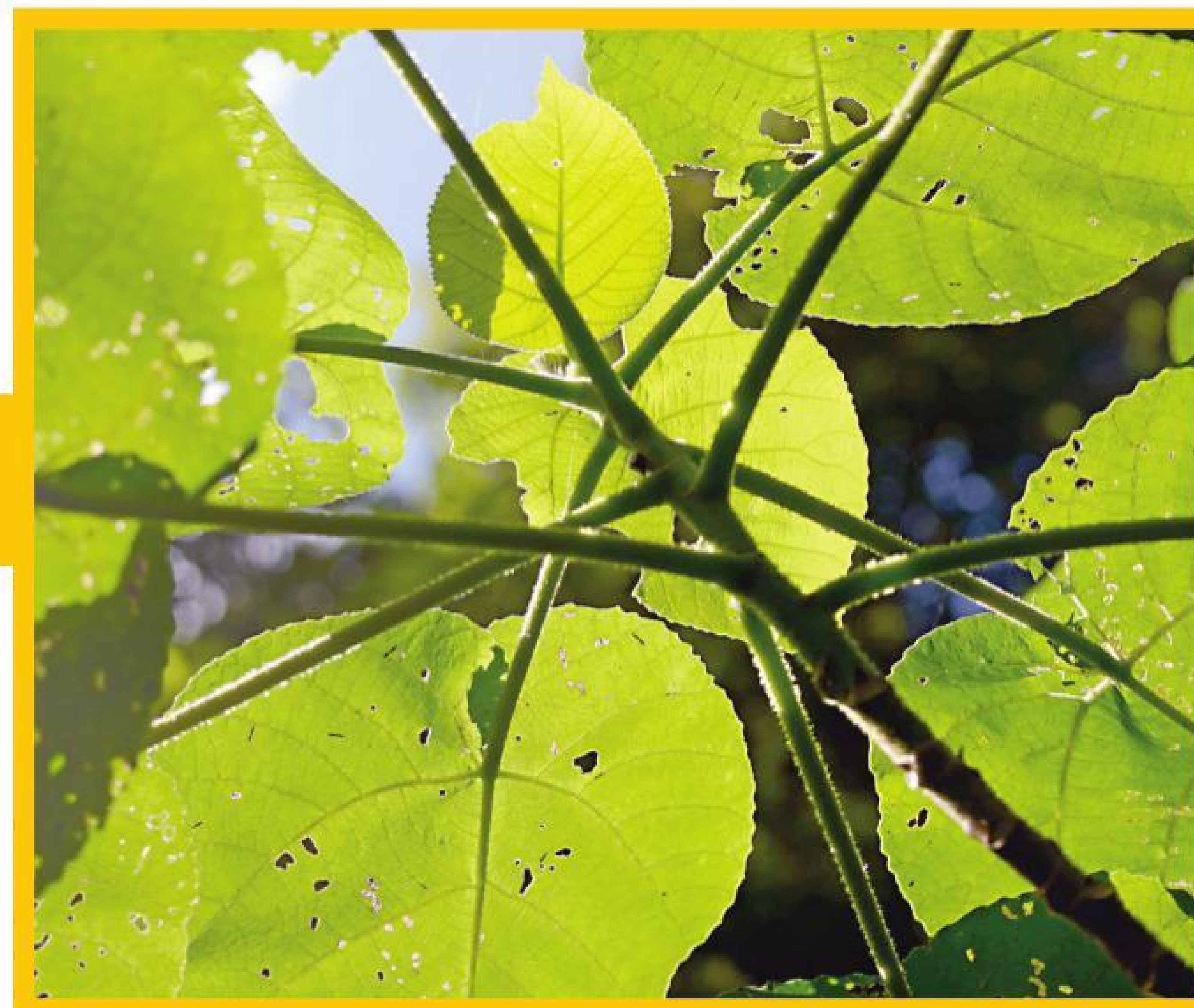
Plants that bite and sting

The stuff they inject has been found to be like the venom of spiders and sea snails

S ANANTHANARAYANAN



Some plants, like the Venus flytrap – move and act to get their prey. Some do not move, but they use venom, which is more common among animals, to keep enemies at bay.

