Science AMA Series: We recently published a manuscript that showed modern humans had sex with Neandertals approximately 100,000 years ago, which is ~50,000 years earlier than previously known human/Nea

NeanderthalDNA [1] and r/Science AMAs[1]

[1]Affiliation not available

April 17, 2023

Abstract

Hi Reddit! The publication can be found here: http://www.nature.com/nature/journal/vaop/ncurrent/full/nature16544.html. Who we are: Co-authors Martin Kuhlwilm, Bence Viola, Ilan Gronau, Melissa Hubisz, Adam Siepel, and Sergi Castellano. Martin Kuhlwilm is a geneticist, currently working at the UPF in Barcelona and previously at the Max Planck Institute in Leipzig. He studies modern human, Neandertal and great ape genomes, to understand what is special for each group and which evolutionary patterns can be found. He also studies migration patterns among hominin groups and great ape populations. Bence Viola is a paleoanthropologist at the University of Toronto. His main interest is how different hominin groups interacted biologically and culturally in the Upper Pleistocene (the last 200 000 years). He combines data from archaeology, morphology and genetics to better understand how the contacts between Neanderthals, Denisovans and modern humans happened. He mostly works in Central Asia and Central Europe, two areas where contacts between modern and archaic humans are thought to have taken place. Sergi Castellano, from the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, focuses on understanding the role of essential micronutrients, with particular emphasis on selenium, in the adaptation of human metabolism to the different environments encountered by archaic and modern humans as they migrated around the world. His group is also interested in the population history of these humans as it relates to their interbreeding and exchange of genes that facilitate adaptation to new environments. Melissa, Ilan, and Adam used to work together in the Siepel lab at Cornell University, and continue to work together from a distance. Currently, Ilan is a faculty member in Computer Science at the Interdisciplinary Center in Herzliya, Israel. Adam is a professor at the Simons Center for Quantitative Biology at the Cold Spring Harbor Laboratory on Long Island, New York. Melissa is a graduate student in Computational Biology at Cornell. They are especially interested in applying probabilistic models to genomic data to learn about human evolution and population genetics. Ask us anything! (Except whether “Neanderthal” should be spelled with an ‘h’.. we don’t know!) Update: Thanks everyone for having us! Hope we were able to answer some of your questions. We’re signing off now!

the WINNOWER

REDDIT

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NEANDERTHALDNA R/SCIENCE

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CORRESPONDENCE:

DATE RECEIVED:
February 24, 2016

DOI:
10.15200/winn.145623.30393

ARCHIVED:

I have heard that the Tibetan's reknowned altitude tolerance has been attributed to a Denisovan Gene, what superpowers did Neandertals imbue us with ?

Would a fair picture of a Neandertal be a tall stocky pale skinned red haired type with green eyes , great strength and cold tolerance but an inability to throw due to a lack of a rotator cuff in the shoulder ?

Is there variation across the Neandertal range about which Neandertal genes survive in us ? Did the Neandertal have regional variation ? Are Denisovia and Neandertal regional variations of the same

February 23, 2016

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type of human ?

Can yous rule out later interbreedings, like with the Maltese Neandertal's of 35,000 years ago ?

Many thanks for extending the boundaries of knowledge.

ford_beeblebrox

Martin: We did not gain superpowers, but it seems like Neandertal alleles helped us to withstand better the new pathogens in Eurasia. A recent study has shown the immunity benefit in Neandertals: https://www.mpg.de/9819763/neanderthal-genes-immune-system Possibly there were a few more advantages for metabolism (digestion of novel foods) or other adaptations. However, the very strong selection signal in the population of Tibetans is quite unique and not observed for Neandertal alleles. For strength and cold tolerance, it's not clear how much different it was in Neandertals compared to modern humans adapting to certain environments. By the way, Neandertals did not live in the very icy north, but rather had their population center towards the Mediteranean coast. There is some variation between Asians and Europeans which Neandertal alleles survived. But rather the Asians have more Neandertal DNA, although Europeans would have had more opportunity to have contact. We need to get more Neandertal individuals to better understand this. http://www.nature.com/nature/journal/v507/n7492/full/nature12961.html Regional variation among the Neandertals was probably small, the individuals we sequenced look genetically quite similar, like present-day people in a region like Europe today. The Denisovan is quite different. Later interbreedings did happen, but didn't always leave traces in later populations for example in Europe: http://www.nature.com/nature/journal/v524/n7564/full/nature14558.html It seems likely that such encounters included interbreeding later, but the many migrations and population movements within Europe make it impossible to see the signal in our genomes today.

Hi there! I'm a current biosciences undergrad doing modules within the realm of evolutionary biology and I have some questions!

1. What events in prehistory resulted in the speciation and divergence between Homo sapiens and Homo neanderthalensis? Was it allopatric or sympatric speciation? Is there much genetic evidence?
2. What caused the two species to come back into contact? Why would H. sapiens interbreed with H. neanderthalensis?
3. Has there been anything that has really excited or intrigued you in your research?

If you could answer these, that would be great :)

lromaine

BV: These are very good questions.

