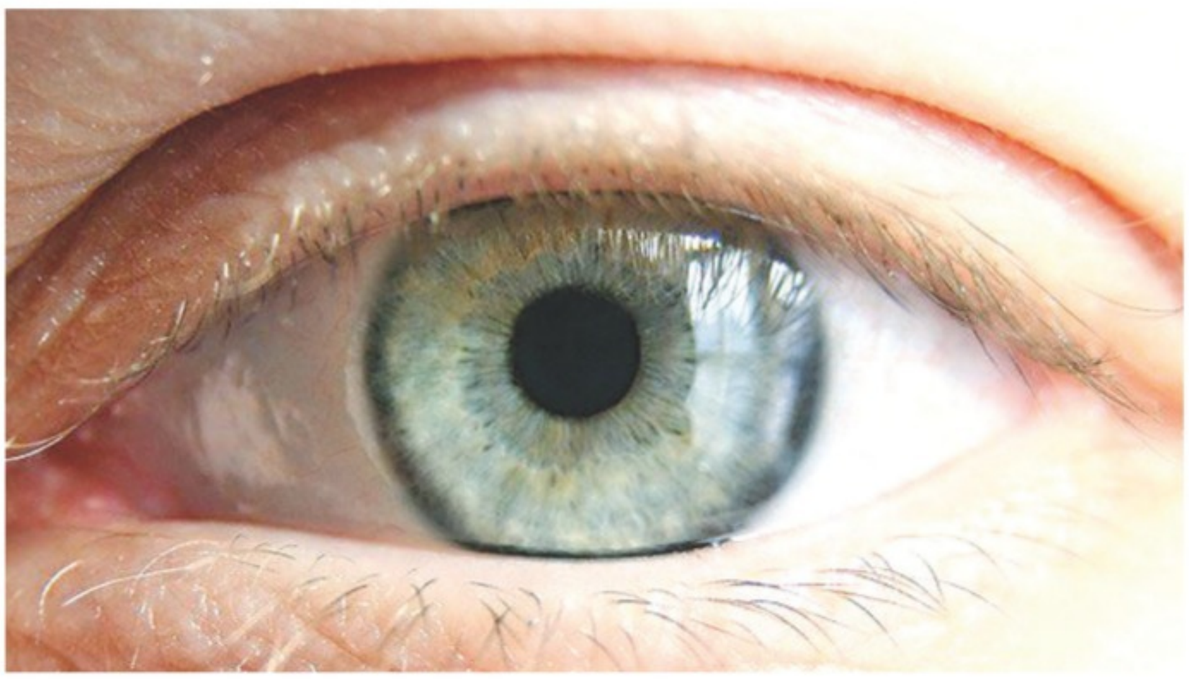
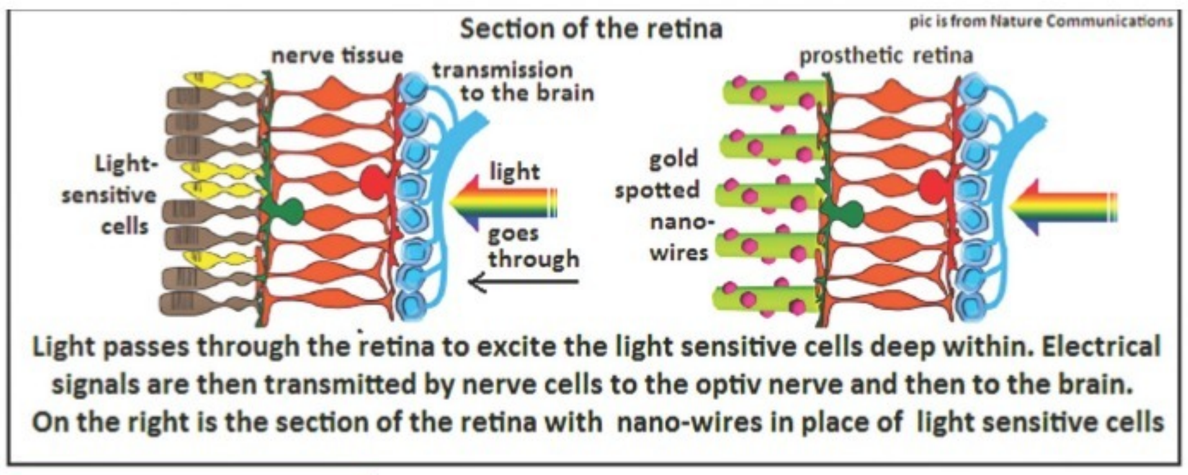
Nano-wires revive the retina





