Last steps to become humans

Looking for the genetic refinement that made the difference

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Humans and other mammals are said to share an ancestor of some 80 million years ago. As various body functions are the same in all mammals, the makeup of the DNA also, to the greatest extent, is found to be the same across species. And this is especially true of the part of the DNA that codes for proteins.

A question that arises is, how much closer are we to our nearest relatives, the chimpanzees, or even the earliest, but extinct, humans, or hominids, like the Neanderthals or the Denisovans? Lucia Coppo, Pradeep Mishra, Nora Siefert, Arne Holmgren, Svante Pääbo, Hugo Zeberg, from Karolinska Institutet, Stockholm, Max Planck Institute for Evolutionary Anthropology, Leipzig and Okinawa Institute of Science and Technology, Japan, in the American Association for the Advancement of Science journal, *Science Advances*, go into a specific genetic difference between modern humans and an extinct, close evolutionary relative, and find that it may have given humans a survival advantage.

While the human genome is fully mapped, and we can do the same with chimpanzees, or other living things, it is not straightforward in the case of an extinct species. There, the genetic information must be extracted from ancient DNA that is in bits of tissue, bone or teeth, often found in fossilised remains. And this is challenging because the material in the samples is miniscule, and what is there gets contaminated, over time and in handling.

The method to deal with scarcity of DNA is to amplify what is available, using the polymerase chain reaction, or PCR, a technique that has become better known with current testing for Covid-19. And contamination, at least the part that arises during handling, can be minimised through care and special methods and procedures.

The first recovery of DNA from the remains of an extinct creature was in 1984, from a museum specimen of the ***quagga***, a zebra-like animal last seen a century earlier. A few years later, with the help of PCR, bits of DNA were recovered of 7,000-year-old soft human brain tissue, found in peat bogs in Florida.

PCR is a powerful tool, which makes it possible to work with very small traces, even in bones and teeth. The problem of contamination, some of which was by the PCR process, however, still remains. Nevertheless, with innovation, like multiple trials and statistical methods, it became possible to sequence the DNA of a 30,000 to 100,000-year-old hominid. And with still more improvements, a draft sequence of the genome of a 38,000-year-old hominid was published in 2010.

The 38,000-year-old remains were of a Neanderthal human, an extinct subspecies first identified in 1856, from bones discovered in a limestone cave in Neandertal, a small valley in North Rhine-Westphalia, Germany. The bones were recognised as different from those of modern humans, but it took half a century before the Neanderthals were considered a legitimate species.

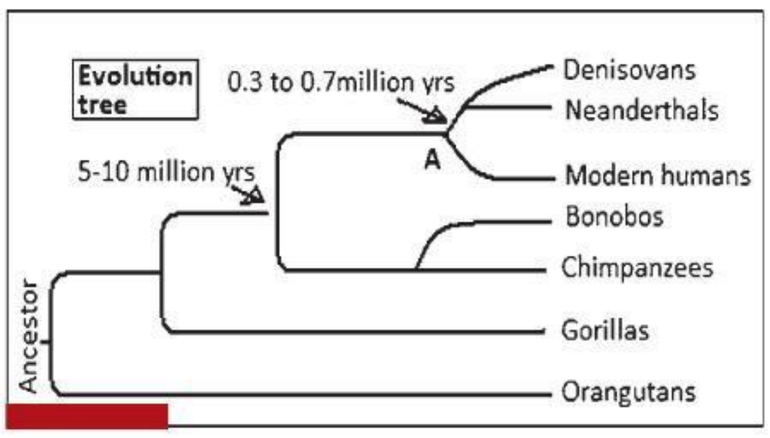
Another strain of early human forerunners were the Denisovans, so named after the discovery of ancient remains in the Siberian Denisova cave. The bones found were of a young female and DNA was extracted from a finger bone, as recently as 2010. The Denisovan DNA compares well with the Neanderthal and it appears that Neanderthals also inhabited the cave, but it is not clear if the two streams met and interbred.

"Neanderthals and Denisovans, so-called 'archaic' humans, shared an ancestral population with the ancestors of modern humans about half a million years ago," the paper in *Science Advances* says. This would be the point, A, in the diagram, where modern humans separated. And, as parts of the DNA of the Neanderthals and Denisovans have been accurately sequenced, it is possible to "identify the changes that characterise modern humans", the paper says.