Edward K Gilding, Sina Jami, Jennifer R Deuis, Mathilde R Israel, Peta J Harvey, Aaron G Poth, Fabian BH Rehm, Jennifer L Stow, Samuel D Robinson, Kuok Yap, Darren L Brown, Brett R Hamilton, David Andersson, David J Craik, Irina Vetter, Thomas Durek, from the University of Queensland at Brisbane, Australia and King's College, London, describe in the journal, *Science Advances*, what gives the giant Australian stinging tree, *Dendrocnide excelsa*, its legendary sting, which is as bad, and often far worse, than those of poisonous insects.

They find that the active agents are akin to those found in the animal kingdom, which suggests an intriguing path of evolution, where plants diverged from animals, but developed related instruments of predator control.

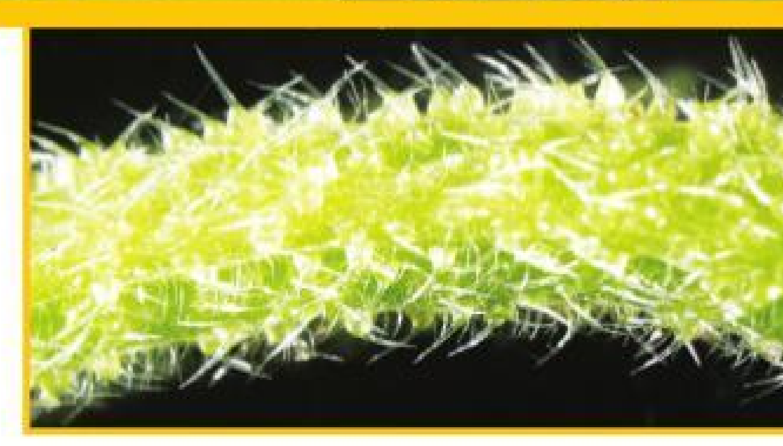
"Australia notoriously harbours some of the world's most venomous animals, but although less well known, its venomous flora is equally remarkable," says the opening line of the paper. The giant Australian stinging tree, also known as the stinging brush, mulberry-leaved stinger, gympie gympie or moonlighter, which is found in the rainforests of North-east Australia and parts of Indonesia, the paper says, stands supreme in size -- it is usually one to three metres high, but can grow as high as 35 metres.

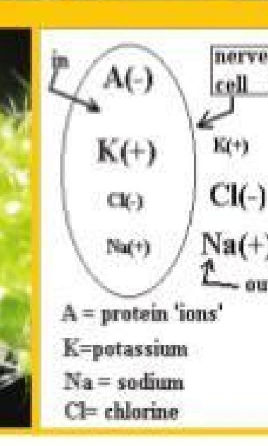
The stinging tree belongs to the family *Urticaceae*, a family that includes the nettles or stinging nettles, well-known shrubs that have stinging hairs. Readers may be familiar with the term, *urticaria*, for the red, itchy welts that sometimes form on the skin. The Australian stingers, however, the paper says, "are far more than oversized nettles." The Australian stinging tree species "are particularly notorious for producing an excruciatingly painful sting, which unlike those of their European and North American relatives, can cause symptoms that last for days or weeks. Like other stinging plants such as nettles, the giant stinging tree is covered in needle-like appendages called *trichomes* that are around five millimetres in length – the trichomes look like fine hairs, but actually act like hypodermic needles that inject toxins when they make contact with skin," says co-author Irna Vetter, in a press release.

The state of Queensland, the paper says, has put up signs along forest tracks, to alert visitors of *Dendrocnide* species and the potency of their sting. The symptoms are usually severe and persistent pain, sometimes with neuromuscular symptoms and respiratory distress. Although most cases do not require hospitalisation, there are instances of patients in intensive care for 36 hours – with acute pain that did not respond to morphine and symptoms that continued for months!