1. Most people think that Neanderthals evolved in Europe, they were mostly isolated from African populations and their adaptations are partly reflecting the glacial climate of Europe, but them being a small isolated population genetic drift probably also played a strong role. Thus, it would be an example of allopatric speciation. We don’t have detailed genetic evidence yet, but some of our colleagues are working on DNA from the Sima de los Huesos hominins, an about 400 ka old assemblage form Spain. Morphologically those guys look like the ancestors of Neanderthals, but their mitochondrial DNA is more similar to the Denisovans (the Asian sister group of Neanderthals, only known from Denisova cave up until now).

2. The main reason for contact was that modern humans moved out of Africa, and migrated into the Neanderthal geographic range.

3. Lots! Ancient DNA really revolutionized the field of human evolutionary studies, allowing us unique insights into how these different species were related and how they interacted. For me, the most

exciting discovery was probably the existence of the Denisovans, a group about which we did not know up until 2010.

Hi All, thanks for the AMA!

Something that might help me clarify what I see in headlines - how do you define terminology? The thing I get stuck on is at what point two interbreeding populations become their own species.

I know evolution is messy, so there's always some subjectivity, but at what point do you cross from "normal genetic mixing within a species" to "interbreeding between two species"? And what consequences does this distinction have for the descendants?

superhelical

We're not considering Neanderthals as a separate species. They definitely could interbreed with modern humans, and it's currently unclear whether the 'hybrids' were selected against or not. There is some indirect evidence for that, but it seems like a small effect at most. Probably the best way to think about Neanderthals and modern humans is as two populations that were separated geographically for a long period and then came into a secondary contact

Were the relationships more cohabitational or through conquest? Is there a way to tell if the relationships were more human males with Neanderthal women, the other way around, or an equal distribution of mating between them?

roque72

Melissa: There is no way to answer this question through genetics. We all know there is Neandertal DNA in humans, and our study has found human DNA in Neandertals. The one thing we can say for certain, then, is that hybrid individuals were successfully integrated into both Neandertal and human societies, and passed their genes on to future generations. Other than that, it is all speculation. My intuition is that babies stayed with their mothers, and that it is therefore likely that the relationships went in both directions. However, there are other scenarios that could also explain our observations (such as mothers being abducted by force into the other society).

Is it plausible that the humans you discovered were related with the Qafzef-Shkul population?

Is the Out-of-Africa model useful anymore if we have humans in eurasia 100k years ago and repeated admixtures with archaic humans?

KrYooNANAra

BV: The Skhul-Qafzeh population, a group of modern humans that lived in the Near East between about 100 and 120 000 years ago is one of the possible sources (I would actually say the most likely) for this gene flow. But of course there are other possibilities as well - some people proposed that modern humans reached South Asia more than 80 ka ago, and there are some teeth from China that could also represent a very early migration.

I think the OOA model is still valid, after all the vast majority of the genome of all modern humans comes from Africa with admixture only in the single digit range. Also, the Near East is a bridge between the African and Asian biogeographic provinces, and thus in many ways an extension of Africa.

Do we know where in the world Neanderthals persisted longest, and is there any higher amount of Neanderthal DNA in descendants in/from that area?

ADavidJohnson

BV: Some of the last Neanderthals we know come from the Iberian peninsula and the Balkans (Croatia). Neither of these areas have much higher percentages of Neanderthal DNA today than the rest of Eurasia, but this is also not to be expected, there have been a lot of population movements over the last 35 000 years!

Thanks for joining us today!!!

Can you explain briefly how you can detect Neanderthal DNA within the human genome?

What to we know about the consequences of these sequences in modern humans? Is there evidence that these segments are undergoing positive selection?

Along those same lines, how impactful is the differing genetic background between humans and Neanderthals? Is there any evidence of amplified interaction effects of introgressed segments and human genes?

Many congratulations on the excellent paper!

p1percub

You can search for segments of the genome of present-day humans that have many alleles that we know appeared in the Neandertal lineage.

There is evidence of adaptive introgression. That is segments from Neandertals that may be beneficial to modern humans.

The last question is still unclear.

Has there ever been any physical evidence that Homo sapiens and Neanderthals lived together in groups? Is the 'warring factions' stereotype thought to be true, or exaggerated?

scisteve

There is no such evidence at this time.

Has the recent discovery of Denisovians and to a lesser extent Flores Hobbits shaken up the paradigm of human/Neanderthal interactions? Was the involvement with Denisovians in Eastern Asia similar to the involvement with Neanderthals in Western Asia and Europe? Is it possible for late Homo erectus to have bred with people?

iorgfeflkd

BV: The interbreeding with Denisovans seems to be very similar to what happened in Europe with Neanderthals. It really looks that whenever two different populations met they interbred - we also see interbreeding between Denisovans and Neanderthals and Denisovans see to have interbred with another, more archaic hominid as well (possibly Asian *Homo erectus*, but it is pretty hard to tell). I

would not exclude that late *H. erectus* did also interbreed with us, but we don't have any clear evidence for it.

