

Photosynthesis used to Power an Animal's Brain

UNLIKE plants, animals and humans cannot carry out photosynthesis to generate their own oxygen, yet human brains cannot function without an adequate supply of oxygen as they need massive amounts of energy to function. Researchers have now found a way to harness photosynthesis to supply neurons with oxygen, as reported in the journal *iScience*.

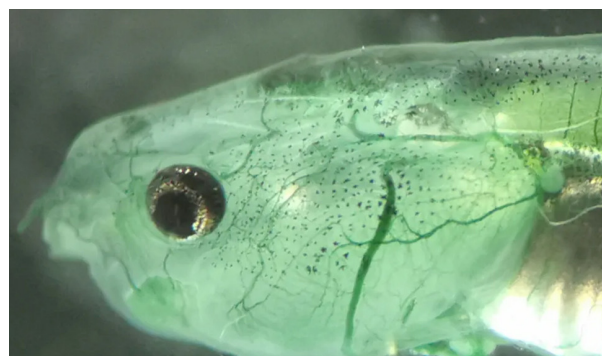
The researchers injected either cyanobacteria or green algae into tadpoles of *Xenopus laevis* and deprived them of oxygen, causing brain activity to cease. Exposing the modified animals to light, which allowed the microbes to make oxygen from CO₂, restored their neural activity.

The researchers employed an elegant and easily reproducible experimental approach to examine the effects of activation of photosynthetic organisms as a way of directly increasing oxygen levels in the brain. The work has been described as proof of principle and “an important first step in using natural resources to address pathological impairments” that deplete oxygen in the brain, such as heart attack and stroke.

Neuroscientist Hans Straka of Ludwig Maximilian University of Munich (LMU) and his group have been interested to study oxygen consumption in the brain and used a well-established technique in which they removed the head of a tadpole and kept it alive and functional for a couple of days in a liquid environment that supplies both oxygen and nutrients. Straka and LMU plant biologist Jörg Nickelsen decided to investigate whether it would be possible to make photosynthetic microorganisms supply the brain with oxygen.

Some researchers grew green algae (*Chlamydomonas reinhardtii*) and cyanobacteria (*Synechocystis* sp. PCC6803), which both produce oxygen upon illumination. Then, they injected a slurry of either algae or cyanobacteria into the hearts of tadpoles just after their forelimbs emerged. Their hearts pumped the microbes throughout the animals' vessels, including into the vasculature of the brain.

The researchers found that upon illumination, the oxygen concentration in the ventricles of injected animals went up. Untreated animals or those that received strains of algae or cyanobacteria that were mutated to not produce oxygen did not show an increase in oxygen concentration. When the researchers depleted oxygen from the water the animals swam in, neuronal activity as measured by electrical recordings of representative nerves



stopped. But they were able to restart activity in the brain by shining light on animals that had received injections of microorganisms. When they turned off the light, neuronal activity ceased again.

Although the experiment was a success, according to the researchers, “it’s not clear whether the findings could be translated to treat conditions in which the brain is starved for oxygen”. They point out that *Xenopus laevis* tadpoles are transparent and light can easily pass through the skin to activate photosynthetic machinery to produce oxygen. Thus, use in more complex animals would be difficult, as light does not easily traverse the skin and may not reach the vasculature to activate the photosynthetic organisms. The researcher also points out that, while low oxygen can be a problem, excess oxygen can also exacerbate brain injuries. “Thus, the inability of oxygen levels to be controlled properly through the use of these photosynthetic organisms would be just as detrimental as the hypoxia itself.” Trying the technique in brain organoids and slices first would give more insight into its physiological effects.

The research is still at the early stages and taking the strategy to the clinic is “very far away”. In the near term, the research team will focus on several questions, including the immunological effects of introducing the photosynthesising microorganisms, and whether or not the sugars that the microbes produce can be used by the tadpoles' brains.

