Extreme weather as the architect

Down the ages, rooftop design styles in China have reflected climate change

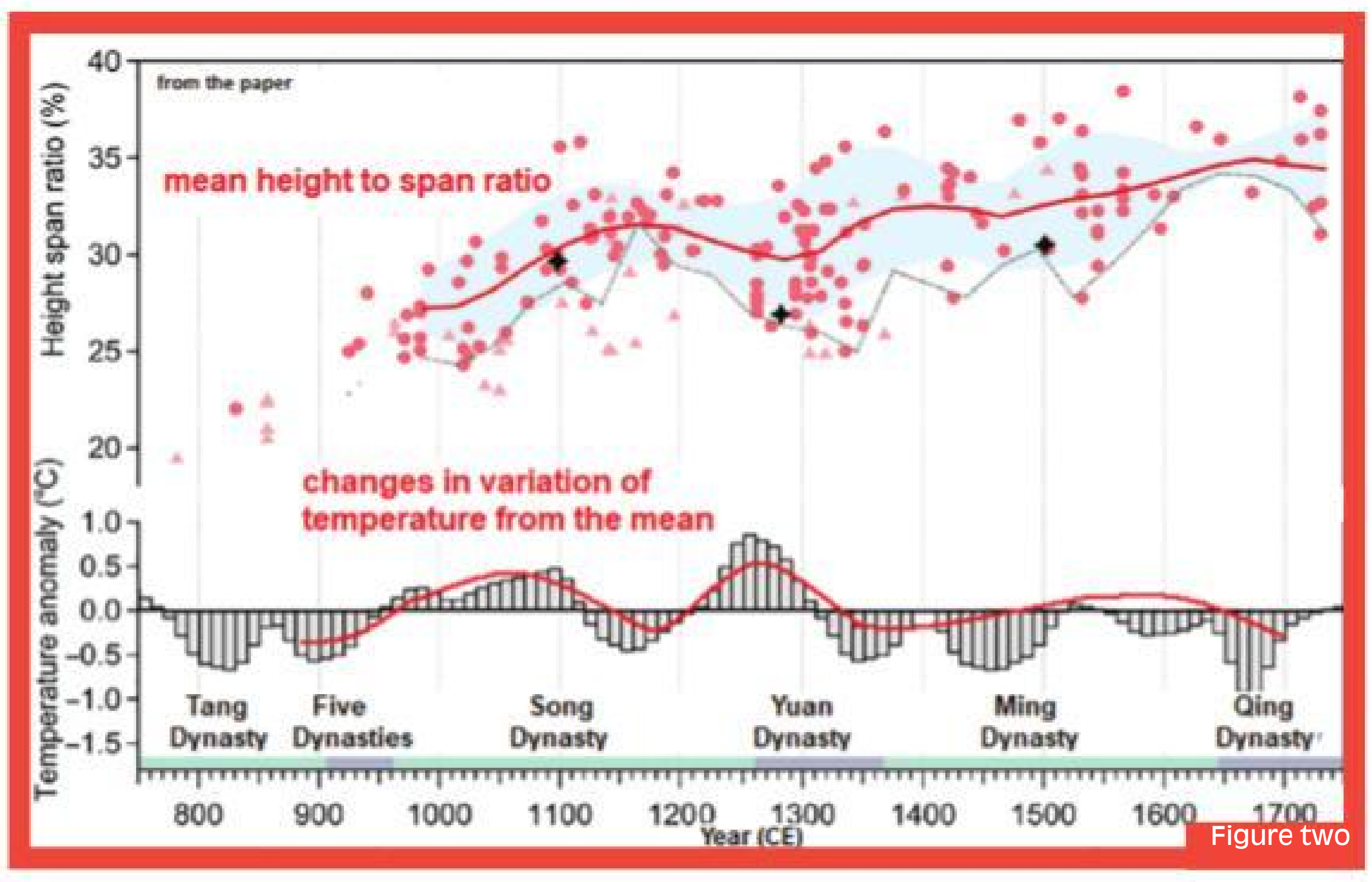

Figure two

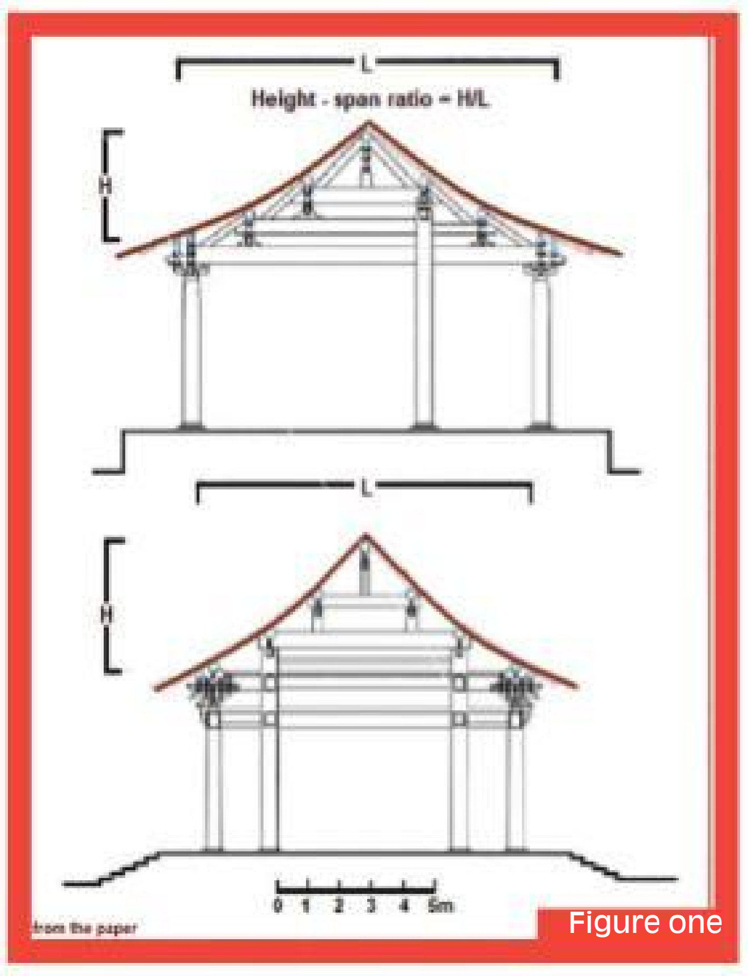

Figure one

S ANANTHANARAYANAN

Meteorological records have been kept for barely a century. In respect of earlier times, there is sporadic rainfall data, tax records show how good crops were and harbours recorded sea levels. The remaining signs of past climate are only the rates of tree growth, or the stalagmite precipitation in caves.

Siyang Li, Ke Ding, Aijun Ding, Lejun He, Xin Huang, Quansheng Ge, Congbin Fu, from Nanjing University and the Collaborative Innovative Centre for Climate Change, Nanjing, and the Chinese Academy of Science, Beijing, write in the American Association for the Advancement of Science journal, *Science Advances*, of the design of rooftops in China, down the ages, as another indicator of changes in snowfall. Apart from being one more instrument in the climate scientist's toolbox, it could bring the spotlight on architecture as a means to tackle the climate challenge we face today.

Climate, while shaping the geology of regions, has also influenced the growth of human settlements and cities. Indeed, climate change has affected commerce and industry, and led to the downfall of dynasties. The current study in *Science Advances*, the authors say, is the first enquiry into how architecture proves to be a record of the climate in parts of Central and Eastern China.

"…although meteorological factors are widely considered in modern architecture design, it remains unclear whether and how ancient people adapted to climate change from the perspective of architecture design, particularly on a millennium time scale," the paper says. The study, however, reveals "a positive trend in roof slope of traditional buildings," and "demonstrates climate change adaptation in traditional Chinese architecture, driven by fluctuations in extreme snowfall events over the past thousand years."

