

CAPSULE



Origin of photosynthesis
Imperial College London researchers, studying *Heliobacterium modesticaldum* - an ancient bacterium - have found structures in it that suggest photosynthesis may have evolved a billion years earlier than is presently believed, and oxygenic photosynthesis need not have evolved from anoxygenic photosynthesis.



Love hormone
Oxytocin is believed to regulate maternal behaviour. Now, a study in *PLOS ONE* finds a group of cells activated by oxytocin present in one area in female mice but not in the same area in males. Activation of the receptors correlates with estrogen presence, implying the cells can induce maternal behaviour. The finding has potential for treating postpartum depression.



Fountain of youth
Senescent cells are the opposite of stem cells: they can never divide again. New research finds that ageing, senescent cells stop producing nucleotides, the building block of DNA. When young cells were prevented from producing nucleotides, the cells became senescent. The findings have potential to help with ageing and related diseases.

IIT Madras: Breath humidity sensors for wearable electronics

It detects ethanol, acetone in oral breath of alcoholics, diabetics, respectively

R. PRASAD

A nanofibre sensor capable of sensing minute variations in relative humidity levels in the exhaled breath has been fabricated by a team led by T. Pradeep from the Department of Chemistry at the Indian Institute of Technology (IIT) Madras. The highly sensitive sensors can be integrated into wearable electronics and might have applications in assessing human metabolism and calorie burn rates.

The sensor can also detect traces of ethanol and acetone, two major components present in the oral breath of alcoholics and diabetics, respectively.

Quick response time

The sensors have very quick response time of about one second and can detect a range of relative humidity from 0-95%. The sensor was found to have high stability. "Even after exposing the sensor to ambient conditions for a week, we still found the response time to be about one second and could match the breathing rates quite effectively," says Sathvik Ajay Iyengar who was a short-term student with Prof. Pradeep's team and is one of the first authors of a paper published in the journal *ACS Applied Electronic Materials*.

The breath rate was measured for one-two hours prior to and after exercise. The heart rate is higher soon after exercise and this is reflected in higher breath rate. "We intend collecting breath rate over a period of few days to establish the relationship between heart and breath rate and metabolism," says Pillalamarri Sri-



Portable: The nanofibre sensor can be easily integrated to the base of wearables such as common place masks, say (from right) Pradeep, Pillalamarri Srikrishnarka and Sathvik Ajay. *SPECIAL ARRANGEMENT

rishnarka from IIT Madras, the other first author of the paper.

The nanofibre mat is fabricated by electrospinning poly(vinylidene fluoride) and reduced graphene oxide. Coating the mat with polyaniline turns the mat into a sensor.

The moisture in the breath reduces the resistance of the sensing material thereby allowing more current to flow. So when a fixed voltage (1-2 volts) is applied to the sensor, there is more current that is detected when the sensor comes in contact with moisture in the breath.

"In the presence of humidity, 100-1000 times more current can be detected using our sensor compared with other sensors," says Iyengar. "So when the current measured is in nanoampere range when other sensors are used, we were able to measure it at microampere range using our sensor." When there are traces of

ethanol and acetone in the breath, the resistance of the sensor increases and conductivity reduces. Hence, there is a dip in the current measured from the baseline. "The reduction in conductivity is because of the absence of moisture - the hydrogen bond between the sensor and analyte [ethanol and acetone] is less likely to form," says Srikrishnarka.

"Polyaniline is the major contributor of current conduction, and reduced graphene oxide complements it. The combination of polyaniline coating and reduced graphene oxide allows higher current conduction," says Srikrishnarka. "In the absence of reduced graphene oxide, polyaniline can still conduct current but at a significantly lower level. The reduced graphene oxide alone does not help conduct current."

"The coating of the mat with polyaniline occurs in water and so can be scaled up to get large-scale coat-

ings. This process also makes it easier, quicker and relatively more eco-friendly than other commercial processes," says Prof. Pradeep. The nanofibre mat obtained is very thin and offers breathability. In order to integrate sensors like this into wearable electronics to monitor breath, resistance-free air flow is the key.

Portable sensor

To make the sensor truly portable, the researchers are using the popular Arduino prototyping platform coupled with Bluetooth module for collecting data wirelessly.

"We initially tested the sensor performance using an Arduino Uno and we observed a good response. We intend to team up with other departments to recognise patterns by using machine learning and to develop mobile-friendly apps to monitor health," says Prof. Pradeep. The team plans to take the work forward via startup initiatives.