Apart from analgesics, the severe pain is often treated with dilute hydrochloric acid, to inactivate the venom, and, maybe under the mistaken impression that it is the stinging hairs stuck in the skin that cause the pain, with wax strips, to pull them out. The needle shaped structures on the leaves and stem of *D excelsa* and *D Moroides*, the leading giant stingers, look like a benign felt cover, the paper says, but they are, in fact, hollow, silica impregnated needles that can inject chemical agents that affect pain-sensitive nerve terminals in ? the skin.

One proposed component of the *Urtica* sting has been the 'small molecule", a structure that is common in developing drugs that can form a "lock and key" fit with portions of cells, to block or promote their action. Examples are histamine (which sets of sneezing or allergic reactions), other agents that affect nerves, formic acid (the component in the ant sting and in nettles) and some other acids. Injecting those compounds, even in combinations, however, the paper says, could not replicate or change the severity of extended duration of the pain that *Dendrocnide* extract could cause. There was hence clearly some other substance, that affected nerves, which they had to find.





It is the tip of the stingers' needles that breaks when it enters the skin and allows the contents of the needle to leak out. The team prepared extracts of the sting hairs and analysed the extract -- using methods to separate the contents. One component, which showed pain-inducing behaviour, was further analysed and a group of small-sized proteins were isolated as the active agents. The proteins, unlike any encountered before, were named gympietides, from the tribal name, *gympie-gympie*, for the stinging trees.

The effect of gympietides was found to arise from the effect that they have on the sodium channels of nerve cells. Nerves function by passing electric signals, which are generated by changes in the material within the nerve cells. The material inside a nerve cell "at rest" has a slight excess of positively charged potassium ions and some negatively charged protein molecules. At the same time, the cell has a slight deficiency of positive, sodium ions. The relative concentration of the charged "ions" within the cell is thus some 70-80 mV negative compared to outside the cell. And, as the cell wall does not allow ions to go through, there is electrical "tension" across the two sides of the cell wall.

That changes when an electrical signal arrives at the cell from the environment or a neighbouring cell. This signal causes gaps, called gateways, in the cell wall to open, and positive sodium ions rush in, and the net change is reversed to about +40 mV. This change opens another set of gateways that allow positive potassium ions to rush to the potassium deficient exterior, which restores the -70 mV polarity of the cell. This in-and-out shiver passes along the body of the cell, until it affects the neighbouring cell, and so the signal is passed on.

What the Queensland team found was that gympietides activated sodium channels and started pulses of pain signals. The team developed a synthetic substance that resembled the gympietides and showed that it had the same effect on sodium channels and again, pain in experimental animal subjects for extended periods.