The authors consider remains of structures in the northern part of Central and Eastern China. Across the period from the second part of the Tang dynasty (618-905 CE) to the middle of the Qing dynasty (1644-1912), or about a thousand years, the region, which is full of traditional Chinese culture, provides a time-series of abundant instances for study, the paper says.

The region is a semi-humid area and the climate is sensitively affected by several factors, which include the summer and winter monsoons, the cold-dry air from the North-west and warm-wet air from the South-east. As a result, conditions in the region respond sharply to climatic fluctuations, which would bring out emphatically the effects of climate change on social life, and hence on architecture, the paper says.

The sloping and curved roofs, a distinctive feature of traditional Chinese architecture, are based on underlying traditions of the beam structure used in construction. Hence, although there would be differences according to social hierarchy and aesthetics, the basic form would be maintained. And so, they are, in China, the paper says, since prehistoric times to the present. Despite this constant basic form, however, there have been significant modifications from time to time, and those, the paper says, are revealing of particular aspects of the periods.

The paper explains that the sloping structure has to do with the function of roofs to protect the dwelling from snow. The cost of the structure depends both on the load of snow the roof must bear, and the material used in building a steep slope. Roofs that face lighter snowfall can make do with a shallow slope, but if there is heavy snowfall, the snow needs to slide off before it builds up. The slope hence needs to be steeper. As a steeper slope costs more, it would be provided only where snowfall is expected to be heavy. Figure one shows two forms of the roof, one where the height to span ratio, or HSR, is low and the other with a steeper slope.

The intensity of snowfall during the period between 950 and 1750 CE was estimated using a combination of data and statistical methods. One step in the estimation was to use the available, current data to estimate the relationship between snowfall levels and variation from the mean temperature, at the relevant spots in China. And, as the topography of the region has not changed, it is considered that the relationship in past centuries would be the same as at present.

Next, the temperature data for the past period was accessed from a published study based on historical data and statistical analysis. The data is of plant and animal cycles affected by cold/warm events, and analysis links the data with available temperature information, to project temperatures where other data is not available. Such projections, which have been cross verified, are fine-grained and show variations across periods as narrow as 10-30 years. By combining that information with the current relationship between temperature and snowfall, it has been possible to arrive at the ancient snowfall intensity with the same 10-30-year resolution.

That done, the data of snowfall over the centuries was compared with the roof slope of some 200 remains of structures in the region of the study. And it was found that the HSR, or the measure of how steep the slope of the roof was, clearly increased or fell, in step with the rise and fall of the intensity of snowfall.

Figure two shows the rise and fall of steepness of the slope, and the rise and fall of the difference in temperature from the mean, over the period from 950 to 1750 CE. And we can see that both measures vary in the same way. In cold periods, the paper says, "Roofs became steeper (1100-1200 CE and 1300-1750 CE, which corresponds to the "Little Ice Age"), whereas, in warm periods, the roof pitch descended notably (1200-1300 CE, which corresponds to the "Medieval Warm Period" in Europe)." The paper points out that the roof slope lags the snowfall by 30 years, as it takes some time for construction methods to adapt to changes in severity of the winter.

"The responses of roof modification to the climatic fluctuations indicate an intelligent long-term adaptive behaviour of the ancient Chinese. They adjusted their buildings for a more stable and suitable roof formation when faced with various weather extremes caused by climate change," the paper says. The data we have of roof architecture is more exact than the estimates of temperature that we have made. The exact HSR information can hence be used to refine the quality of temperature data, and in turn, sources of that data.

The study underlines the need, the paper says, for architects to consider the rapid climate change and frequency of extreme events that we now face. Designs hence need to be both sustainable as well as future-proof, as we may not have 30-year margins to adapt.