According to experts, approaches where microbes are artificially inserted into cells or tissues to modify their function are largely unregulated and under-scrutinised in comparison to widely used genetic modification techniques such as CRISPR that target one gene. The unknowns, as well as examples of pathogenic algae, make this strategy a bit risky. “But the potential implications are also just fascinating to speculate about: Can we get away from breathing as a way to keep our brains going?” Maybe, there is a need to look at it.

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First Record of a New Range of Snake Species

THE distribution of *Fowlea sanctijohannis* Boulenger, 1890 has been restricted to South Asia (eastern Afghanistan, northeastern Pakistan, northern and northeastern India, Nepal, and northern Myanmar). In India, various studies indicated that the species has been reported from the Jammu & Kashmir, Himachal Pradesh (Kullu district), Arunachal Pradesh (Changlang district), and West Bengal (Darjeeling district). Some ambiguous records on the presence of this species in Assam and the Himachal Pradesh States have also been provided. Similarly, some workers have included the species in the checklists of reptiles of India, without providing descriptions or locality records.

This study constitutes the first-ever record of a new range of *Fowlea sanctijohannis* in North India. We discovered an individual of *F. sanctijohannis* of unknown sex from the residence campus of the Divisional Forest Officer in Kotdwar city. The area lies in the Kotdwar forest range of the Lansdowne Forest Division. The snake was rescued successfully and released in the nearby forest. The morphological characters of the living specimen were documented properly. Gernot

Vogel, Patrick David, and Ashok Captain, the renowned herpetologists & conservationists, were contacted for providing valuable inputs in the identification of the species reported herein.

The Lansdowne Forest Division is one of the most diverse wildlife habitats in the northwestern Shivalik landscape, which constitutes an important repository for the regional reptilian fauna. The area from where the species was recorded lies within the tropical dry deciduous forest, and a tributary of the river Ramganga (Kho river) flows across the area.

Considering that records for the presence of *F. sanctijohannis* in Uttarakhand State were previously unconfirmed, our report constitutes the first-ever record of a new range of the species in north India.

F. sanctijohannis is listed in Schedule IV of the Indian Wildlife (Protection) Act, 1972. The Upper Gangetic Plains constitutes an important herpetofauna repository. It is proposed that a baseline study be initiated to demarcate the geographical distribution and status of *F. sanctijohannis* in north India.

This study has been published in *National Academy Science Letters*.

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Living specimen of *Fowlea sanctijohannis* recorded from the Lansdowne Forest Division, Uttarakhand, North India



The Miraculous ‘Mirchi’

THE Chilli plant began synthesising the alkaloid capsaicin in its attempts to survive the onslaught of fungi and mammals. Capsaicin has however become an indispensable ingredient of a large number of cuisines all over the world with potential in several therapies and even control of riots.

Capsaicin is responsible for the pungency, hotness, and piquancy of the chillies. The chilli plant belongs to the family Solanaceae and the group called nightshades, so named for their ability to grow in shades and bloom at night. They are also known to contain toxic chemicals that induce hallucinations as well as narcotic-like substances. There are five domesticated species of chillies grown all over the world – *Capsicum annum*, *Capsicum frutescens*, *Capsicum chinense*, *Capsicum pubescens*, and *Capsicum baccatum*.

As a means of fighting predation, the chilli plant employs capsaicin, a nitrogen-containing compound belonging to the class alkaloids, that gives the feeling of ‘fire’ to the attacking animals. Capsaicin binds and activates the receptors that sense heat. Animals including squirrels, bears and bats find the fruits too ‘hot’ and unpalatable. In Assam, it has been a practice to make fences of ropes dipped in chilli extract to ward off elephants from damaging crops. Birds, that do not contain the capsaicin-sensitive heat receptors, find the chilli fruits desirable, eat them, swallow their seeds which pass through their guts and germinate at far off places from their droppings.