Light passes through the retina to excite the light sensitive cells deep within. Electrical signals are then transmitted by nerve cells to the optiv nerve and then to the brain. On the right is the section of the retina with nano-wires in place of light sensitive cells

A mesh of metal spikes, the size of living cells, and decorated with gold spots, may help blind persons see again

S ANANTHANARAYANAN

The retina is the light-sensitive part of the eye, which helps us to see. Damage to the light-sensitive cells in the retina is the reason for a great many cases of vision loss. A common disease of the retina is macular degeneration, where the central part of the retina loses its function. Another is retinitis pigmentosa, where vision loss starts at the periphery and progresses inwards. In both cases, the remaining structure of the eye, which collects lights and forms images, and then the nerves that carry electrical signals to the brain, are intact. It is the mechanism to convert light into electrical impulses that has failed.

Jing Tang, Nan Qin, Yan Chong, Yupu Diao, Yiliguma, Zhexuan Wang, Min Jiang, Jiayi Zhang and Gengfeng Zheng from Fudan University, Shanghai and a Tian Xue from the Heifi National Laboratory, China, report in the journal, Nature Communications, an advance in the drive to find man-made devices to take the place of the failed light-sensitive cells. The team of researchers has created a mat made of tiny bits of titanium dioxide wire, dotted with nano-particles of gold, which is able to resolve light falling on the retina with fineness not achieved so far. The device has been tested on laboratory mice and there is promise of helping human patients as well.

When light strikes the photoreceptor cells in the retina of the natural eye, there is a structural change in molecules in a pigment within the cell, and this affects the movement of charged sodium ions, creating electrical tension. This is the signal that gets transmitted down, to other nerve cells within the retina and then to the brain, as brightness in the part of the visual field that the photoreceptor cell represents. There are about 120 million photoreceptor cells in the average human eye, and these are connected to some two million nerve terminals leading to the brain.

When the photoreceptor cells are damaged, what we need is a method to generate electrical signals and send them to the nerve cells. One method that has been developed has head-mounted cameras with photocells to generate signals. Users learn to associate the neural stimuli received to approximate shapes. The implanted electronics, however, is bulky and the surgery to pass cables through the lining of the eye, to transfer signals, is complex. Another system places the camera and related electronics in a chip that is implanted behind the retina. This device contains tiny photocells to capture light, amplifiers to boost their signal and electrodes to stimulate retinal nerve cells. The surgery is even more complex, the cost in both cases is astronomical and the resolution of images is limited.

An improvement that was reported in 2015 consists of photocells, with basic electronics, mounted on a chip that is implanted with less invasive surgery and communicating directly with the mat of nerve cells. A chip that was one mm square and implanted behind the retina of experimental rats had 250 photocells, which permitted reasonable resolution of detail.

The current development by the group writing in *Nature Communications* goes one further and replaces the very photocell with photosensitive material, at the dimensions of nano-metres, which allows far greater resolution of images.

Apart from not needing diodes and other electronics to transfer charge, nano-materials have a different mechanism of sensitivity to light. The principle of the photocell is that atoms of semiconductor materials, like silicon, have loosely bound electrons in their outer orbits, which can get knocked free when struck by a photon or particle of light. These electrons represent charge, which can be tapped through one-way gates, called diodes, and initiate electrical effects.