Genetic change consists of accidental changes in the structure of units of the DNA. These units, the nucleotides, are of four kinds, the difference being which of four "bases" -- A, C, T or G -- the nucleotide contains. Along the lineage leading to humans, we know of about a hundred instances, where the base in one of the units has been changed, which are in the DNA of most humans, but not in the known DNA portions of Neanderthals and Denisovans, the paper says.

While Neanderthals and Denisovans arose in Europe and Asia, the line that has come down as humans originated in Africa. This line migrated out of Africa and became dominant. When the line left Africa and encountered Neanderthals, the paper says, there was interbreeding, and some Neanderthal DNA variants were introduced into the human gene pool. And these markers of contact with Neanderthals can be detected to this day, the paper says.

A challenge faced by oxygen-dependent organisms, like mammals, is to overcome cell damage by a reactive form of oxygen. The way animals down the evolutionary chain have managed is with the help of the antioxidant glutathione. Glutathione consumes reactive oxygen, which saves important cell components. And then, it is recycled, with the help of an enzyme, glutathione reductase, or GR.



And one of the 100-odd genetic differences between humans and Neanderthals, the paper says, is one that affects the form of GR. The variant in most humans has the amino acid, glycine, in the sequence, but the Neanderthals have the amino acid, serine in place of glycine. And as a result of the gene flow from Neanderthals to humans, the Neanderthal form, or the ancestral form, of GR is found in a small proportion of humans, one to two per cent in the Indian subcontinent and much less in Europe, the paper says.

Analysis shows, the authors say, that the ancestral form of GR is associated with disease of the circulatory system and with irritable bowel syndrome, or IBD. Both conditions are associated with oxidative stress -- overproduction of reactive oxygen causes inflammation of blood vessel membrane and reduced availability of glutathione is a characteristic of IBD, the paper says. And further, GR is found in many parts of the body and oxidative stress is the reason for other diseases too. The modern, human form of GR may hence play a protective role in more areas than the two that have been identified.

It is possible, the paper says, that this difference in the form of GR gave humans an advantage, which enabled them to dominate, while the so-called archaic humans went extinct.

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PLUS POINTS

Dark origin

Researchers from the Indian Institute of Technology-Guwahati have found distinctive similarities between the nature of dark matter and neutrinos.

In the endeavour to unfold the nature of dark matter, a trio of theoretical physicists, professor of physics Arunansu Sil and two of his PhD students Arghyajit Datta and Rishav Roshan from the physics department of IIT-Guwahati, found that the origin and production of dark matter can actually be connected to the origin of neutrino mass. The work has recently been published in the journal, *Physical Review Letters*.

For decades, physicists have speculated about the presence of dark matter in our universe. Though its existence is inferred from its gravitational effect on visible matter, supposed to make up 27 per cent of the universe, very little is known about it. At the same time, among all the known particles in nature, neutrinos are perhaps the most elusive. There are three flavours of neutrinos according to the Standard Model of particle physics, the immensely successful theoretical framework describing matter and interactions in nature.

Highlighting the unique aspect of their work, Sil said, "Although strongly hinted at by several astrophysical observations, the lack of any direct evidence of dark matter particles suggests that it has a very feeble interaction with ordinary matter. Our proposal provides a clue to such a miniature interaction by showing that its smallness is connected to the lightness of the neutrino mass (smallest one) which is uniquely predicted to be in the pico electron-volt range."

Covid 19 research

Researchers have identified abnormalities in the lungs of Long Covid patients who are experiencing breathlessness that cannot be detected with routine tests.

The Explain study, which involves teams at the United Kingdom's Universities of Sheffield, Oxford, Cardiff and Manchester, is using hyperpolarised xenon magnetic resonance imaging, or MRI, scans to investigate possible lung damage in Long Covid patients who have not been hospitalised with the disease but who continue to experience breathlessness.

The study, which received British government funding in 2021, is supported by the National Institute for Health Research Oxford Biomedical Research Centre. The findings were published on the *medRxiv* pre-print server.

Hyperpolarised xenon MRI is a safe scanning test that requires the patient to lie in the MRI scanner and breathe in one litre of the inert gas xenon that has been hyperpolarised so that it can be seen using MRI. As xenon behaves in a very similar way to oxygen, radiologists can observe how the gas moves from the lungs into the bloodstream. The scan takes just a few minutes and, as it does not require radiation exposure, it can be repeated over time to see changes to the lungs.