Has anyone found Neanderthal DNA straight from the source - ie, any frozen Neanderthals like there have been mammoths? If so, did that go into determining what genetic markers in modern humans come from our stocky cousins?

bigoldgeek

The available Neandertal genome sequences all come from fossil remains, not frozen samples.

Has anyone found Neanderthal DNA straight from the source - ie, any frozen Neanderthals like there have been mammoths? If so, did that go into determining what genetic markers in modern humans come from our stocky cousins?

bigoldgeek

Sure, there is a complete Neandertal genome sequenced.

The elephant in the room question:

Is there any evidence that traces of Neanderthal DNA has had any impact on cognitive abilities in humans alive today, compared to those without Neanderthal DNA?

RetrospecTuaL

Martin: Modern humans outside Africa carry small amounts of Neandertal DNA. That means, each individual carries only 1-3% of their genome, mostly randomly distributed (and rather less in functional elements). There is no single region in the genome where all Non-Africans look like Neandertals but Africans not, and those regions with quite high percentage are related to immunity. Also, cognitive abilities are not different between Africans and Non-Africans. That means there is no hint that Neandertal DNA would have such an impact, and it also seems very unlikely.

There have been several headlines about the medically unfortunate results of our Neanderthal heritage, but I usually expect to see 'hybrid robustness' when genetic lines are mixed. What genetic *benefits* have been identified or postulated?

A40

Melissa: There has been a lot of postulation that interbreeding with Neanderthals helped modern humans adapt to the harsh, cold European climate as they moved out of Africa. There is also evidence that Tibetans inherited their high-altitude adaptation from the Denisovans.

A recent study did link Neanderthal DNA to many human diseases and unfortunate phenotypes like Nicotine addiction. However, it is important to note that this study used medical records and was thus focused on finding links with negative phenotypes. Also, while the results were statistically significant, the effect sizes were very small (only a few percent of the variance explained).

I recently read this article, suggesting the genetic overlap does *not* come from interbreeding, but is

simply a result of common ancestry. The counter-argument was that we "have shared genes in common with Neanderthals for only a few tens of thousands of years". Could these new findings bring the shared ancestry theory back into play?

Kjell_Aronsen

Neandertals and modern humans split around 600,000 years ago so the long and young fragments found in one genome coming from the other can only be explained by much more recent interbreeding.

In my last undergraduate anthropology class, I was told that the percentage of Neanderthal DNA in modern humans was very small, and thus suggested that there was only limited intermixing.

My question is, if there is evidence for interbreeding earlier, does that mean we may actually be more neanderthal than we thought or just that we met earlier?

Pirunner

Melissa: Our study detected human DNA in Neandertal, not the other way around. We propose that it occurred in an ancient human population that left Africa and died out, so we don't expect to see traces of it in modern human DNA. Therefore the amount of Neandertal DNA in human DNA should not be affected by our conclusions.

However, if there had been older interbreeding events which did leave traces in our DNA, they would be much more difficult to detect. The older the event, the shorter the genomic segments that are left by the Neandertals. It is possible that there are older events that we do not have power to detect. The 2-4% is more of a lower bound for the amount of admixed Neandertal material, indicating the amount that we can confidently identify.

What were the main differences between the two species? Why did Homo Sapiens survive and not Neanderthals?

Stuck_In_the_Matrix

Very much unknown at this time.

How does the human genetic bottle neck event of 75,000 years ago factor into this story?

ladule

I believe you refer to the 'main' out of Africa migration of the ancestors of present-day non-Africans. What we propose is that early modern humans had already left Africa by 100,000 years ago and met and interbred Neandertals. Thus, modern humans left Africa at least in two waves.

What anthropological ramifications would such a discovery have to our current understanding of the origin of homo sapiens?

Lord_Widnes

It means that modern humans left Africa in at least two waves and in both occasion they met and interbred with Neandertals.

How could (maybe one solid reason) this additional 50,000 years factor into our overall generational evolution? Is this amount of time significant in terms of evolution?

Thank you!

greent26reddit

Martin: Modern humans are around since 200,000 years, which means that the oldest fossils that look like modern humans are that old. Since then, there was no general change of our body shape and most likely our abilities. These 50,000 years are well within that range, and the population that met Neandertals earlier seems to be extinct. It also takes much longer time for complex traits to evolve significant changes, so it does not change the view of our overall evolution.

did the neanderthals go extinct or did they just become us?

starvingm4n

Martin: This is a good question. Neandertals had a very small population size compared to modern humans, and the theory exists that modern humans just soaked up the small Neandertal groups. After some more migrations and expansions, this signal could have been lost (no difference between different European populations now). But we don't know if this is true or they went extinct following some environmental changes yet.

did the neanderthals go extinct or did they just become us?

starvingm4n

IG: they did go extinct in the sense that most of their heredetary traits vanished. Only a few made it through via introgression with modern humans

did the neanderthals go extinct or did they just become us?

starvingm4n

They became extinct while passing some of their genes to us.

