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WHY DO SOME HUMANS HAVE NEANDERTHAL DNA?

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YOUNG REVIEWERS:


ANNA-MARIE
AGE: 15


CAROLYN
AGE: 14


NADYA
AGE: 13

Did you know that most people have about 3% Neanderthal DNA? About 40,000 years ago, ancient humans and Neanderthals had kids together. The mixing of these two species resulted in the exchange of DNA, a process that biologists call introgression. When the Neanderthals became extinct, humans could only have kids with other humans. Over time, the percentage of Neanderthal DNA diminished, but about 3% remains. The Neanderthal genes stuck around in our genomes because they are useful for us. Genes that humans received from Neanderthals play roles in different parts of the body, including the brain and the digestive system. These Neanderthal genes might have made humans smarter and sped up our adaptation to new diets. Several Neanderthal genes are also involved in the immune system and help us fight harmful viruses and bacteria. Looking back, it might have been good that our distant ancestors had kids with Neanderthals. Their genes helped our species survive to the present day.

INTRODUCTION

When you cross a lion with a tiger, you will get a liger. These big animals are generally sterile, which means they cannot have offspring. For a long time, scientists thought that offspring from crosses between different species—called **hybrids**—were always sterile. But further research revealed that some hybrids can have their own offspring. In 1943, for example, a liger had cubs with a lion in the German Hellabrunn Zoo. When hybrids interbreed with one of their parental species, such as the liger and the lion in Germany, DNA can flow from one species into the other. This process is known as **introgression** [1].

HYBRID

A cross between two different species.

INTROGRESSION

The exchange of DNA between species by means of hybridization.

Introgression explains how humans obtained some Neanderthal DNA. For a long time, humans only lived on the African savannahs. About 45,000 years ago, they left Africa and migrated into Europe, where they came into contact with another human-like species–the Neanderthals (*Homo neanderthalensis*). The Neanderthals did not look very different from humans. They were a bit sturdier, had longer arms, and had a striking brow ridge above their eyes (Figure 1A). Some humans had kids with these Neanderthals. When those kids grew up, they had kids of their own. And so on. The mixing of these two human species resulted in introgression, the exchange of DNA. Because humans and Neanderthals only had kids outside of Africa, you will not find Neanderthal DNA in present-day African people. However, in the rest of the world, people have about 3% Neanderthal DNA.

MIXING PAINTS

But why do most people only have about 3% Neanderthal DNA? The DNA of the first human-Neanderthal hybrids was 50% human and 50% Neanderthal. If these hybrids had kids with a human, the percentage of Neanderthal DNA would drop to about 25%. In the next generation, the percentage would be halved again. At some point, the Neanderthals went extinct. We still do not know exactly why. The consequence of this extinction event was that humans could only have kids with other humans. No new Neanderthal DNA could be added to the human genome, and the percentage of Neanderthal DNA diminished to the 3% we see today.

You can compare this scenario to mixing paint of two colors. Let us say you pour yellow (Neanderthal) and red (human) paint in a big bucket. The result is an orange mixture, which represents the first human-Neanderthal hybrid. When you add more red paint, the mix will become more and more red over time. In other words, the DNA becomes more and more human over time, as humans have kids with other humans.

