Cable network cocks an ear

Optical fibre could become the Earth's sensory organ

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Thanks to the explosion in communications and transfer of data worldwide, vast surfaces are crisscrossed by optical fibre cable. As optical fibre uses laser beams to transmit digital signals, fluctuations of the laser beam help detect even minute disturbances of the ground where the fibre is laid.

This quality has enabled optical fibre networks, on land and in the sea, to keep watch over tremors below the surface of the Earth. Apart from great sensitivity and accuracy, the use of fibre is easier and cheaper than arrays of expensive mechanical sensors. Tieyuan Zhu and David J Stensrud, from the departments of geosciences, and of meteorology and atmospheric sciences, University of Pennsylvania, write in the American Geophysical Union's *Journal of Geophysical Research: Atmospheres*, of an extension of the application to detect seismic effects that are induced by the weather, to watch over events in the atmosphere as well. "Fiber-optic cable … will provide a high resolution monitoring tool, which has real potential," says Zhu.

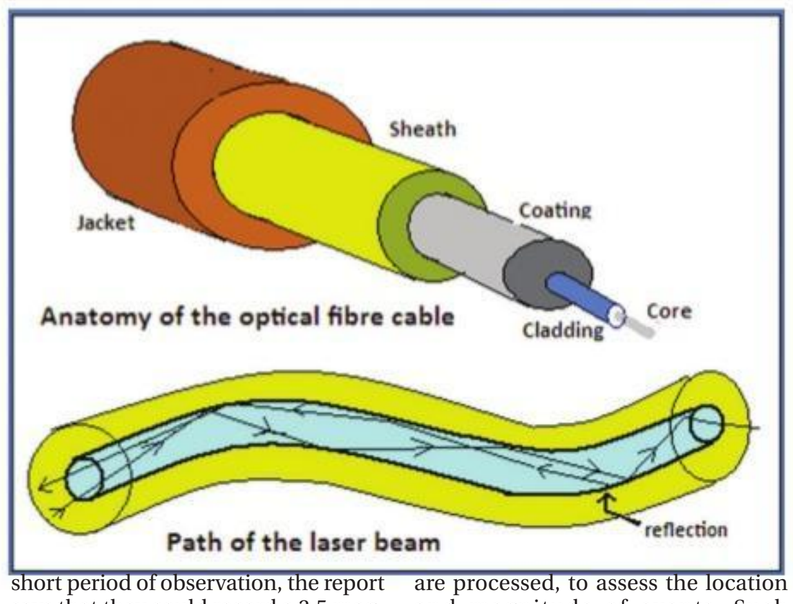
The optical fibre used for communications is a thin glass capillary that guides laser beams along its length. The laser beams traverse the fibre by reflecting off its sides at a glancing angle. Rapid, electronic, off-and-on switching of the beam allows digital data to be transmitted with great speed and accuracy. By using different glancing angles, many beams of light can be sent at the same time and a cable with a bundle of fibres can carry huge data.

Although transmission is highly efficient, there is an element of "back reflection" at each reflection off the sides of the fibre, and this causes some loss of signal strength. For use in communications, the loss is compensated by boosters and it has no other consequence.

For the seismologist, however, this back reflection turns out to be of value. This is because the composition of the back reflection changes quite perceptibly with even a minute change in the position or angle of reflection. Monitoring changes in back signals, and their timing, hence provides a means of getting the location of movements of the optical fibre cable, over its entire length, if a seismic wave should pass through. As the wavelength of laser beams is measured in nanometres, even a small movement of the fibre cable would show up as distinct and measureable change in the back signal.

As a large number of back-reflection signals are picked from all along the length of the cable, rich data is returned, as if from a large number of individual seismic sensors, and detailed information of seismic or other disturbances becomes available. Groups of scientists in the US and Europe have shown that data picked up by a 15-20 km piece of cable can identify different sources of seismic signals, including local earthquakes, quakes at intermediate distances and signals from very large distances. The data from the cable tallies with the signals picked up by conventional sensors in the same area, which helps calibrate the signals detected by the cable.