We've seen evidence that allergies may have come from Neandertal /Homo Sapien cross breeding; and there has been speculation that Neandertals had near total recall. Do you think we will eventually find evidence that certain types of autism (specifically Asperger's syndrome) will be linked to a more Neandertal mental wiring?

moodog72

Not really allergies. The paper only stated that some variants in immune-related genes come from Neandertals. These may have helped modern humans to adapt to the environments already inhabited by Neandertals.

Not sure about the autism relationship.

Have you ruled out the possibility that this shared DNA wasn't due to other effects like incomplete lineage sorting?

Aceofspades25

IG: we have been quite careful in considering the influence of incomplete lineage sorting. First we used a model-based approach that explicitly models lineages coalescing back in time. Then, we designed a series of tests that compared genealogical relationships of present-day Africans with Denisovan and the Altai Neanderthal and we use the Denisovan genome as a control to rule out ILS.

Have you ruled out the possibility that this shared DNA wasn't due to other effects like incomplete lineage sorting?

Aceofspades25

ILS should result in haplotypes that are short and old as they sorted in the common ancestor of Neandertals and modern humans. We find long and young 'African' fragments in the Altai Neandertal genome that are incompatible with ILS. They are also only reproduced by simulations that incorporate 'recent' gene flow from modern humans into Neandertals.

I was taught in Undergrad, that in order to define two creatures as the same species, they must be able to produce "fertile and viable offspring". Lions and Tigers are different species, because while they can reproduce, their offspring cannot. When talking about Humans I often find we disregard this definition and say "Homo Sapiens and Neanderthals interbred... but oh yeah, we're different species"

With all of recent evidence, including the bits you worked on stating humans and Neanderthals did in fact reproduce fertile and viable offspring, is it fair to suggest they are one in the same species?

EDIT: If not, do we need to rework the definition of species?

jgovs

We usually do not talk about difference species but about modern and archaic humans that could genetically mix.

Were they aware at the time they were not the same species? Did they care?

photojoe

The concept of species is difficult to precise. It is perhaps better to speak of human forms, archaic and modern.

how will this discovery change the way we see history? What is the significance of this find??

soopermun

Ilan: first, this discovery further validates previous evidence of interbreeding between the two groups of humans. Because this is a different event at a different time, it demonstrates that interbreeding was likely the rule and not an exception. Another important implication of the study is the first genetic evidence of modern humans out of Africa as soon as 100,000 years ago. This complements archaeological findings of early modern humans in the Near East and also in China.

how will this discovery change the way we see history? What is the significance of this find??

soopermun

We provide evidence for an early migration of modern humans out of Africa around 100,000 years ago, that is thousands of years before the migration of the ancestors of present-day non-Africans. So, modern humans left Africa at least in two waves and met Neandertals in both occasions.

I have heard that while Europeans and Asians have some Neanderthal DNA, some Africans have no traces of Neanderthal DNA in them. If this is true, then does anyone know what 'Neanderthal-like' species they evolved from?

blind_eyed

It is true, sub-Saharan Africans have no Neandertal DNA.

The lineages leading to modern humans and Neandertals separated around 600,000 years ago. After this divergence, the ancestors of Neandertals migrated out of Africa much before modern humans did.

Were the Neanderthals and humans distinguishable easily? That is, was the interbreeding a sort of "accident," or were early humans and Neanderthals aware that the other person they're having sex with is a different species from them?

orangegluon

BV: Neanderthals and modern humans show clear morphological differences, even though I am not sure if you would recognize them as a different species (and of course there is the question whether our ancestors had a concept of different species). Look for example for pictures of the "Neanderthal George Clooney", a recent reconstruction (http://coctel-de-ciencias.blogs.quo.es/files/2012/07/Steinzeit-Clooney_12.jpg).

Science news articles describing your findings included the following diagram showing the bi-directional gene flow from the modern human and neanderthal lines of the genus homo. While it is unclear whether this diagram came from your own work or was synthesized by the journalist, a strange feature of the diagram is that it shows 4 different lineages of modern humans alive today, including two separate lineages in Africa, and two more outside of Africa. Can you comment on the identification of these 4 lineages? Are the two outside of africa the Europeans/Asians with Neanderthal gene, and the Papau New Guinea/Australians with Denisovian genes?

shiningPate

Ilan: I drew up the diagram. I admit that showing 4 separate present-day lineages is confusing. I meant for them to symbolyze later expansions of modern humans (population splits) in Eurasia and Africa. So that gene flow from Neanderthals into modern humans occurred before the main expansion into Europe and East Asia, but after some of the deeped splits in Africa (e.g. split of Khoe-San and Yoruba populaitons).

The range of Neanderthals shown on wikipedia extends into England. How would they have crossed the English Channel?

Also, is it hypothesized that there was interbreeding wherever human and neanderthal populations overlapped, or only happened in certain regions?

HowIsntBabbyFormed

BV: There are a few Neanderthal fossils from Wales (Pontnewydd cave), and even earlier humans reached the British islands (Boxgrove for example). They had no problem getting there, as during the colder periods of the ice age the sea levels were considerably lower (up to 120 m below present sea level), so they could simply walk there. We don't know where the interbreeding happened exactly, but as all modern human populations outside of Africa carry comparable levels of Neanderthal DNA this likely happened soon after leaving Africa. There was additional interbreeding as well, a 40 ka old modern human from Oase (Romania) had a great-great-great-grandparent who was a Neanderthal!