In contrast, in the case of very small dimensions, light waves set up mechanical and electrical oscillations in the material. The dimensions of nano-particles are suitable for resonance, or frequency matching of the light wave and the oscillations in the material, and there can be transfer of energy from the light wave. An array or matrix of such nano-wires of titanium dioxide was created by depositing the titanium material on a substrate from a solution, followed by heat treatment. Nano-particles of gold were then deposited on the nano-wires by soaking the array in a solution of a gold salt, and then washing and annealing. Spikes of nano-wires and a nano-wire spotted with gold can be seen in the picture.

The interesting thing about this array of nano-wires is that while it will give off electric charge when exposed to light, the array can be directly in contact with nerve tissue, to transfer charge in the same way that the natural rods and cones of the eye excite the nerve cells.

While this is similar to the arrangement in the 2015 development, the big difference is that the light sensitive elements are now nano-wires, not full-fledged photocells. The diameter of the nano-wires was 100 nm (a nanometre is a millionth of a millimetre) and their length was two microns (a micron is a thousandth of a millimetre). There were about 10 nano-wires to every square micron. This works out to be 10 million nano-wires in every square millimetre. We can see that this is a huge improvement over the 250 photocells we could have in a square millimetre in the work reported in 2015.

The arrays of nano-wires were then tried out, first in experimental mouse retinas in the lab and then after implantation in the retinas of living mice. The nano-wire implanted retinas showed robust sensitivity to light of all relevant frequencies (colours) both in the retina test as well as in living mice. "…the pupillary light reflex experiment showed that the sensitivity of blind mice implanted with NW arrays was similar to that in wild-type mice", the paper says.

What has been designed and manufactured hence mimics the way real rod and cone cells of the eye function, and has several good features flowing from the nano-metre scale dimensions, the paper says. Although the design of nano-wires still does not make colour vision possible, that is also within reach. The paper says the capability that has been demonstrated point towards adaptation for use as prosthetic devices in human patients.

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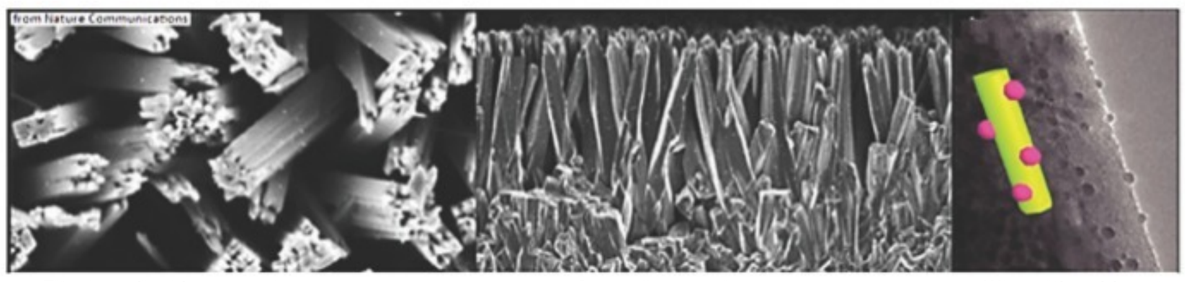


Titanium dioxide nano-wires | Array of nano-wires | Wire with gold spots

How the sky lit up

Scientists have seen the very beginning of stars for the first time, in a breakthrough that could unlock mysteries of the universe

ANDREW GRIFFIN

Scientists have received signals from the very first stars ever, and could use them to unlock some of the most profound mysteries of the universe.

The new discovery sheds light on how stars — and everything that surrounds us — began. It is a picture of the beginnings of light as we know it today, scientists write in two breakthrough papers published in *Nature* recently.

