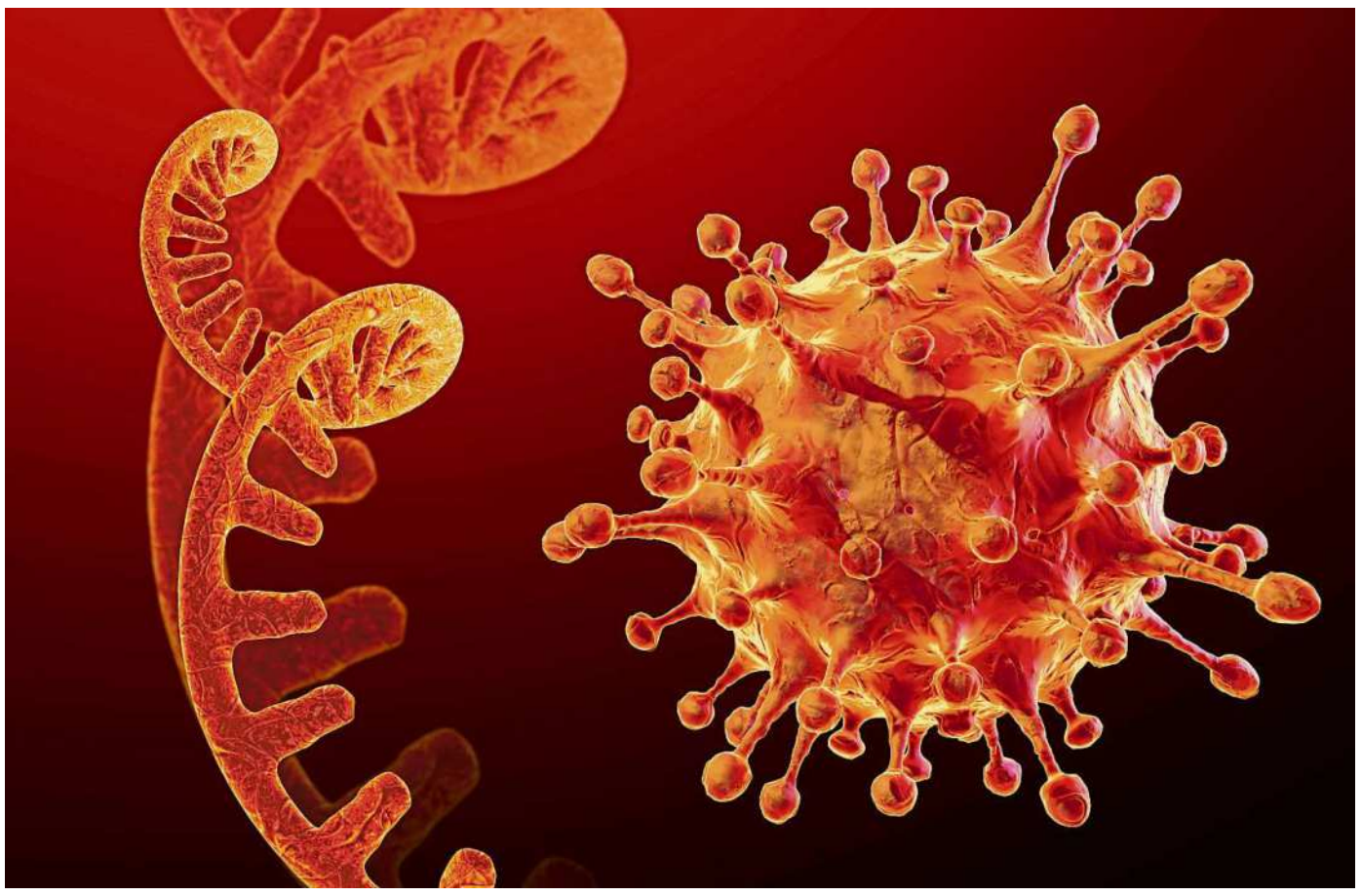
A coronavirus epidemic from 20,000 years ago

An epidemic that swept East Asia was devastating enough to leave an evolutionary imprint on the DNA of those who are alive today, writes Carl Zimmer



Researchers have found evidence that a coronavirus epidemic swept East Asia some 20,000 years ago and was devastating enough to leave an evolutionary imprint on the DNA of people alive today.