Given how early this was, and that Neanderthal DNA is spread throughout the non-sub-Saharan population, presumably it occurred shortly after we'd left Africa for South Arabia. Is there any evidence for a second "infusion" of Neanderthal DNA later on and confined to Europeans and Northwest Africans? If not, are there any hypotheses why?

DaddyCatALSO

Ilan: the event that we discovered is an ancient one (~100,000 years ago), but it did not involve the ancestors of present-day Eurasians. What we hypothesize is that these people are descendants of an early migration out of Africa, and that they met Neanderthals in the Near East. The later event that left traces of Neanderthal DNA in present-day Eurasians occurred 45,000-65,000 years ago and we do not have a good idea where it could have happened

I have seen theories that posit that the Basque people are descendants of Neanderthal culture. The Basque people have a higher percentage of Rh blood type. The Basque language is an independent language not related to any other.

Does your research lend any credence to this theory?

Do you have any theories as to why we have Neanderthal DNA, but not Neanderthal Mitochondria?

alose

This theory is not correct. Basque people are very much modern humans. I have never seen that they have more Neandertal DNA than other Europeans.

Think of mitochondria as a single non-recombining gene. Not always informative.

Can we not reasonably intuit that, given how expansive our sex drives are, we probably had sex with Neanderthals as soon as we met them?

Johnny_Fuckface

So far we can say that there have been multiple and independent events of interbreeding between modern humans and Neandertals.

Extremely intriguing work! Congratulations on the recent publishing!

My questions are: Are Neanderthal's older as a species than Homo Sapiens? Did our evolutionary intermingling have any significant effects on Homo Sapiens' ability to migrate successfully to the new environments of Europe/Eurasia - for example, transmission of immunity to pathogens in the new climates?

pnutbuttersmellytime

Martin: Neandertals and modern humans have a common ancestor around 600,000 years ago, and since around 200,000 years ago the fossil record shows the distinct features of each population. We describe that modern humans left Africa early and contributed genetically to Neandertals (100,000 years ago), but that group of modern humans seems to be extinct. If at all, it may have helped the Neandertals in this case. Later on, as already known, modern humans left Africa and received gene flow from Neandertals (65,000 years). It has been shown that some alleles in immunity-related genes came from Neandertals into modern humans outside Africa, and reached a higher frequency than the 3% average. There are also signals of selection around such genes, so it seems likely that adaptation to pathogens happened as a ressult of the gene flow.

Do you think those "modern" humans knew they were having sexual intercourse with "not quite humans"?

Littlewigum

They are all humans, modern or archaic. They would have notice some of the more obvious morphological differences.

On NPR the other day, I heard a conversation along the same lines with Tony Capra (Vanderbilt) on a study he and some colleagues did, which I've found here:

http://science.sciencemag.org/content/351/6274/737

Did you work in tandem with these people or share research? What do you think of their findings?

totallykeanureeves

Melissa: We did not work with them on this project, it was entirely separate, though I have worked with Tony Capra on other projects in the past. I think their findings were very interesting, and it was an innovative approach to use currently available medical data. However, since they were using medical data, they naturally found associations with "bad" phenotypes such as diseases and addictions. So it definitely only tells part of the story. It is also important to note that the effect sizes they found were very small. The most we can say is that Neanderthal DNA may increase your chances of having some of these conditions by a small percentage.

Something I've been wondering for a while now. As I understand it, there is evidence not only that homo sapiens mated with H. neanderthalensis, but that modern humans have neanderthal DNA. That surely means that at least some of those matings produced fertile offspring, who are ancestors of some or all of us alive today.

In that case, why are neanderthals still classified as a separate species? If two organisms can mate and produce fertile offspring, doesn't that make them members of the same species?

mishagale

We do not usually talk about difference species but of different human populations, one modern and another archaic, that could mate.

You detected signatures of "our" genetic influence in a localised group of Neanderthals. Was there equal genetic flow into our genetics or did the offspring primarily end up diluting into the Neanderthal population?

bostwickenator

Ilan: We can't really say, primarily because we do not have descendant of that early modern human population. So it's not unlikely that the admixture was symmetric, but we find signatures of it in the Neanderthal DNA just by chance.

Can you tell me why it is for sure that this happened through sex and not simply because humans and Neanderthals come from a similar lineage?

Also, is this shown through mitochondria DNA? If not I find it problematic that a female human could birth a neanderthal baby due to size and 12 month gestation period assumed to be necessary for neanderthal children to mature.

hockeyrugby

Because they diverged about 600,000 years ago and the segments from their shared ancestry are short and old (recombination). The young and long fragments we find are compatible with interbreeding around 100,000 years ago.

Think of mtDNA as a single gene. Not very informative.

Can you tell me why it is for sure that this happened through sex and not simply because humans and Neanderthals come from a similar lineage?