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LOOKING AT THE ENDS OF THE UNIVERSE

An astronomer on the James Webb Space Telescope team explains how to send a giant telescope to space, and why

MARCIA RIEKE

The James Webb Space Telescope is scheduled to head to space on 18 December this year. With it, astronomers hope to find the first galaxies to form in the universe, will search for Earth-like atmospheres around other planets and accomplish many other scientific goals.

I am an astronomer and the principal investigator for the Near Infrared Camera — or Nircam for short — aboard the Webb telescope. I have participated in the development and testing for both my camera and the telescope as a whole.

To see deep into the universe, the telescope has a very large mirror and must be kept extremely cold. But getting a fragile piece of equipment like this to space is no simple task. There have been many challenges my colleagues and I have had to overcome to design, test and soon launch and align the most powerful space telescope ever built.

Young galaxies & alien atmospheres

The Webb telescope has a mirror over 20 feet across, a tennis-court sized sunshade to block solar radiation and four separate camera and sensor systems to collect the data.

It works kind of like a satellite dish. Light from a star or galaxy will enter the mouth of the telescope and bounce off the primary mirror toward the four sensors — Nircam, which takes images in the near infrared; the Near Infrared Spectrograph, which can split the light from a selection of sources into their constituent colours and measures the strength of each; the Mid-Infrared Instrument, which takes images and measures wavelengths in the middle infrared; and the Near Infrared Imaging Slitless Spectrograph, which splits and measures the light of anything scientists point the satellite at.

This design will allow scientists to study how stars form in the Milky Way and the atmospheres of planets outside the Solar System. It may even be possible to figure out the composition of those atmospheres.

Ever since Edwin Hubble proved that distant galaxies are just like the Milky Way, astronomers have asked: how old are the oldest galaxies? How did they first form? And how have they changed over time? The Webb telescope was originally dubbed the "First Light Machine" because it is designed to answer those very questions.

One of the main goals of the telescope is to study distant galaxies close to the edge of the observable universe. It takes billions of years for light from those galaxies to cross the universe and reach Earth. I estimate that images my colleagues and I will collect with Nircam could show protogalaxies that formed a mere 300 million years after the Big Bang — when they were just two per cent of their current age.

Finding the first aggregations of stars that formed after the Big Bang is a daunting task for a simple reason: These protogalaxies are very far away and so appear to be very faint.

Webb's mirror is made of 18 separate segments and can collect more than six times as much light as the Hubble Space Telescope mirror. Distant objects also appear to be very small, so the telescope must be able to focus the light as tightly as possible.

The telescope also has to cope with another complication — since the universe is expanding, the galaxies that scientists will study with the Webb telescope are moving away from Earth, and the Doppler effect comes into play. Just like the pitch of an ambulance's siren shifts down and becomes deeper when it passes and starts moving away from you, the wavelength of light from distant galaxies shifts down from visible to infrared light.

Webb detects infrared light — it is essentially a giant heat telescope. To "see" faint galaxies in infrared light, the telescope needs to be exceptionally cold or else all it would see would be its own infrared radiation. This is where the heat shield comes in. The shield is made of a thin plastic coated with aluminium. It is five layers thick and measures 46.5 feet by 69.5 feet and will keep the mirror and sensors at minus 234o Celsius.