Chillies and capsaicin are currently in news

because of the researches conducted by a team of Dr David Jay Julius, of the University of California at San Francisco, in which they have characterised the heat receptors of humans, sensitive to capsaicin. They were able to transfer the gene that synthesised the heat receptor, present abundantly in nerve cells, to a type of cell that lacked it. The gene produced the receptor in the cells which were activated by heat as well as capsaicin and became a useful tool for the characterisation of the receptor and discovery of drugs that control chronic pain. Their researches that unveiled the process by which the nerve cells respond to heat were published in 1997 in *Nature*. Dr Julius also shared this year’s Nobel Prize in physiology and medicine with Dr Arden Patapoutian, from Scripps Research in La Jolla, California, who worked on receptors that respond to pressure.

It is interesting that humans, like other mammals, contain capsaicin-sensitive receptors on the tongue and some other parts of the body, including the skin, eyes and gut. The burning sensation/piquancy caused by capsaicin is however loved by people all over the world, who seem to derive a feeling of euphoria and pleasure after consuming chillies in limited quantities.

Chillies have emerged as the most widely used spice globally and are cultivated in a majority of countries in land spread over 1.9 million hectares. The demand for capsaicin products like hot sauces like Tabasco, salsas, and pickles is high and almost all major manufacturers of ketchups also market “hot” varieties containing chillies.

While it is erroneously assumed that the hotness of chillies and peppers is one of the tastes that the human tongue can detect, it is actually a sensation akin to exposure to high temperatures.

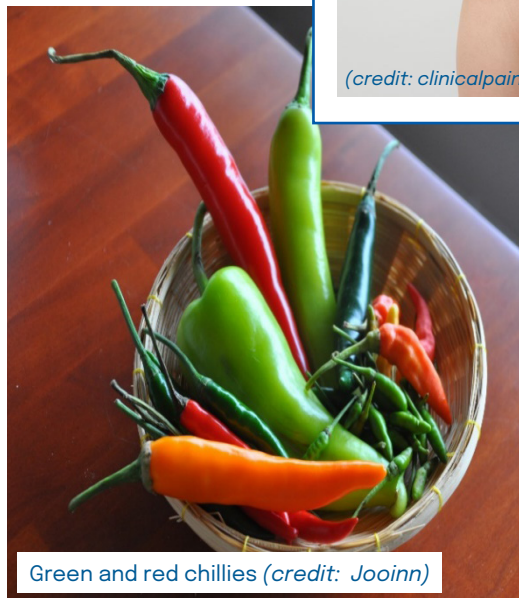
Chillies are rich in vitamin C, vitamin A and vitamin B6. They contain about 10% protein, 10% carbohydrates and 0.5% fat, are rich in calcium and magnesium and iron. Capsaicin has anti-bacterial properties and helps fight foodborne illnesses. It is known to stimulate the production of saliva and gastric juices and aid digestion. Chillies are claimed to promote a healthy heart, relieve joint pains, mitigate migraine, prevent allergies. Claims have also been made of its stimulatory effect on blood circulation and even in fighting

stomach ulcers. Capsaicin as an analgesic has been used in ointments and dermal patches for pain relief.

Sprays containing capsaicin are also used for self-defence. Chilli may even become a part of India’s defence armoury and efforts are being made to develop tear gas canisters and hand grenades containing India’s hottest chilli *Bhut Jolokia* to control violent crowds without causing serious harm to them.

Capsaicin containing a patch for pain relief

(credit: clinicalpainadvisor.com)



Green and red chillies (credit: Jooinn)

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Plastic Eating Bacteria: Solution to Plastic Pollution

IN 2016, Japanese researchers while studying the biodiversity of the soil around a plastic bottle recycling facility, were surprised to find a strain of bacteria that was capable of not only decomposing a particular type of plastic known as Polyethylene Terephthalate (PET) but also use the breakdown products as a source of carbon and energy for their growth. It suggested that the discovery could provide a solution to the mounting problem of plastic pollution around the globe.