Also, is this shown through mitochondria DNA? If not I find it problematic that a female human could birth a neanderthal baby due to size and 12 month gestation period assumed to be necessary for neanderthal children to mature.

hockeyrugby

BV: The idea that Neanderthals had very long gestational periods was proposed in the 1980s, but more recent research shows that this might not necessarily be the case. Weaver and Hublin (PNAS, 2009) reconstructed the pelvis of Tabun 1 (a Neanderthal female from Israel) and showed that though shaped somewhat differently than modern pelvic outlets - wider mediolaterally (from side to side) but shorter anteroposteriorly (from front to back) - the total space available for the head of the newborn is comparable. As the several Neanderthal newborns have about the same head size as recent babies, I do not see why they would have had much longer gestation periods than we do. There are also numerous studies of dental development that indicate that Neanderthal children grew faster than modern kids.

Hello,

keeping in mind all of the above discoveries, where/how would you put Neanderthals on the genetic tree?

I remember they were considered a seperate species which went extinct just a few years ago. Do you think this view needs changing?

Ysbreker

Melissa: Our study did not change their place on the genetic tree. We believe they diverged from humans around 600,000 years ago, and from the Denisovans around 400,000 ago. They are very closely related to modern humans and there was clearly interbreeding. The definition of species is very fuzzy at this level. There has been some evidence of natural selection against hybrids, so the speciation process may have begun. They went extinct ~40,000 years ago. I think our study continues to move our understanding in a direction that is breaking down the "species" barrier between these different hominids. The sequencing of the Neanderthal genome has allowed us to confidently assert that interbreeding successfully occurred on multiple occassions.

Do we have the whole Neanderthal genome and would it be possible to eventually bread a pure bread Neanderthal.

Since we probably made them extinct, it seems like the only ethical thing to do.

Central_Incisor

IG: We have a complete genome, but breeding an individual based on that will be a major technical feat. The ethics question of it is a different issue. It's unclear that 'we' made Neanderthals extinct, and even if modern humans did, the ethical question is left open

Hi guys, thanks for the AMA!

I have heard of the theory before, but I am consistently puzzled at how this works in practice. What I mean is, a horse and donkey can cross breed but it renders the mile sterile. Different breeds of dogs, though, can obviously mate. At what point do the family trees get too far removed for procreation, and what's a similar distance today to humans and Neanderthals?

Thanks!

Babumman

BV: The big problem for mules is that horses and donkeys have different number of chromosomes, which makes the offspring sterile. If you have the same number of chromosomes it is surprising how different animals can be and still have fertile hybrids, for example baboons and geladas diverged about 5 million years ago and they produce at least some fertile hybrids. The divergence between Neanderthals and us was much more recent than that!

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Thanks!

Babumman

Ilan: Modern humans and Neanderthals are quite similar and might not really constitute two separate biological species. Probably something like wolves and dogs that can freely interbreed. The extent to which the hybrids were nonviable or infertile is unclear. There are some signs of natural selection acting against introgression, at least in some regions of the genome. Even if natural selection did 'weed out' some hybrids, the effect was quite small

What do we know about the role that natural selection played in terms of preserving or eliminating genes that come from Neanderthals?

Medhivcellar

We know that regions of the genome of both modern humans and Neandertals that are under strong purifying selection (likely to be functional) tend to resist introgression more than other regions. This suggests that modern human and Neandertal alleles were often not compatible with each other's genetic background.

I have heard from multiple sources, from uni to TV documentaries, that a reason why Homo sapiens and Homo neadthertalis didn't "interbreed" was an assumption that they wouldn't have been attracted to each other. What is the validity to this?

It seems a ridiculous assumption/theory.

sonny_jim_

Not valid. We have now multiple evidence of interbreeding between modern humans and Neandertals 50,000-60,000 years ago and now also 100,000 years ago.

Hi does the earlier date mean more of the modern genome may be of Neanderthal origin than previously thought?

zxcvbnm9878

Ilan: Probably not because this event involved a modern human population that does not have descendants in present-day humans

Very cool research. Thanks for helping advance our collective knowledge about ourselves. Have you found that certain ethnic groups or population subsets have higher, or lower, percentages of Neandertal DNA? or does it appear to be to be relatively evenly distributed and shared throughout all humans?

seuleterre

There is now evidence for a second pulse of Neandertal gene flow into the ancestors of Asians, explaining their somewhat larger amounts of Neandertal DNA than Europeans. Most Africans do not have Neandertal DNA.

Is it possible that Neanderthal and Human mtdna so different that it caused fertility issues for human male/Neanderthal female mating pairs? I've done adna classes in grad school, but I did more on forensic anthropology with an emphasis in genetics.

Vio_

There is some evidence that fertility issues could have occurred between Neandertals and modern humans. But not of enough importance to prevent interbreeding at some low to moderate level.

Most molecular clock approaches to dating events on a phylogenetic tree require that the sequences under investigation not be subject to selection... that is all variations observed are the result of random chance. However, recently function-conferring gene variants, such as the high-altitude adaptation gene of Tibetans, have been shown have been shown to be inherited from ancient interbreeding between anatomically modern humans and ancient proto-humans (Denisovans in the case of the Tibetan gene). Since such genes have functions, and those functions in turn inform the fitness of the organisms that carry them, how valid is it to assume an absence of selection for molecular clock statistics?