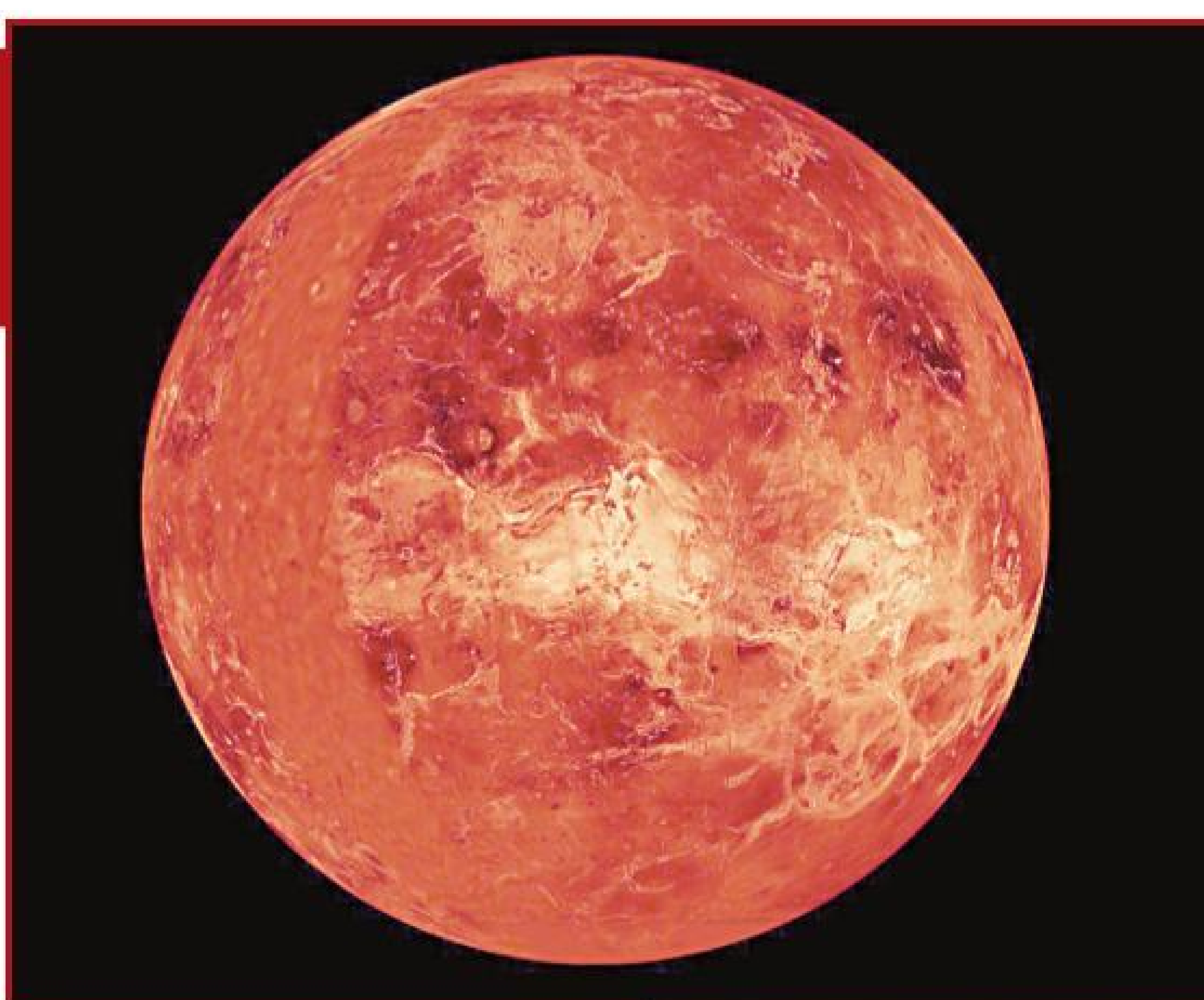
The work is a step forward in understanding how pain-causing agents work and a suggestion that agents that block the sodium channels could be a way to relieve pain. It also reveals a similarity of plant proteins with the way agents in animal venoms, whose ancestral connection is exceedingly remote, function to cause pain.

The writer can be contacted through the website, www.simplescience.in

TIME TO VISIT THE NEIGHBOUR

The detection of phosphine in Venus' clouds is a big deal – here's how we can find out if it's a sign of life

PAUL K BYRNE



On 14 September 2020, a new planet was added to the list of potentially habitable worlds in the Solar System: Venus. Phosphine, a toxic gas made up of one phosphorus and three hydrogen atoms, commonly produced by organic life forms but otherwise difficult to make on rocky planets, was discovered in the middle layer of the Venus atmosphere. This raises the tantalising possibility that something is alive on our planetary neighbour. With this discovery, Venus joins the exalted ranks of Mars and the icy moons Enceladus and Europa among planetary bodies where life may once have existed, or perhaps might even still do so today.

I'm a planetary scientist and something of a Venus evangelical. This discovery is one of the most exciting made about Venus in a very long time – and opens up a new set of possibilities for further exploration in search of life in the Solar System.