More recently, a paper published in the journal, *Science*, describes using a stretch of undersea cable in Monterey Bay, off the coast of California, for the same purpose. Over a four-day trial, the group of researchers "turned 20 kilometres of undersea fibre optic cable into the equivalent of 10,000 seismic stations along the ocean floor," a news report says. During the short period of observation, the report says that they could record a 3.5 magnitude quake and reflected signals from fault zones along the seabed.



Monitoring of seismic activity is important in earthquake prone regions. If tremors are detected near the site of an event and conveyed electronically, surrounding populated areas could be warned even minutes before the seismic disturbance strikes. Sensors of earth tremors are hence installed over vast areas, and connected to a control centre, where signals are processed, to assess the location and magnitude of events. Such arrangements, which are found on land, are not equally practicable at sea. Although there are no urban centres located in the sea, not covering the seabed is to ignore 70 per cent of the Earth's surface. This shortcoming, too, may be set right by the use of undersea optical fibre cables, which are now proliferating.

Watching the weather

The work of the researchers at Pennsylvania, writing in the AGU journal, is not about using optical fibre networks to detect seismic activity, but to detect the reaction of the Earth's surface to events in the atmosphere. As extreme weather events, like thunderstorms and hurricanes, can cause serious damage and loss, it is important to be able to detect such events, on land and in the high seas, well in time. At the same time, as these events affect overall climate, their monitoring is important for understanding atmospheric dynamics. There is evidence that such events do transfer energy to the Earth's surface, which can allow seismologists, in addition to meteorologists, to detect, track and assess large hurricanes, the authors say. The manner in which atmospheric events transfer energy to the Earth, however, is complex and needs to be studied in detail, the authors say.

The authors say that detecting, ranging and assessing thunderstorms and lightning using arrays of microphones and instruments that measure minute variations of air pressure have led to understanding of the characteristics of acoustic pressures that arise when these events occur. And, it has been found that the pressure exerted by sound waves can induce motion near the surface of the Earth, to generate elastic waves that propagate. Seismometers, which detect such movement of the surface of the Earth, have then identified these waves. The possibility, however, has been of limited value as a great many seismometers are needed for results that are reasonably accurate.

This is where the use of optical fibre cables comes to the rescue. In the case of detecting ground waves aris-ing from earthquakes, landslide, or even vehicular movement, a few kilo-metres of optic cable amounts to the equivalent of thousands of seismome-ters. The authors hence made use of an existing optical fibre array in the Penn State campus and recorded half an hour's data during a thunderstorm in the region. Thanks to the high den-sity of sensors that the fibre cable rep-resents, it was possible to pinpoint the source of the thunder and ground vibration and its timing, with accuracy and sensitivity. Analysis of the fre-quency of the ground waves helps identify the nature of the thunder-storm or the lightning strokes and whether it is a cloud to ground light-ning stroke or one from cloud to cloud. And, it becomes possible to trace the path the storm follows, as it moves.

Frequency of extreme weather events is expected to rise in the decades to come. The network of optical fibre cable, that covers large parts of the globe, could be the foundation of a system of painless and automated weather surveillance.

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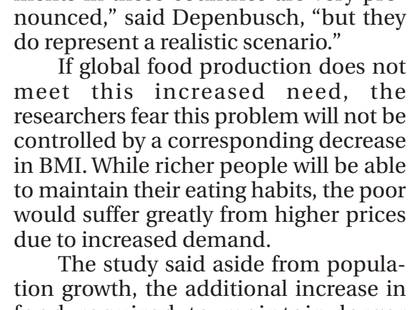
PLUS POINTS

Food in short supply



Bigger people and growing populations could mean the world may soon face such an increase in demand for food, suppliers may be unable to keep up, scientists have warned. A rising Body Mass Index, which evaluates weight in relation to height, alongside increasing body heights across most countries, are leading to a marked increase in global calorie requirements.

A study by academics at the University of Göttingen, which forecasts how calorific intake could change between 2010 and 2100, estimates global food consumption could rise by 80 per cent by the end of the century.

The vast majority — 60 per cent of the increase — would be due to population growth. Even if height and BMI remained static, demand for food is forecast to surge. But a further 20 per cent rise in demand will be due to the greater quantity of food required by larger humans.