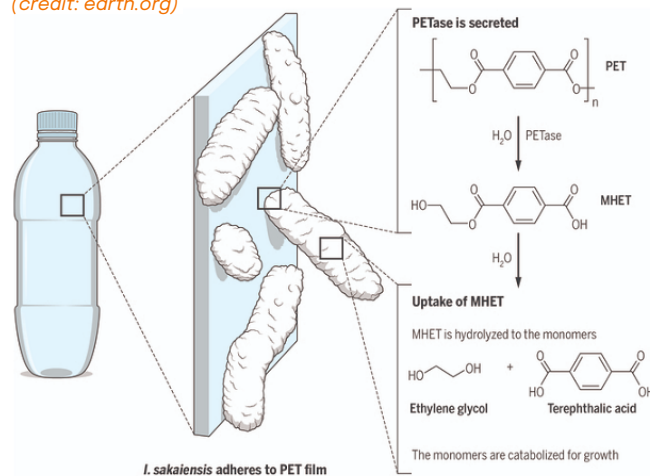
PET is one of the most abundant types of plastics produced. It is estimated that 70 million tonnes of PET are produced globally for the manufacture of single-use plastic bottles, textiles, carpets, solar panels, table tennis balls, automobile parts and so on. Though PET can be recycled by thermo-mechanical process, it is not practised because of its high cost. Alternatively, a small part of the used PET items is crushed for recycling.

The Japanese discovery observed that a gram-negative, rod-shaped soil bacteria named *Ideonella sakaiensis* 201-F6 can depolymerise PET into its monomers TPA and EG, which can be reused, without consuming more of the starting petroleum products. The researchers observed that the bacteria secretes two enzymes (PETase & MHETase), which act in tandem to hydrolyse the ester bond holding the monomers and thus depolymerise PET. The whole process suggests opportunities for biobased plastic recycling of PET by extracting these enzymes in an industrial set-up.

Ideonella sakaiensis 201-F6 decomposes a thin film of PET in 6 weeks at 30°C. But this is too slow for industrial applications. Dr John McGeehan from the Centre for Enzyme Innovation in the UK and his team have tweaked genes for PETase and MHETase in *Ideonella sakaiensis* 201-F6 and produced variants that can depolymerise PET faster.

Furthermore they joined the two enzymes to produce a 'super enzyme' which was found to be six times more

(credit: earth.org)



Steps in PET depolymerisation by *I. sakaiensis*

efficient than the wild type and can also degrade an important PET replacement biopolymer Polyethylene-2,5-furandicarboxylate (PEF).

Subsequently, several other PET and other plastics hydrolysing enzymes have been reported. In 2020 scientists from Carbios have reported an enzyme Leaf-branch Compost Cutinase (LCC) that outperformed all the known enzymes in depolymerising PET. They have reported that under optimum conditions a tonne of waste plastic bottles was 90% degraded within 10 hours. These degraded materials were used to create new food-grade plastic bottles.

Researchers at the Shiv Nadar University in Greater Noida have isolated in 2019 two strains of bacteria *Exiguobacterium sibiricum* strain DR11 and *Exiguobacterium undae* strain DR14 that would eat polystyrene, which is used in the manufacture of disposable cups, cutlery, toys, packing materials, etc.

Another plastic of interest in this context is Polyurethane (PU). Millions of tonnes of PU are produced every year. It is used in the manufacture of sports shoes, nappies, kitchen sponges, foam for insulation, etc. After use, most of these items go to landfills since it is too tough for recycling. In 2020 researchers in Germany found in PU dumps a bacteria identified as *Pseudomonas* sp capable of breaking down PU. Generally, the degradation of PU releases toxic chemicals which would kill most types of bacteria. But this strain can survive and use the breakdown products as a source of carbon and energy.

Experts feel that the production of such enzymes to meet industry requirements can be achieved in a few years and it can open a strategy to remediate the environmental scourge due to the accumulation of plastic.

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