And the findings could further illuminate some of the most central mysteries in our universe — how our own galaxy and its stars was formed, and the dark matter that is thought to surround us but remains entirely mysterious.

Scientists examining radio waves from deep in the universe found the faintest of signals from the moment the earliest stars "switched on" — just 180 million years after the birth of the universe. It showed the effect those early stars lighting up had on the hydrogen around them. Ultra-violet radiation disturbed the hydrogen atoms, leading to a characteristic signal emission.

Before all that, the universe was dark and filled mostly with hydrogen gas. How the stars of today could have formed out of such a place remains difficult to imagine, given that most of the material found scattered through the universe today was itself formed in stars. Alan Rogers, one of the scientists from Massachusetts Institute of Technology, said, "This is the first real signal that stars are starting to form, and starting to affect the medium around them.

"What's happening in this period is that some of the radiation from the very first stars is starting to allow hydrogen to be seen. It's causing hydrogen to start absorbing the background radiation, so you start seeing it in silhouette, at particular radio frequencies."

"The whole history of the early universe was vital for seeding all of the structures that we see in the universe today," said Carole Haswell, Head of Astronomy at the Open University. "So our own Milky Way galaxy would have begun forming around that time, and the properties of those first stars could have profoundly influenced the way galaxies built up."

One of the stranger parts of the findings was that the hydrogen in the early universe must have been far colder than we'd previously thought — about twice as chilly as expected. It isn't clear why that is the case, but finding out could offer an understanding of dark matter, one of the most mysterious things in our universe.

Dark matter has never been seen but is thought to make up most of the mass of the universe. Scientists think that the cold could be the result of an interaction between "normal" matter and this dark matter — offering a glimpse at a previously unseen physics.

If dark matter is interacting with the matter that we can see, then we could potentially infer certain important details about what it actually is. For the moment, that is just a suggestion and a way of explaining the unexpected data — but if proven right could shed light on one of the greatest mysteries of the universe.

"The question of the nature of dark matter ranks amongst the greatest astrophysical mysteries of our age," said Poshak Gandhi, associate professor in the University of Southampton's Astronomy Group. "Global efforts over the past several decades have failed to identify a clear candidate source. This is almost embarrassing given that dark matter appears to be at least five times more abundant (in mass) than all the normal matter that we are able to perceive!

"These new studies open up new possibilities in this research field. A strong deficit in an expected radio signal from the time when the universe was in its infancy could be due to the influence of dark matter particles. If confirmed, we need to revisit ongoing searches for dark matter particles."

All of that new understanding is based on discoveries from a small radio antenna sitting in the desert. The important detection was found among sources of noise that can be a thousand times louder than the actual signal, which Peter Kurczynski, from the US government's National Science Foundation likened to "being in the middle of a hurricane and trying to hear the flap of a hummingbird's wing".

To manage to get a peek at the beginnings of the universe among all that distraction showed the power of science, said researchers away from the new work. "This allows us to apply human ingenuity and logic to things that are well beyond our everyday world, and learn things that at first glance we didn't know anything about," said Haswell. "This is a really nice example of how you can point a radio detector at the sky, and just by plugging away and thinking about the implications, you can get quite a long way."

Part of the difficulty of the experiment is that it requires incredibly precise work to find something that is missing, rather than something that is there. The research community hailed the breakthrough technical work done by the scientists behind the study in finding their results.

"This is one of the most technically challenging radio astronomy experiments ever attempted," said Ron Ekers, an adjunct professor at Curtin University. "The lead authors include two of the best radio astronomy experimentalists in the world and they have gone to great lengths to design and calibrate their equipment so that they have convincing evidence that the signal is real. Dozens of other groups around the world have searched unsuccessfully for this signal and, with such a difficult experiment; we will have to wait for independent confirmation."

The difficulty of making the observation means that scientists have been cautious about hailing the results until they can be thoroughly confirmed. But if true they will mark a discovery that could open the door to many new kinds of breakthroughs, researchers said.