Professor Stephan Klasen and doctoral student Lutz Depenbusch investigated how rapid changes recorded in the Netherlands and in Mexico could provide a benchmark for changing patterns around the world. In Mexico, BMIs have risen sharply, while in the Netherlands, average heights have increased. Dutch men now have an average height of 183cm (six ft), an increase of 13.1cm between 1914 and 2014."The developments in these countries are very pronounced," said Depenbusch, "but they do represent a realistic scenario."

If global food production does not meet this increased need, the researchers fear this problem will not be controlled by a corresponding decrease in BMI. While richer people will be able to maintain their eating habits, the poor would suffer greatly from higher prices due to increased demand.

The study said aside from population growth, the additional increase in food required to maintain larger humans by the end of the century "amounts to more than the combined calorie requirements of India and Nigeria in 2010. These increases would particularly affect Sub-Saharan African countries, which will already face massively rising calorie requirements due to the high population growth."

Mexico has the second-highest BMI in the world, after the US, but changes have happened in Mexico more rapidly. Until the 1980s malnutrition was the biggest dietary issue in Mexico, but by 2010, seven out of ten Mexicans were overweight, with a third clinically obese. As of 2012, diabetes — associated with obesity — was the largest single killer of Mexicans.

The study has been published in the journal *PLOS ONE*.

The independent

Happy six feet

Ancient penguins were as tall as humans but scientists have discovered the species that started the downsizing trend

JACOB BLOKLAND

A new species of extinct penguin has been discovered. It's helping us bridge the gap between modern penguins and their counterparts from the Paleocene epoch — the 10-million-year period following dinosaur extinction.

The world's oldest known penguins existed only a few million years after the mass-extinction event that wiped out the dinosaurs — except for birds, the only dinosaurs that didn't go extinct.

Some of those earliest penguins had longer legs than their living relatives. And some species, including the colossal *Kumimanu biceae*, would have rivalled the size of you or me.

Published in the journal *Palaeontologia Electronica*, our research describes a unique, archaic penguin species that lived alongside these giant early species, between 62.5 and 60 million years ago.

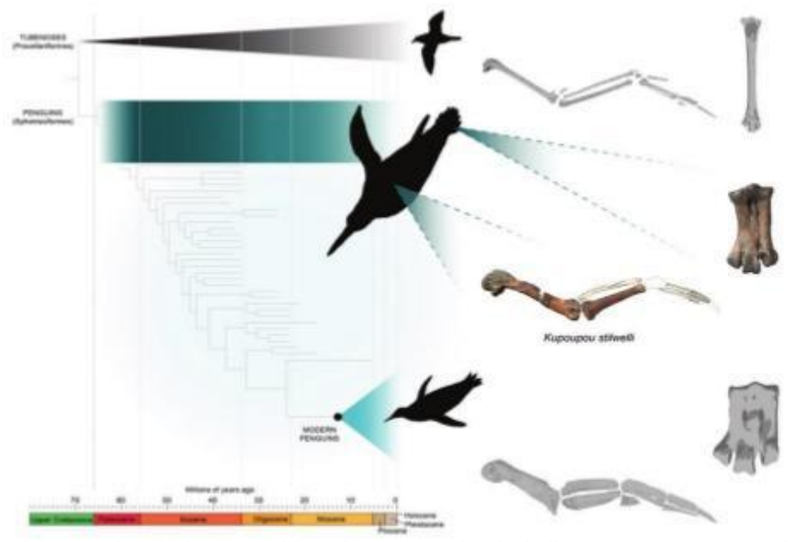
Unlike its huge counterparts, *Kupoupou stilwelli* was only about the size of a modern king penguin. It also had leg bone proportions akin to living penguins.

Agile ancient divers

Penguins today are well-adapted for a largely aquatic lifestyle.

They're specialised for flying seamlessly through water — a medium 800 times denser than air. Modern penguins have dense bones to counteract buoyancy, and flat, wide, flipper-like wings with stiffened joints, which powerfully propel them underwater.

The oldest penguins we know of had already begun to fly down this watery path. *Kupoupou* was no exception. Although its flattened wing bones weren't as wide or stiff as its modern relatives, CT scans of Kupoupou bones reveal they were dense, too.



The general evolutionary position of early penguins, including *Kupoupou*, compared to modern penguins and their closest living relatives, tubenosed birds (such as albatrosses and shearwaters).