Atmospheric mysteries

First, it's critical to point out that this detection does not mean that astronomers have found alien life in the clouds of Venus. Far from it, in fact.

Although the discovery team identified phosphine at Venus with two different telescopes, helping to confirm the initial detection, phosphine gas can result from several processes that are unrelated to life, such as lightning, meteor impacts or even volcanic activity.

However, the quantity of phosphine detected in the Venusian clouds seems to be far greater than those processes are capable of generating, allowing the team to rule out numerous inorganic possibilities. But our understanding of the chemistry of Venus' atmosphere is sorely lacking – only a handful of missions have plunged through the inhospitable, carbon dioxide-dominated atmosphere to take samples among the global layer of sulfuric acid clouds.

So we planetary scientists are faced with two possibilities – either there is some sort of life in the Venus clouds, generating phosphine, or there is unexplained and unexpected chemistry taking place there. How do we find out which it is?

First and foremost, we need more information about the abundance of phosphine in the Venus atmosphere, and we can learn something about this from Earth. Just as the discovery team did, existing telescopes capable of detecting phosphine around Venus can be used for follow-up observations, to both definitively confirm the initial finding and figure out if the amount of phosphine in the atmosphere changes with time. In parallel, there is now a huge opportunity to carry out lab work to better understand the types of chemical reactions that might be possible on Venus – for which we have very limited information at present.

Once more unto the breach

But measurements on and from Earth can take us only so far. To really get to the heart of this mystery, we need to go back to Venus. Spacecraft equipped with spectrometers that can detect phosphine from orbit could be dispatched to the second planet with the express purpose of characterising where, and how much, of this gas is there. Because spacecraft can survive for many years in Venus' orbit, we could obtain continuous observations with a dedicated orbiter over a much longer period than with telescopes on Earth.

But even orbital data can't tell us the whole story. To fully get a handle on what's happening at Venus, we must actually get into the atmosphere.

And that's where aerial platforms come in. Capable of operating above much of the acidic cloud layer – where the temperature and pressure are almost Earth-like – for potentially months at a time, balloons or flying wings could take detailed atmospheric composition measurements there. These craft could even carry the kinds of instruments being developed to look for life on Europa. At that point, humanity might finally be able to definitively tell if we share our Solar System with Venusian life.

A new dawn for Venus exploration?

Thirty-one years have elapsed since the United States last sent a dedicated mission to Venus. That could soon change as Nasa considers two of four missions in the late 2020s targeting Venus. One, called Veritas, would carry a powerful radar to peer through the thick clouds and return unprecedented high-resolution images of the surface. The other, DaVinci+, would plunge through the atmosphere, sampling the air as it descended, perhaps even able to sniff any phosphine present. Nasa plans to pick at least one mission in April 2021.

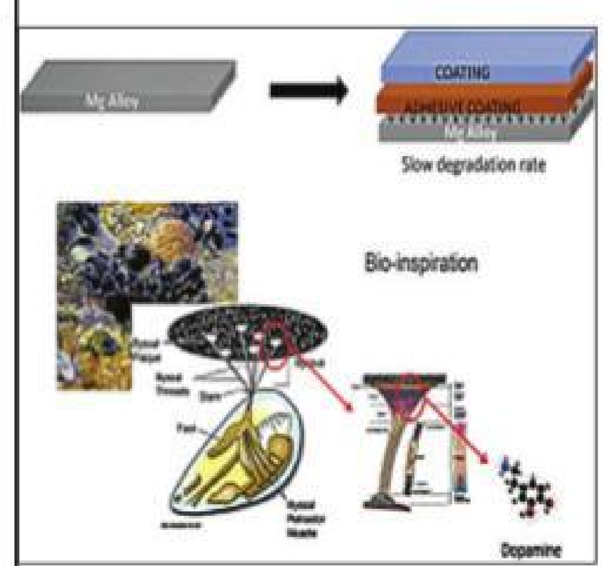
I have argued before for a return to Venus and will continue to do so. Even without this latest scientific discovery, Venus is a compelling exploration target, with tantalising evidence that the planet once had oceans and perhaps even suffered a hellish fate at the hands of its own volcanic eruptions.