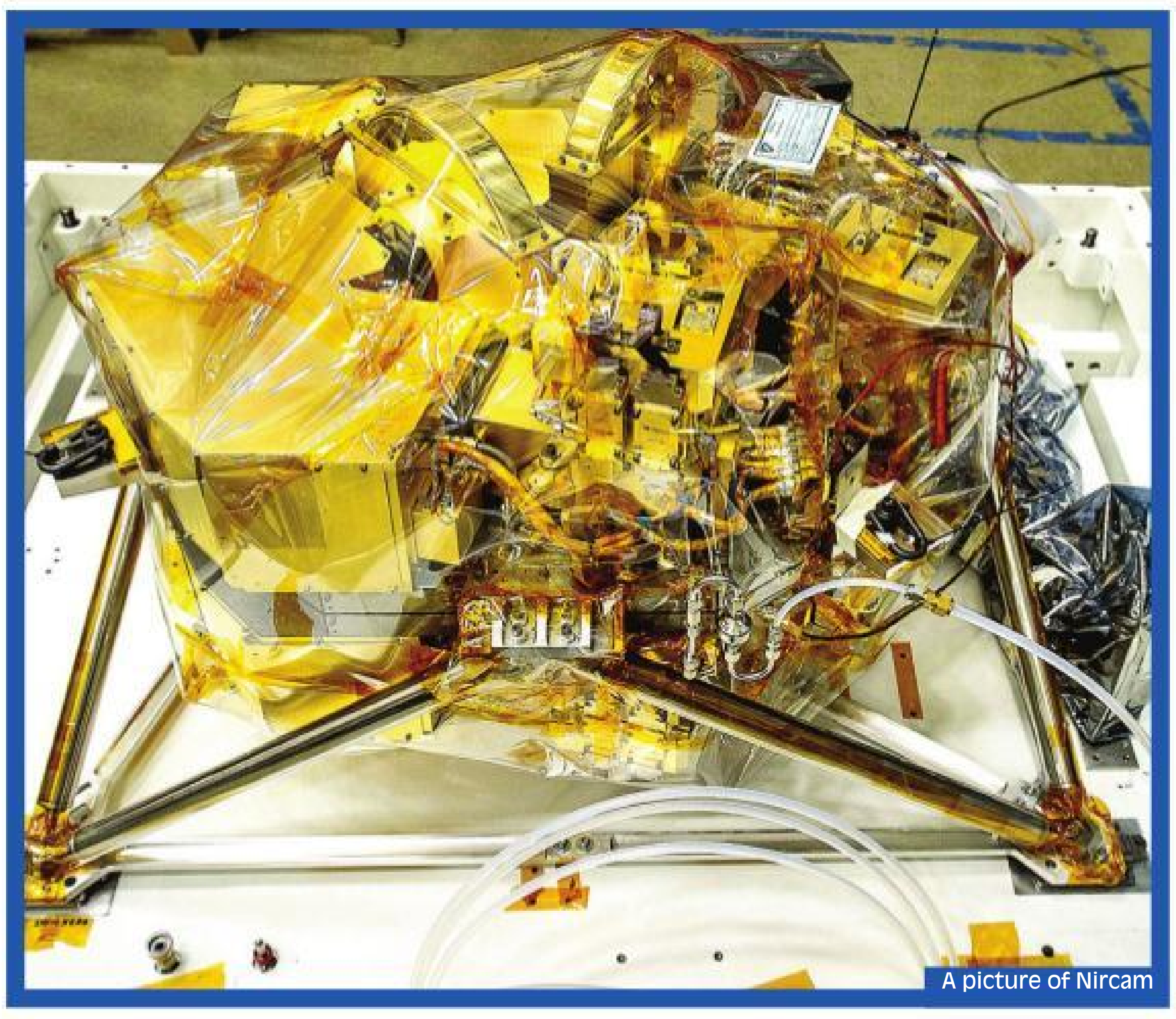
The Webb telescope is an incredible feat of engineering, but how does one get such a thing safely to space and guarantee that it will work?

Test & rehearse

The James Webb Space Telescope will orbit a million miles from Earth — about 4,500 times more distant than the International Space Station and much too far to be serviced by astronauts.

Over the last 12 years, the team has tested the telescope and instruments, shaken them to simulate the rocket launch and tested them again. Everything has been cooled and tested under the extreme operating conditions of orbit.

I will never forget when my team was in Houston testing the Nircam using a chamber designed for the Apollo lunar rover. It was the first time that my camera detected light that had bounced off the telescope's mirror, and we couldn't have been happier — even though Hurricane Harvey was fighting us outside.