Lucretius

Martin: Only a small fraction of the genome is functional, and there are many regions that are not functional. For a molecular clock, obviously you would prefer to use those non-functional regions because they should mutate in a random manner. In our study, we used supposedly neutral regions, which were outside coding genes and functional regions. It seems unlikely that those were subject to selection. But even for functional regions it will be fine if you use as many genetic regions as possible, because it will average out. The mutation rates will just be smaller. Anyway, those very strong signals of positive selection like in Tibet are extremely rare.

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Lucretius

Many analyses can be done with putatively neutrally evolving sequences that are away from genes. This is unrelated to the adaptive introgression you mention.

Bence, could you link to a good, easily digestible overview of what we currently know about how humans and other homininin species interacted more generally? It's fascinating to imagine different clans from different species trading, fighting, intermarrying, etc... and even more fascinating to speculate as to how those interactions might have influenced humans in the long term.

krwulff

BV: Hmmm. There is not much popular literature in this direction (besides novels and such). There are a few good books on Neanderthals, but a lot of them are a bit outdated - the last few years saw a lot of changes due to the ancient DNA work. One I would recommend is Steven Churchill's "Thin on the ground" from 2014. It goes into quite bit of detail but is quite understandable.

How exactly these guys interacted is a fascinating question, but the problem is that it is pretty hard to show how these interactions happened using the archaeological record. We assume that there was cultural exchange as well, as some technologies seem to spread from modern humans to

Neanderthals, but we can only identify it as a general pattern.

Isn't modern human based on the interbreeding? Why are the humans that co-existed with the neanderthals called modern humans? Does this mean the neanderthal contribution to our present-time humans traits are non-existent?

Second question: Think of a game's characters. What were the strenghts, quirks and weaknesses of the neanderthals at that time compared to modern humans?

DeafLady

They are more precisely called anatomically modern humans (look like us) compared to other anatomically archaic humans of which Neandertals and Denisovans are the closest to us.

Second question is hard at this point.

This is an amazing find! Two questions. First, how far across the spectrum of academia, and in what areas, do you think this find will have ripples?

As big a find as this is, do you believe you found the earliest case of this sexual liaison between the two comparative species? If not, how much farther in the past do you suspect these events to have initially started?

Thanks!

scrovak

We cannot rule out that earlier interbreeding happened. We think that this earlier modern human population diverged from other modern humans early in the history of modern humans in Africa. We do not know when this population left Africa, only that by 100,000 years was out and met Neandertals, possibly in the Near east.

Hi, curious if you the authors can post the paper for people not at an academic institution to read

EquationForLife

IG: You can find an open online version in http://www.readcube.com/articles/10.1038%2Fnature16544

Do we have any evidence for human DNA in Neanderthals?

What's your take on the finding of early homo sapiens evidences in southern China (~100,000 years ago. see: http://www.nature.com/nature/journal/v526/n7575/full/nature15696.html)

Spielzeugauto

BV: The paper we published last week showed exactly that - there was also gene flow from modern humans into Neanderthals. Previous studies could only show gene flow in the other direction. With regards to the earliest modern humans in China: the teeth look perfectly modern to me, but I am not completely convinced that they are really that old. I hope they will get a few more dates from the site. Having modern humans in China at 100 ka would actually be one good explanation for having DNA from modern humans in the Denisova Neanderthal!

Thank you *so* much for doing this! I am fascinated by ancient DNA.

I had a question on a somewhat related topic - the Denisovans. My understanding is that the Denisovan genome contains an unidentified admixture from a sort of mystery hominin - whose genome was very different from those of the Denisovans, Neanderthals, and Early Modern Humans. First of all, can you shed a light on the nature of this admixture? How long ago it happened, the percent of the strange genome in the Denisovans, etc? Basically, what we know about the hominin species which contributed the admixture to Denisovans?

My second question is on neanderthals themselves, and will require some speculation. How *human* were they? We know they used the same stone tools for hundreds of thousands of years without any apparent innovation. We know that they had *very* different cranial features than Early Modern Humans. But should they be a separate species? Or is it more akin to say, the difference between an Aboriginal person and a Native American?

patrice12345

BV: Sadly, we known very little about the hominin who contributed to Denisovans. All we see is that the Denisovan individual (we can only study it in one of the three, the others have insufficient DNA preservation) has some segments of its genome that are very strongly diverged from modern humans and Neanderthals, with a last common ancestor about 1 million years ago (the rest of the genome shares an LCA with modern humans about 600 ka or so ago). These segments must have introgressed from some kind of more archaic hominin then. In my opinion, the most likely candidate for this is Asian *Homo erectus*, maybe the Denisovans met them when expanding into Asia. Unless we get DNA from *Homo erectus* this will remain speculation though.