While the full Explain study will recruit around 400 participants, this initial pilot had 36 people taking part, consisting of three groups,

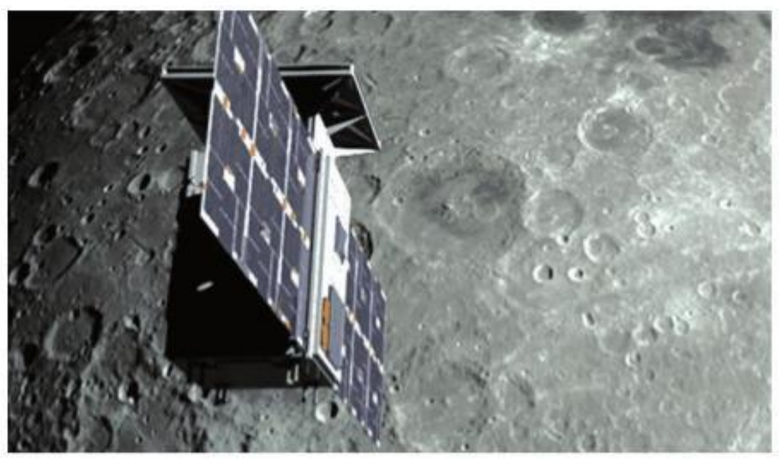
- Patients diagnosed with Long Covid, who have been seen in Long Covid clinics and who have normal computerised tomography, or CT, scans.
- People who've been in hospital with Covid and discharged more than three months previously, who have normal or nearly normal CT scans and who are not experiencing Long Covid.
- An age- and gender-matched control group who do not have Long Covid symptoms and who have not been hospitalised with Covid-19.

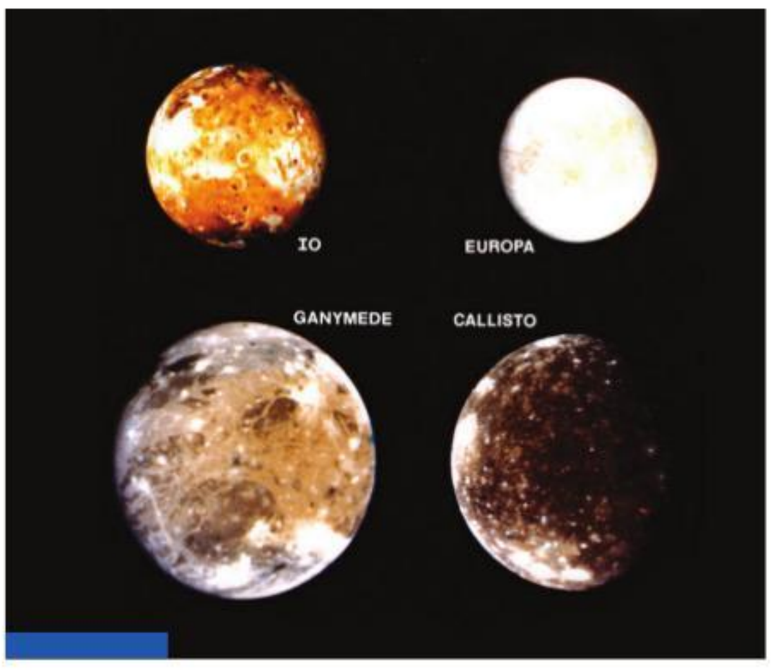
These initial results show that there is "significantly impaired gas transfer" from the lungs to the bloodstream in these Long Covid patients when other tests are normal.

The method, development and clinical applications of hyperpolarised xenon MRI was pioneered by professor Jim Wild and the Pulmonary, Lung and Respiratory Imaging Sheffield research group at the University of Sheffield, U K.

JOURNEYING INTO SPACE & TIME

This year may be humanity's busiest ever in the history of spaceflight





Space travel is all about momentum. Rockets turn their fuel into momentum that carries people, satellites and science itself forward into space. Last year was full of records for space programmes around the world, and that momentum is carrying forward into 2022.

In 2021, the commercial space race truly took off. Richard Branson and Amazon founder Jeff Bezos both rode on suborbital launches -- and brought friends, including actor William Shatner. SpaceX sent eight astronauts and one ton of supplies to the International Space Station for the National Aeronautics and Space Administration, or Nasa.

The six tourist space flights in 2021 were a record. There were also a record 19 people weightless in space for a short time in December, eight of them private citizens. Finally, Mars was also busier than ever thanks to missions from the United States, China and United Arab Emirates sending rovers, probes or orbiters to the red planet.