But with the detection of a potential biomarker in Venus' atmosphere, we now have yet another major reason to return to the world that ancient Greek astronomers called phosphorus -- a name for Venus that, it turns out, is wonderfully prescient.

The writer is associate professor of planetary science, North Carolina State University, US. This article first appeared on www.theconversation.com

PLUS POINTS

For bone defects



Researchers have developed nano-coated magnesium alloys that can repair bone defects in rabbits. Encouraged by the results, the research team is planning to study medical applications of nano-coated magnesium alloys in other animals and repairing human bones.

Alloys of magnesium are being considered as a good option for orthopaedic applications as magnesium is biocompatible, biodegradable and has other important mechanical properties. Magnesium is the fourth abundant metal in the body and is known to accelerate the healing of bones.

The research was led by Mukesh Doble, department of biotechnology, IIT-Madras, and the team comprised Govindaraj Perumal, post-doctoral research associate, IIT-Madras, Boopalan Ramasamy, Christian Medical College, Vellore, A Maya Nandkumar, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, D Sivaraman, Sathyabama Institute of Science and Technology, Chennai and R Selvaraj from Bioscience Research Foundation, Chennai. Their latest research has been published in the journal *Nanomedicine* and a patent has also been filed.

For this study, the researchers deployed AZ31 alloy of magnesium and used it for developing magnesium mesh cage implants. Further, they coated the implants with polycaprolactone and nano-hydroxyapatite by dipping and electrospinning. The nano-coated magnesium mesh was then used to heal the bone defect in the femur of rabbits.

The researchers found that the rabbit femur implanted with the coated magnesium alloy showed bone formation and bridged the defect region. The team emphasises that it was possible due to the biocompatible nature of polycaprolactone and nano-hydroxyapatite, which ensured good recovery without any adverse reactions such as "fibrosis".

The team is exploring funding opportunities to further test the newly-developed nano-coated magnesium alloy in repairing bone defects in large animals such as goats or sheep to demonstrate the efficacy of the product and show clinical significance of this research.

Sparing animals

A new laboratory model that can be used to test treatments for preventing and curing eye infections caused by fungi, bacteria and viruses, while also reducing the number of animals used in medical research, has been developed at the University of Sheffield, UK in collaboration with LV Prasad Eye Institute, Hyderabad.

The breakthrough, which will be used to develop novel alternatives to antibiotics to reduce the emergence of antibiotic-resistant superbugs, has been made by engineers and scientists working together at the University of Sheffield's Collaboratorium for Antimicrobial Resistance and Biofilms.

Currently, around 285 million people globally are visually impaired, and seven million people lose their eyesight each year. Over 90 per cent of people affected are from developing countries. In approximately 80 per cent of these people the loss of eyesight can be easily avoided with bespoke healthcare solutions that fit with the unique socio-economic conditions prevalent in developing countries.

Using the *ex vivo* porcine eye model – the eyes of pigs which are deemed as waste by the food industry – researchers can mimic infection in human eyes. The cornea is the transparent portion in the front of the eye that allows us to see. Using the ex vivo porcine models, researchers were able to study ulcer formation and the development of opacity which leads to the loss of vision in humans.

The new model, which is being developed by PhD researcher Katarzyna Okurowska, gives a better prediction of how effective the new treatments are likely to be in humans. Such data is currently obtained from expensive and highly regulated animal research, which must precede any human clinical trials before the treatment can be made available to patients.

The availability of the model will immediately help to reduce and refine the use of animals in medical research and may one day help to completely replace the use of animals in this kind of study. The added advantage of the ex vivo porcine eye model is that it uses waste from the food chain. As the eyes are a waste product, no animals are specifically bred for the study, helping to reduce their numbers for exclusively research purposes.