The new study suggests that an ancient coronavirus plagued the region for many years. "It should make us worry," said David Enard, an evolutionary biologist at the University of Arizona in USA who led the study, which was published in *Current Biology* recently. "What is going on right now might be going on for generations and generations."

Until now, researchers could not look back very far into the history of this family of pathogens. Over the past 20 years, three coronaviruses have adapted to infect humans and cause severe respiratory disease: Covid-19, SARS and MERS. Studies on each of these coronaviruses indicate that they jumped into our species from bats or other mammals.

Four other coronaviruses can also infect people, but they usually cause only mild colds. Scientists did not directly observe these coronaviruses becoming human pathogens, so they have relied on indirect clues to estimate when the jumps happened. Coronaviruses gain new mutations at a roughly regular rate, and so comparing their genetic variation makes it possible to determine when they diverged from a common ancestor.

The most recent of these mild coronaviruses, called HCoV-HKU1, crossed the species barrier in the 1950s. The oldest, called HCoV-NL63, may date back as far as 820 years.

But before that point, the coronavirus trail went cold — until Enard and his colleagues applied a new method to the search. Instead of looking at the genes of the coronaviruses, the researchers looked at the effects on the DNA of their human hosts.

Studying DNA

Over generations, viruses drive enormous amounts of change in the human genome. A mutation that protects against a viral infection may well mean the difference between life and death, and it will be passed down to offspring. A lifesaving mutation, for example, might allow people to chop apart a virus's proteins.

But viruses can evolve, too. Their proteins can change shape to overcome a host's defences. And those changes might spur the host to evolve even more counteroffensives, leading to more mutations.

When a random new mutation happens to provide resistance to a virus, it can swiftly become more common from one generation to the next. And other versions of that gene, in turn, become rarer. So if one version of a gene dominates all others in large groups of people, scientists know that is most likely a signature of rapid evolution in the past.

In recent years, Enard and his colleagues have searched the human genome for these patterns of genetic variation in order to reconstruct the history of an array of viruses. When the pandemic struck, he wondered whether ancient coronaviruses had left a distinctive mark of their own.

He and his colleagues compared the DNA of thousands of people across 26 different populations around the world, looking at a combination of genes known to be crucial for coronaviruses but not other kinds of pathogens. In East Asian populations, the scientists found that 42 of these genes had a dominant version. That was a strong signal that people in East Asia had adapted to an ancient coronavirus.

Limited to East Asia

Whatever happened in East Asia seemed to have been limited to that region. "When we compared them to populations around the world, we couldn't find the signal," said Yassine Souilmi, a postdoctoral researcher at the University of Adelaide in Australia and a co-author of the study.

The scientists then tried to estimate how long ago East Asians had adapted to a coronavirus. They took advantage of the fact that once a dominant version of a gene starts being passed down through the generations, it can gain harmless random mutations. As more time passes, more of those mutations accumulate.

Enard and his colleagues found that all the 42 genes had about the same number of mutations. That meant that they had all rapidly evolved at about the same time. "This is a signal we should absolutely not expect by chance," Enard said.

They estimated that all of those genes evolved their antiviral mutations sometime between 20,000 and 25,000 years ago, most likely over the course of a few centuries. It's a surprising finding, since East Asians at the time were not living in dense communities but instead formed small bands of hunter-gatherers.

Aida Andres, an evolutionary geneticist at the University College London who was not involved in the study, said she found the work compelling. "I'm quite convinced there's something there," she said.

Still, she didn't think it was possible yet to make a firm estimate of how long ago the ancient epidemic took place. "The timing is a complicated thing," she said. "Whether that happened a few thousand years before or after — I personally think it's something that we cannot be as confident of."

Scientists looking for drugs to fight the new coronavirus might want to scrutinise the 42 genes that evolved in response to the ancient epidemic, Souilmi said. "It's actually pointing us to molecular knobs to adjust the immune response to the virus," he said.