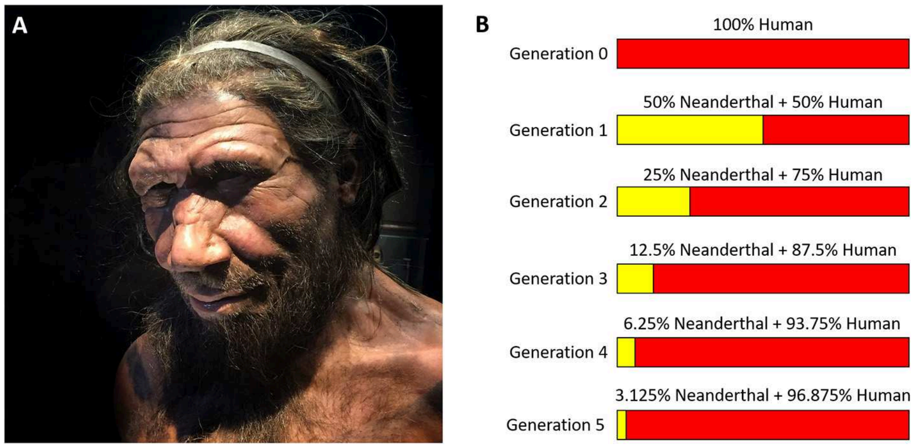

Figure 1

Figure 1

(A) A picture of a Neanderthal at the Natural History Museum in London (UK) (by Allan Henderson|CC BY 2.0 Flickr). **(B)** When a human interbred with a Neanderthal, the resulting hybrid had 50% human DNA and 50% Neanderthal DNA. If these hybrids had kids with a human, the percentage of Neanderthal DNA dropped to 25%. In each consecutive generation of having kids with a human, the percentage of Neanderthal DNA was halved and decreased as follows: 50–25–12.5–6.25–3.125.

If we do the math, we can see that we reach 3% Neanderthal DNA in about five generations of humans breeding with other humans. In each generation, the percentage of Neanderthal DNA is halved and decreases as follows: 50–25–12.5–6.25–3.125 (Figure 1B). Let us assume that one generation equals 25 years, the age at which people might have kids. Then, humans should have reached 3% Neanderthal DNA in about 125 years (5 × 25). But humans and Neanderthals mated more than 40,000 years ago! That is a big difference. The percentage of Neanderthal DNA should be much, much lower. To understand why we have not lost all Neanderthal DNA, we need to learn about another concept: adaptive introgression.

BLACK WOLVES

To understand adaptive introgression, we will travel to North America, where packs of wolves roam the forests. If you watch nature documentaries, you might have noticed that these wolves mostly have gray fur. But perceptive scientists observed that there were some wolves with darker fur. Where did that dark fur come from? The scientists studied the DNA of these wolves and discovered that the dark fur was caused by a particular variant of a gene. Surprisingly, wolves normally do not have this variant of the gene. But dogs do! Further analyses revealed that, in the past, dogs and wolves had pups together. The mixing of these two species led to the exchange of DNA, including the variant gene that gave wolves darker fur [2]. Because of this darker shade, these wolves were better camouflaged in the forest, making them better hunters. The exchange of DNA—or introgression—helped the wolves adapt to their environment. That is why this process is called adaptive introgression. Individuals with darker fur survived better than their gray friends and had more pups. These pups looked like their parents and also had darker fur. Over time, the genetic variant for darker fur became common in the population (Figure 2). Evolutionary biologists say that the dark fur trait was subject to **natural selection**.

NATURAL SELECTION

The evolutionary process by which organisms with favorable traits are more likely to reproduce. In doing so, they pass these traits on to the next generation. Over time, this process allows organisms to adapt to their environment.

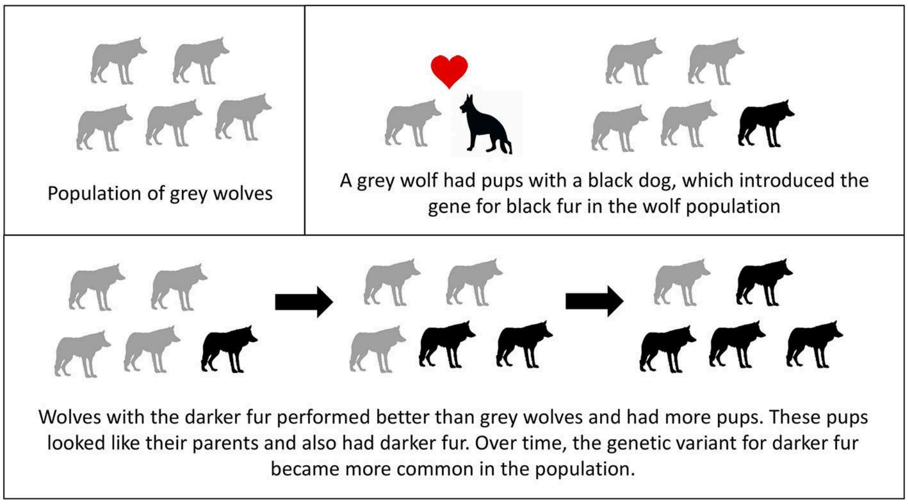

Figure 2

Figure 2

Because of hybridization with dogs, wolves acquired the genetic variant for black fur. This dark coat color made the wolves better camouflaged in the forest, and thus better hunters. Those wolves were more likely to have pups. Over time, the genetic variant for darker fur became more common in the population.

