOUTH AUSTRALIA June, 2010
- 51 Sayoko Ueda et al., A Comparison of Facial Color Pattern and Gazing Behavior in Canid Species Suggests Gaze Communication in Gray Wolves (*Canis lupus*), Plos One, June 11, 2014, doi.org/10.1371/journal.pone.0098217
- 52 Juliet Clutton-Brock et al., A review of the family Canidae, with a classification by numerical methods, Bulletin of the British Museum, Zoology, (1976), (29)3:117-199
- 53 Robert Losey et al., Burying Dogs in Ancient Cis-Baikal, Siberia, PLoS One, (2013), (8),5: e63740.
- 54 Paul Langenwalter and Kevin Buffington, A Preshistoric Dog Burial from the Intermediate Period at CA-ORA-1055, Journal of California and Great Basin Anthropology, (2014), (34)1
- 55 Juliet Clutton-Brock, Origins of the dog: domestication and early history, in The Domestic Dog, ed. James Serpell, (1995), Cambridge University Press
- 56 Desiree C. Petersen et al., Complex Patterns of Genomic Admixture within Southern Africa, PLoS Genetics, (2013) (9)3: e1003309
- 57 James Suzman, Affluence Without Abundance: The Disappearing World of the Bushmen, (2017), Bloomsbury
- 58 Brian Hare and Vanessa Woods, "Dogs Follow the Friendliest, Not the Alpha", Duke University, October 15, 2013 livescience.com/40453-dogs-follow-friends-not-alphas.html
- 59 D.C. Glahn et al., Genetics of cognitive control: Implications for Nimh's research domain criteria initiative, American Journal of Medical Genetics B Neuropsychiatric Genetics, (2016), (171)B(1) 111-120
- 60 C.M.A. Manwell and C. Baker, Origin of the dog: from wolf or wild *Canis familiaris*?, Speculations in Science and Technology, (1983), (6)3, 213-224
- 61 Janice Koler-Matznick, The Origin of the Dog Revisited, Anthrozoös, (2002), (15)2: 98-118
- 62 Janice Koler-Matznick, Dawn of the Dog: The Genesis of a Natural Species, Koler-Matznick Publishing, (2016)
- 63 Kim Hill et al., Co-residence Patterns in Hunter-Gatherer Societies Show Unique Human Social Structure, Science (2011), 331:: 1286-1289

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