Anders agreed, saying that the genes identified in the new study should get special attention as targets for drugs. "You know that they're important," she said. "That's the nice thing about evolution."

The New York Times

EVOLUTION OF RAINFALL

Human impact on monsoon could exceed natural changes

AKHIL KADIDAL

Asian monsoons impact the lives of more than a third of humanity. A new study has found that the human impact on monsoonal rainfall could exceed the changes wrought naturally over the last 30 million years.

Scientists said that this is because of the important influence of CO_2 on the strength of the monsoon.

The study, which was conducted by a large cross-section of researchers from The Open University (OU) in the United Kingdom, found that East Asian and Indian monsoon rainfall amounts have evolved in response to tectonic and climate influences millions of years ago.

One surprising finding was the overturning of a widely-held assumption that the Indian monsoon is almost entirely the result of the uplift of Tibet and the Himalayas.

The study provides a strong indication that the rise of these mountains is only one of several important factors, explained Professor Nigel Harris, Professor Emeritus, OU, and an expert in tectonics. "For example, the impact of closing the Panama gateway on the Indian monsoon is a fascinating example of how elements of the Earth's climate may be influenced by factors many thousands of miles away," he said. The Panama gateway refers to the water connection between Pacific and Atlantic oceans which was open millions of years ago but is not any longer.

Researchers found that the Indian monsoon rainfall amount, in particular, has been sensitive to a complex mix of drivers in the past, particularly CO_2 and ice sheets changes.

The findings were made after researchers modelled the evolution of Asian monsoon rainfall over the last 30 million years, considering the effects of Himalayan-Tibetan growth, evolving atmospheric CO_2, the growth and decay of continental ice sheets, changes to ocean circulation due to shifting continental plates, and changes to Earth's orbit.

Large-scale study

"The study used a quarter of a million data points of changes to the major climate drivers over the last 30 million years to calculate how monsoon rainfall has varied. This was done separately for India and South-East Asia," explained Dr James R Thomson, a freelance engineering consultant involved in the project. "The achieved level of detail of rainfall changes has never been possible before. The results aid judgments about the future effects of rising CO_2 levels."

The researchers said that although these different drivers have all been modelled separately before, it has never been possible to study how they work together because of the huge computing requirements.

"We used a statistical approach called emulation to get around this," said Dr Phil Holden, senior lecturer in Earth System Science, OU. "The new study considers eight 'forcing factors' together using a few hundred simulations with a low-resolution ocean-atmosphere General Circulation Model to derive statistical models for the Indian and South-East Asian monsoons. These models were applied to reconstruct rainfall for the past 30 million years at exceptionally high temporal resolution (over 1000 year segments) and to quantify the relative significance of the different drivers in controlling annual rainfall which is dominant in summer months."

Dr Anand added that further validation of findings that the ice-sheet and CO_2 have competing effects on Indian monsoon rainfall is needed through proxy-based rainfall reconstructions during the Pliocene and Miocene. "To study these geological time intervals, continuous sediment archives such as long cores obtained from the International Ocean Discovery Programme are necessary," she said.

The OU-led project is the first detailed evaluation of tectonic and climatic influences of Asian monsoon rainfall. The paper, Tectonic and climatic drivers of the Asian monsoon evolution, was published in *Nature Communications* on June 29.

DID YOU KNOW?

7 things to know about asteroids

Asteroids are relics from the time the solar system was born

Billions of years ago, when the solar system was forming, space dust and debris fused to form rocks and rubble. As the rocks churned, they rammed into one another, merged and formed planets and moons. Asteroids are the leftover rubble from those times. They have remained unchanged over billions of years.

There are millions of asteroids in the solar system

Once Jupiter formed, its massive gravity held the remaining millions of space rocks captive and prevented them from forming more planetary bodies between Mars and itself. These rubble remnants in their pristine forms make up a rocky world — the Asteroid Belt— in the vast expanse between Mars and Jupiter. These millions of asteroids are of varying sizes and circle the sun in wide elliptical orbits.