If we return to the analogy of mixing two colors of paint, you can compare a beneficial genetic variant like dark fur with a hard blob of yellow paint. No matter how much red paint you add, the yellow blob will not mix, it keeps floating around in the red mixture.

BENEFICIAL NEANDERTHAL GENES

The same adaptive introgression happened with Neanderthal DNA. Some genes turned out to be helpful for humans and did not disappear from the human DNA. The 3% Neanderthal DNA can be compared with several yellow blobs that float around in the red human-paint. What **adaptations** did these Neanderthal genes provide us? Scientists are making a catalog of all the beneficial genes we received from Neanderthals [3, 4]. Let us have a look at some of these genes. The gene microcephalin (MCPH1), for example, ensures that the development of the brain goes according to plan. Perhaps this Neanderthal gene made humans smarter and better able to survive in unexplored territories. Other Neanderthal genes, such as olfactory receptor 12D3 (OR12D3), are important for the digestion of food. Humans that arrived in Europe were confronted with all types of new food. The genes from Neanderthals helped them to adapt quickly to a new diet. Some genes might even have changed the shape of our teeth!

ADAPTATION

A trait that increases the survival and reproduction of an individual compared to other individuals in the population.

Several genes that humans received from Neanderthals also seem to play a role in the immune system, protecting us against certain diseases. These genes make proteins that search the human body for harmful bacteria and viruses. When they encounter one, they capture it and make sure it does not do any more damage to the body. This is similar to a police officer who patrols the streets looking for criminals and putting them in jail. When humans arrived in Europe, they encountered many new diseases that do not occur in Africa.

Their bodies were not familiar with these diseases and they got sick quickly. The Neanderthals, however, had coped with these diseases for thousands of years and their DNA had the right genes to fight the viruses and bacteria that caused these European diseases. When humans received Neanderthal DNA, they also got the genes to fight the new viruses and bacteria. You could say that humans got a team of police officers familiar with the criminals in the area. That made it easier to capture the criminals and put them in jail. As you can see from these examples, the Neanderthal genes in our DNA have been very helpful.

CONCLUSION

So, if you are not African, your DNA contains a dash of Neanderthal genes. These genes stuck around because they were probably beneficial for humans, helping our species survive to the present day. Looking back, it might have been good that our distant ancestors had kids with Neanderthals. And, if you think about it, Neanderthals never went extinct–they live on in the DNA of modern humans.

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CONFLICT OF INTEREST STATEMENT: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANNA-MARIE, AGE: 15

My favorite subject is biology, I like bionics. In the future I would like to work on new materials, new substances. I am curious about the mysteries of the universe, there is so much to discover.

CAROLYN, AGE: 14

I once used to dream of becoming a scientist. I was interested in animals and plants, but when I realized that I had to dissect a frog, I decided to change my future dream to an author. So now I love writing stories in clips. I still like science enough, and love the experiments that have to do with plants. I believe science is essential to saving the planet from global warming, which I am very interested in.

NADYA, AGE: 13

I love to paint and read and I want to become an art teacher when I grow up. My favorite books are the Harry Potter series. I am usually in my room painting or making jewelry. Art and science are my favorite subjects in school. It is interesting to learn about this planet and I want to make a difference in it someday.

AUTHOR

JENTE OTTENBURGHS

I obtained my Ph.D. at Wageningen University (in the Netherlands) where I studied hybridization between different goose species. Currently, I am extending this line of research as a postdoc at Uppsala University (Sweden). In my own research, I use several methods that have been developed to explore hybridization between humans and Neanderthals. I am interested in how hybridization and the consequent exchange of DNA influences the evolution of different species. On my blog Avian Hybrids I explore the role of hybridization in bird evolution. *jente.ottenburghs@ebc.uu.se