Importantly, *Kupoupou* is the first non-giant penguin species discovered to have relatively short legs, similar to penguins today. Modern penguins use their short hind limbs for waddling on land.

But in water, these short legs allow a hydrodynamic shape that maximises swimming efficiency and helps the bird steer.

It could be *Kupoupou* used its legs in a similar way, and was likely a good swimmer.

These short legs coincide with the *Kupoupou*'s stout and short tarsometatarsus (a foot bone unique to birds, made out of fused elements), which is distinctly different from the longer bones found in the feet of other similar-sized Paleocene species.

Other giant penguins alive at that time had shorter legs like *Kupoupou*, and their greater mass possibly allowed them to forage even deeper in the aquatic realm.

What makes *Kupoupou* unique is that it's the oldest species known to resemble living penguins in both size and leg proportions.

How we made our discovery

In 2003, Monash University associate professor Jeffrey Stilwell discovered a variety of fossils on coastal platforms at Chatham Island, a landmass 800km east of New Zealand's South Island.

An assortment of fossils was collected during expeditions over the next several years, ranging from isolated bones to partial skeletons encased within hard rock. Some of this material appeared to belong to long-extinct penguins.

Exposed and isolated bones could be studied directly. However, for bones of single individuals surrounded by hard rock, CT scanning was required to virtually reveal what lay inside.

Using these methods, we were able to identify at least two species of ancient penguin from Chatham Island.

The newly named species, *Kupoupou stilwelli*, was represented by multiple specimens consisting of numerous wing and leg elements. "Kupoupou" means diving bird in Te Re Moriori, while "stilwelli" honours Stilwell, who organised and led the parties involved in the fossil collections.

By today's standards *Kupoupou* was large (although likely not exceeding one metre). That said, it was certainly dwarfed by many other fossil penguins from throughout the entire fossil record, with the oldest being around the same age of *Kupoupou* and the youngest living about 25 million years ago.

CT scanning helped to virtually model bone material that lay within hard rock.

However, because we do not have the full skeleton for *Kupoupou*, and because penguin fossils are often of different proportions to the bones of living penguins, exact size estimates for these ancient birds must be taken with caution.

Other bones revealed *Kupoupou* lived alongside at least one other penguin on Chatham Island, which is slightly larger and more robust. However, these fossils were not named as a new species because the skeleton was too incomplete.

Another piece of the penguin puzzle

The ancestors of penguins rapidly radiated into empty oceans following the mass-extinction that wiped out the dinosaurs.

These Chatham Island fossils add to the already large diversity of penguins that lived only a few million years after this event, all of which — apart from *Crossvallia unienwillia* — were from New Zealand. This massive diversity in the eastern region of New Zealand's South Island adds to the hypothesis that penguins first evolved in this region.

It also supports the idea that penguins branched from the lineage leading to their closest living relatives, such as albatrosses and petrels, before dinosaurs went extinct.

The writer is a palaeontology Phd candidate and casual academic, Flinders University. This article first appeared on www.theconversation.com

Plastic to chemicals

Scientists in Singapore have developed a way to convert plastic waste into useful chemicals using sunlight.

This is the first reported process that can completely break down a non-biodegradable plastic such as polyethylene using visible light and a catalyst that does not contain heavy metals, said assistant professor Soo Han Sen from Nanyang Technological University.

His team from the School of Physical and Mathematical Sciences created a catalyst that harnesses light energy, such as sunlight, to break down chemical bonds in plastics within days. The three main plastics, which can be converted by this method into useful chemicals, are polyethylene, polypropylene and polystyrene. These make up 80 per cent to 90 per cent of the plastics in the world. The method is one of two known processes that use sunlight to convert plastic waste into useful chemicals, said Soo. The other method, photoreforming, was developed by scientists from the University of Cambridge last year.

Photoreforming combines plastic with water and sunlight to produce hydrogen gas, which can be used for energy generation by hydrogen fuel cells. However, the catalyst it uses contains cadmium, a toxic heavy metal. The NTU research team uses a vanadium-based catalyst instead.

Vanadium is an affordable metal that is less toxic and about 1,000 times more abundant than cadmium. As a catalyst, it is thus more abundant, affordable and environmentally friendly, the NTU team said.

The straits times/ann