A picture of Nircam

After testing came the rehearsals. The telescope will be controlled remotely by commands sent over a radio link. But because the telescope will be so far away — it takes six seconds for a signal to go one way — there is no real-time control. So, for the past three years, my team and I have been going to the Space Telescope Science Institute in Baltimore, United States and running rehearsal missions on a simulator covering everything from launch to routine science operations. The team even has practised dealing with potential problems that the test organisers throw at us and cutely call "anomalies."

Some alignment required

The Webb team will continue to rehearse and practise until the launch date in December, but our work is far from done after Webb is folded and loaded into the rocket.

We need to wait 35 days after launch for the parts to cool before beginning alignment. After the mirror unfolds, Nircam will snap sequences of high-resolution images of the individual mirror segments. The telescope team will analyse the images and tell motors to adjust the segments in steps measured in billionths of a metre. Once the motors move the mirrors into position, we will confirm that telescope alignment is perfect. This task is so mission critical that there are two identical copies of Nircam on board — if one fails, the other can take over the alignment job.

This alignment and checkout process should take six months. When finished, Webb will begin collecting data. After 20 years of work, astronomers will at last have a telescope able to peer into the farthest, most distant reaches of the universe.

The James Webb Space Telescope

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

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PLUS POINTS

Frogs to the rescue

Amphibian foam has been used in drug delivery for the first time, in research which could help combat the rise of antimicrobial resistance.

Researchers from the University of Strathclyde, Queen's University Belfast, Glasgow Caledonian University and the University of Glasgow in the United Kingdom discovered that the foam, found in frogs' nests, has the potential to offer benefits to topical, vaginal and rectal drug delivery, and in cases such as the treatment of burns. It provides a controlled-release delivery, which minimises risk of infection and antimicrobial resistance, while being very compatible with skin and tissue.

Industrial foams have long been used for the delivery of cosmetics and medications but there is high variability in the foamability and long-term stability of synthetic foams. The research has been published in the journal *Royal Society Open Science*.

Professor Paul Hoskisson, of the Strathclyde Institute of Pharmacy and Biomedical Sciences, who led the study said, "This is the first time amphibian foam has been used for drug delivery. It should give us a nice, safe delivery vehicle that could be administered to patients without any fear of making them sick, unlike many of the other synthetic delivery vehicles.

"We are now looking at reproducing the exact foam in the laboratory and investigating the types of drugs that lend themselves better to this type of drug delivery."

The researchers collected foam from wild Túngara frogs, which is made by the species to protect its eggs and tadpoles from the elements in its native Trinidad, including extreme temperatures and harmful bacteria.

As the foam offered protection in such extreme conditions, the researchers hypothesised that it could offer a more durable and compatible system for drug delivery and carried out laboratory tests to assess its structure and composition. The researchers also made nanoparticles to deliver drugs through the foam and found that it released the compounds slowly while the structure held together.

Ancient penguins

The "incredible" fossilised remains of an unusual long-legged giant penguin, first found by schoolchildren in New Zealand, belonged to a previously unknown species, researchers have said.

In 2006, the group of schoolchildren, who were taking part in an organised fossil hunting field trip, discovered the giant set of fossilised penguin bones in Kawhia Harbour, in the Waikato region of New Zealand's North Island. The fossils were recovered from the sandstone rock soon afterwards and donated to the Waikato Museum in 2017.

New analysis of the bones, using 3D scanning, enabled the research team, from Massey University in New Zealand and Bruce Museum in Connecticut, United States, to produce a 3D-printed replica of the skeleton, and found the penguin would have stood at around 4.60 feet tall. In comparison, the tallest penguin species alive today, the emperor, stands at 3.94 feet.

Daniel Thomas, a senior lecturer in zoology from Massey's School of Natural and Computational Sciences, New Zealand, said the fossil is between 27.3 and 34.6 million years old and is from a time when much of the Waikato was underwater.

Steffan Safey, who was there for both the discovery and rescue missions, said, "It's sort of surreal to know that a discovery we made as kids so many years ago is contributing to academia today. And it's a new species, even!"

The research is published in the *Journal of Vertebrate Paleontology*.

— The independent