Asteroids can have moons, rings and tails

Asteroids are just specks of space dust and rubble, are tiny in size and hence have a weak gravity. However, when a smaller rock comes in the periphery of a larger one, it gets pulled by the bigger one and becomes its moon. In 2013, scientists observed that an asteroid could also have rings, which are nothing but a stream of dust particles circling the asteroid. Also, sometimes two or more small asteroids fuse to form a tail-like extension to the asteroid.

They are odd-shaped masses

The rocky mass and weak gravity make asteroids irregularly shaped, varying between 2m to 1000m in size. Most of them are covered by a layer of dust. They cannot hold an atmosphere, and their average surface temperature is around -70 degrees Celsius.

Asteroids are rich in minerals and water

Asteroids are rich sources of carbon, silica and metals. Some have water-ice trapped in the rubble mass. Astronomers conjecture that when the asteroids frequently collided with planets in the early days, they delivered some of these vital elements to the planets. They believe life processes on earth could have kickstarted this way with carbon deposits. Humans are exploring asteroids aggressively with an intent to mine asteroids' mineral repositories. Some probes are on their way back to earth with asteroid rock samples for scrutiny.

Asteroids have water gullies

In 2015, scientists observed water trails called gullies on the asteroid Vesta. When a small asteroid collides with a bigger one, the impact melts the trapped water ice in the smaller asteroid, trickling on the bigger asteroid, leaving a water trail in the rocks.

Research Matters

SNIPPETS

New type of 'Homo' discovered

Researchers from Tel Aviv University and the Hebrew University of Jerusalem have identified a new type of early human at the Nesher Ramla site, dated to 140,000 to 120,000 years ago. According to the researchers, the morphology of the Nesher Ramla humans shares features with both Neanderthals (especially the teeth and jaws) and archaic Homo (specifically the skull). At the same time, this type of Homo is very unlike modern humans — displaying a completely different skull structure, no chin, and very large teeth. Researchers believe that the Nesher Ramla Homo type is the 'source' population from which most humans of the Middle Pleistocene developed.

Israel Hershkovitz, a professor said that the discovery of a new type of Homo is of great scientific importance. "It enables us to make new sense of previously found human fossils, add another piece to the puzzle of human evolution. The Nesher Ramla people can tell us a fascinating tale, revealing a great deal about their descendants' evolution and way of life," he said.

The important human fossil was found by Dr Zaidner of the Hebrew University during excavations at a Nesher Ramla prehistoric site.

ScienceDaily

A 'quantum compass' for birds

Scientists could be a step closer to understanding how some birds might exploit quantum physics to navigate.

Researchers suspect that some songbirds use a "quantum compass" that senses the Earth's magnetic field, helping them tell north from south during their annual migrations. New measurements support the idea that a protein in birds' eyes called cryptochrome 4, or CRY4, could serve as a magnetic sensor. If the idea is shown to be correct, it would be a step forward for biophysicists who want to understand how and when quantum principles can become important in various biological processes.

In laboratory experiments, the type of CRY4 in retinas of European robins responded to magnetic fields, researchers report in *Nature*.

Scientists think that the magnetic sensing abilities of CRY4 are initiated when blue light hits the protein. That light sets off a series of reactions that shuttle around an electron, resulting in two unpaired electrons in different parts of the protein. Those lone electrons behave like tiny magnets.

ScienceNews

Mongooses live in a fair society

Certain human problems are common among other social animals. The banded mongoose has come up with some never-seen-before solutions. New research reveals mongooses have evolved a unique way of reducing the risk that some members of the pack start life unfairly disadvantaged.

Banded mongooses have developed a pattern where an average of five members give birth on the same night, known as birth synchrony. This probably originated to make it easier for males to guard the whole litter at once, while the new mothers go out to feed, preventing adults from killing others' pups. However, it has had the intriguing consequence that mothers don't exclusively suckle their own young, instead, they care for pups communally.

"Mothers don't know which pups are their own, and therefore cannot choose to give them extra care," explained Dr Harry Marshall of the University of Roehampton. "Our study shows that this ignorance leads to a fairer allocation of resources."

As reported in *Nature Communications*, Marshall and the University of Exeter's Professor Michael Cant conducted an experiment on seven groups of mongooses.

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