In total, in 2021 there were 134 launches that put humans or satellites into orbit -- the highest number in the entire history of spaceflight. Nearly 200 orbital launches are scheduled for 2022. If things go well, this will smash last year's record.

I'm an astronomer who studies supermassive black holes and distant galaxies. I have also written a book about humanity's future in space. There's a lot to look forward to in 2022. The Moon will get more attention than it has had in decades, as will Jupiter. The largest rocket ever built will make its first flight. And of course, the James Webb Space Telescope will start sending back its first images.

I, for one, can't wait.

Everyone's going to the Moon

Getting a rocket into orbit around Earth is a technical achievement, but it's only equivalent to a half a day's drive straight up. Fifty years after the last person stood on Earth's closest neighbour, 2022 will see a crowded slate of lunar missions.

Nasa will finally debut its much-delayed Space Launch System. This rocket is taller than the Statue of Liberty and produces more thrust than the mighty Saturn V. The Artemis I mission will head off this spring for a flyby of the Moon. It's a proof of concept for a rocket system that will one day let people live and work off-Earth. The immediate goal is to put astronauts back on the Moon by 2025. Nasa is also working to develop the infrastructure for a lunar base, and it's partnering with private companies on science missions to the Moon. A company called Astrobotic will carry 11 payloads to a large crater on the near side of the Moon, including two mini-rovers and a package of personal mementos gathered from the general public by a company based in Germany.

The Astrobotic lander will also be carrying the cremated remains of science fiction legend Arthur C Clarke -- as with Shatner's flight into space, it's an example of science fiction turned into fact. Another company, Intuitive Machines, plans two trips to the Moon in 2022, carrying 10 payloads that include a lunar hopper and an ice mining experiment.

Russia is getting in on the lunar act, too. The Soviet Union accomplished many lunar firsts -- first spacecraft to hit the surface in 1959, first spacecraft to soft-land in 1966 and the first lunar rover in 1970 -- but Russia hasn't been back for over 45 years. In 2022, it plans to send the Luna 25 lander to the Moon's south pole to drill for ice. Frozen water is an essential requirement for any Moon base.

All aboard the Starship

While Nasa's Space Launch System will be a big step up for the agency, Elon Musk's new rocket promises to be the king of the skies in 2022. The SpaceX Starship -- the most powerful rocket ever launched -- will get its first orbital launch in 2022. It's fully reusable, has more than twice the thrust of the Saturn V rocket and can carry 100 tons into orbit. The massive rocket is central to Musk's aspirations to create a self-sustaining base on the Moon and, eventually, a city on Mars.

Part of what makes Starship so important is how cheap it will make bringing things into space. If successful, the price of each flight will be $ (United States) two million. By contrast, the price for Nasa to launch the Space Launch System is likely to be over $ (U S) two billion. The reduction in costs by a factor of a thousand will be a game-changer for the economics of space travel.

Jupiter beckons

The Moon and Mars aren't the only celestial bodies getting attention next year. After decades of neglect, Jupiter will finally get some love, too.

The European Space Agency's Icy Moons Explorer is scheduled to head off to the gas giant midyear. Once there, it will spend three years studying three of Jupiter's moons -- Ganymede, Europa and Callisto. These moons are all thought to have subsurface liquid water, making them potentially habitable environments. Additionally, in September 2022, Nasa's Juno spacecraft -- which has been orbiting Jupiter since 2016 -- is going to swoop within 350 kilometres of Europa, the closest-ever look at this fascinating moon. Its instruments will measure the thickness of the ice shell, which covers an ocean of liquid water.

Seeing first light

All this action in the Solar System is exciting, but 2022 will also see new information from the edge of space and the dawn of time.

After successfully reaching its final destination, unfurling its solar panels and unfolding its mirrors in January, Nasa's James Webb Space Telescope will undergo exhaustive testing and return its first data sometime midyear.

The 21-foot telescope has seven times the collecting area of the Hubble Space Telescope. It also operates at longer wavelengths of light than Hubble, so it can see distant galaxies whose light has been redshifted -- stretched to longer wavelengths -- by the expansion of the universe.

By the end of the year, scientists should be getting results from a project aiming to map the earliest structures in the universe and see the dawn of galaxy formation. The light these structures gave off was some of the very first light in history and was emitted when the universe was only five per cent of its current age.

When astronomers look out in space they look back in time. First light marks the limit of what humanity can see of the universe. Prepare to be a time traveller in 2022.

The writer is University Distinguished professor of astronomy, University of Arizona, United States. This article first appeared on www.theconversation.com