How human were Neanderthals? This is a very hard question. I think that when meeting them, we would instinctively recognize them as humans. They did go through periods of little cultural change, but so did our ancestors as well. They are genetically much more different from us than any two recent humans are, but I am not sure that we could call them a different species. If you apply the biological species concept than they wouldn't be, but using other species concepts they would be recognized as different.

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patrice12345

Indeed, the Denisovan genome contains traces from an unknown and deeply divergent hominid. This is likely to have happened after Denisovans separated from Neandertals, roughly 400,000 years ago. It is unknown when the actual gene flow happened.

The second question is unclear. We usually talk about modern and archaic humans and not species.

I read recently, and with in the comments, that geneticists have hypothesized that general atmospheroc allergies (ie. Pollen, grass, trees) might have been influenced by neanderthal genetics. What is your take on this, or what does the current reseaech indicate?

Gooder-n-Better

I have never seen evidence for this.

I've seen data that shows Neanderthal descent for European and Asian populations and none for African populations. I've also seen a paper that shows varying proportions of Neanderthal descent for North African populations.

Has any work been done on other populations like South Asian, Central Asian, Southeast Asian and Native American?

falsestprophet

Martin: Some of these populations have been included in admixture studies. Different Asian populations carry similar amounts of Neandertal DNA. Generally, Asians carry a bit more than Europeans, and also a small amount of Denisovan DNA. Native American seem to have similar amounts as Europeans.

Fascinating study! I was wondering if you could explain your procedure once you extracted the DNA from the bone a little more? I read through your methods but was still a little confused as to what you actually did with the DNA.

McBrizzles

In short, we searched for alleles and genome fragments in the Altai Neandertal that come from modern humans and dated them to rule out that they are the result of their common ancestry. Young and long modern human fragments in the Altai Neandertal genome are compatible with 'recent' admixture.

Did Neanderthals have weaker immune systems that were unable to cope with any diseases Homo sapiens might have passed on to them and could this have been a factor in their extinction?

rembilo

There is no evidence for that, but we cannot rule out that infections brought by any of the two groups played a role in their history.

I heard that everyone has a "percent" of neanderthal in them, and that certain genetic tests can determine how "neanderthal" (..or by extension, lackthereof) you are. What are your thoughts on this? Is there any scientific credibility behind these claims? What are then the implications of such findings?

Note that percent is " " because whilst I understand we share many genetic similarities, it feels like it is a slight misnomer.

idigress1337

I think they look at a number of alleles that we think came from Neandertals, but they do not look for the complete chunks of Neandertal DNA in your genome. So, it is unclear to me how accurate these tests are.

I have a science background, but genetics is my weakness. Can you explain why you examined Chromosome 21 specifically?

PhosphoErk

Obtaining DNA from fossils is very complicated. We went for the smallest chromosome as new techniques were being tested for their recovery.

If neanderthals and modern humans coexisted then how come modern human evolved while the neanderthal did not? Would they have been able to reproduce?

Causative

Martin: Every group "evolves", if you define it as having offspring and some mutations in their DNA and sometimes adapting to new environments. Neandertals did quite well for several 100,000 years in Western Eurasia, and we don't exactly know why they disappeared. Competition with humans, environmental changes, small population sizes or possibly a combination of several factors led to their extinction. Anyway, groups and whole species die out for various reasons all the time, that's part of the life.

Thank you for this AMA.

Are there any modern human populations that have a larger percentage of Neanderthal DNA than other populations?

What impact did modern humans have on Neanderthal population and society? It's clear that we might have bred with Neanderthal populations but did Neanderthals and humans have much influence on their respective development?

What is the most important factor in the demise of Neanderthals? Did humans kill them off, out compete them for resources or did they fail to adapt to a changing climate?

What are your feelings on Denisovans and how do they fit into the human tree? Do you reckon that there are many more 'homo's that we haven't discovered yet that all emerged around the same time as modern humans. Parallel branches that might have similarly developed in Africa and some that left Africa like us.

lamahorses

Yes, Asians have somewhat more than Europeans due to a likely second interbreeding of the ancestors of Asians with Neanderthals.

Second question is unclear at this time. Same for the third. I wish I knew.

Denisovans are a sister group to Neandertals. The two groups split from each other ~400,000 years ago.

Additional hominins may indeed exist. Perhaps in Asia.

Sorry if they may seem like a, well, foolish question, but I'm rather confused by the abstract. It seems the findings were that " a population that diverged early from other modern humans in Africa contributed genetically to the ancestors of Neanderthals from the Altai Mountains" In other words (and to my understanding means) **modern humans contributed to the Neandertal's genetic code. Not neceassarily Neantherthals contributed to modern human's genetic code.**

How do we then conclude that the specific tribe of Altai Neanthertals that the sample was drawn from would then "contribute(d) genetically to modern humans outside Africa 47,000–65,000 years ago?" Couldn't they have had no further contact with homo sapiens and/or have died out in isolation?

siraolo

We are saying that modern humans contributed to the ancestors of the Altai Neandertal around 100,000 years ago, probably as they moved from Europe to Asia. Conversely, we know that the ancestors of European Neandertals contributed to modern humans around 50,000 years ago.