"The apparent detection of the signature of the first stars in the universe will be a revolutionary discovery if it stands the tests of time," said Brian Schmidt, a Nobel Prize-winning astrophysicist.

"While the detection appears robust, it is an incredibly challenging measurement, and needs to be confirmed. The fact that the detection is much stronger than expected, and easily explained, is particularly exciting.

"Exciting because it might reflect new physics (as suggested in the paper and companion paper), but also exciting because it suggests that the upcoming generation of radio telescopes will have lots to look at."

The Independent

PLUS POINTS

Surviving on blood

Collecting a vampire bat's faeces is not easy. You must go into the jungle, to the cave where the bats live, then lurk at the entrance at dawn or dusk. As the bats come winging in or out, you catch them in net spread across the cave mouth and transfer them to a cloth bag. Then, you wait.

Sometimes, says M Lisandra Zepeda Mendoza, who works in bioinformatics and is an author of a recent paper drawing on this raw material, you don't get what you need. "They get shy," she says, and one has to let them go before they release a sample.

By combining an understanding of what lives in a vampire bat's gut with the flying mammal's genome sequence, they have revealed tantalising insights into how the blood-supping creatures manage to survive on such an unusual food.

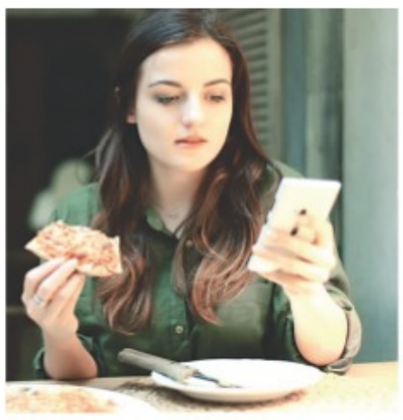
Blood, it turns out, is a very difficult thing to live well on. There are almost no carbohydrates — it's nearly all protein — and few vitamins. Even worse, it's often laced with viruses. As blood-eating mammals, vampire bats, which live in the forests of Mexico and Central and South America, are particularly intriguing.

For the study, which was published last month in *Nature Ecology and Evolution*, Mendoza and colleagues compared their vampire bat genome and gut microbiome with those of three other bat species — a bat that eats fruit, one that eats insects and one that eats mice, lizards and other small animals.

Vampire bats had the same general groups of bacteria in their guts as other bats. But when the researchers looked at what the microbes were making and doing, they found big differences. In vampire bats, the microbes looked to be focusing on metabolic tasks such as breaking down proteins and producing vitamins that the bats might otherwise lack. That suggests that only by looking at the microbiome and the genome together is it possible to understand how animals with odd diets have made it work.

The Independent

No phones please



You probably already know this, but using your phones at the dinner table is not a good idea — and new research shows not doing so is for your own good.

Researchers from the University of British Columbia in Canada have found that using your phone during a meal could negatively affect your own enjoyment. The study, which was published in the *Journal of Experimental Social Pyschology*, found that phones at the table means distracted diners who are less socially engaged.

According to one of the researchers, Elizabeth Dunn, the difference may be small but it still has a significant enough impact. The professor of psychology was quoted by *Time* magazine as saying, "(Phones) do make a difference. But it's a small enough difference that you could easily overlook and not even necessarily realise how they are altering your experience in subtle ways during social interactions."

The study involved 300 people, who were asked to have dinner with friends or family. Half of the group were told to keep their phones on the table, as they would receive a question related to the study by text during the meal, while the other half were told to keep their phones away as they would receive the questions on paper. After the meal, all participants were surveyed on their levels of enjoyment, phone use, and overall dining experience.

The experiment found that even when the phone users were engaging in face-to-face interactions, they felt more distracted and had lower enjoyment. Distraction among phone users also meant higher levels of boredom and a worse overall mood.

The Straits Times/ANN