Predicting pollution levels using oceans' memory

Patterns like El Nino can help predict weather conditions and pollution, nearly a season in advance

ASWATHI PACHA

Researchers from China and the U.S. have been successful in predicting air pollution levels in northern Indian States. The model they have developed shows 75% accuracy in predicting pollution levels, and the prediction can be done even a season in advance. The model takes into account certain climatic patterns related to the ocean which have a regulatory effect on the wintertime air pollution over northern India. Studying these patterns can help predict pollution levels.

India has been emerging as one of the world's most polluted countries, with particulate matter PM 2.5 levels spiking more than 999 microgram per cubic metre in parts of Delhi last year.

Studying a combination of El Nino, Antarctic Oscillation and the anomalies in sea surface temperature during autumn (September-November), can help forecast the pollution conditions in winter (December-February).

The statistical model developed by the team can also help the government in adjusting policies and strategies for pollution control before winter comes, the paper published in *Science Advances* adds.

It is known that the aerosol over an area is modulated by meteorological conditions and circulation patterns. Stagnant weather conditions such as low wind speeds and descending air can favour rapid aerosol formation and accumulation. Understanding these climatic factors which influence the wintertime haze pollution can help foresee the future ventilation conditions too.

Also, the ocean data serves as a memory and large-scale climate patterns like El Nino can tell what the weather conditions and pollution will be, nearly a season in advance.

The team constructed a computer model which incorporates the El Nino and Antarc-



Winter haze: The ocean data serves as a memory to foretell how the weather conditions and pollution will play out. *FILE PHOTO

tic Oscillation data for autumn. Climatic data from the National Oceanic and Atmospheric Administration, U.S for the period 2003-2018 and the aerosol optical depth observed by various satellites were also used.

"It will help identify if the weather conditions will be favourable or unfavourable for pollution, helping the government frame a more stringent pollution control plan if needed," explains Dr. Meng Gao, assistant professor at the Hong Kong Baptist University, China. He is the first author of the study.

The Antarctic Oscillation does not act directly to influence Indian climate but affects the Indian Ocean Meridional Dipole which in turn plays a role in our climatic conditions.

He added that there have been several studies in China connecting extreme pollution with East Asia winter monsoon, Arctic sea ice loss, the El Nino-Southern Oscillation, and Pacific sea surface temperature anomalies. The predictions from these studies have helped the government make the needed reforms, especially in its industrial sector, helping bring down pollution levels in the country.

Bees use complex memory for communication

Waggle run correlates with distance from food site to hive

L.T. ILAVENIL

Bees use waggle dance to communicate with their nest mates the flight distance and direction to foraging sites. Now, a research team led by Axel Brockmann at the National Centre for Biological Sciences (NCBS), Bengaluru, has studied how bees use complex memory to generate dance duration to communicate a change in foraging distance.

Bees are known to waggle dance near the entrance of the hives. The duration of the waggle run of a dancing bee correlates with the distance between the food site and the hive. For instance, as the distance to the foraging site increases, the duration of waggle increases too.

The team used the honey bee species *Apis mellifera* for the study. "Most of the research on the brain and behaviour of bees around the world is done with the help of *A. mellifera* and therefore we could put our results into the context of all the research done previously," says Dr. Brockmann.

Memory formation

To understand in detail memory formation in bees for waggle dance, the researchers trained a group of honey bees to forage food kept 300 metres away from the hive. When the food source was shifted to 400 metres, most of the bees took multiple trips to the new foraging site to update their dance. Till such time the bees formed the new memory, they displayed an intermediate dance duration indicating distances in between the new and old foraging locations.

"One must assume that the bees, when arriving at the new feeder site, know the distance between the feeder and the hive. If not, they will not be able to find the way back. The occurrence of intermediate dance durations indicates that the bees use memo-

ry of both distances when they update the dance information," says Dr. Brockmann.

It was also noticed that the memory processes of bees responded differently depending on whether the foraging distance was extended or shortened from the original distance of 300 metres. When the feeder was shifted from the original distance of 300 metres to 200 metres and back to 300 metres, the bees were able to update the feeder distance following each shift and communicate the distance correctly through waggle dance.

In contrast, when the feeder was shifted from the original distance (300 metres) to 400 metres the bees were able to communicate the longer foraging distance. But when brought back to the original distance of 300 metres, it continued to exhibit the waggle duration for 400m.

"The foraging site at 400 metres was new to the bees unlike the one at 200 metres which the bees visited earlier during the training process. Therefore, when the feeder was first shifted to a novel site [400 metres] and then back to the original site [300 metres], honey bees did not update the waggle duration after the second shift. This is likely due to new memory interfering with the recall of an older one," says Arumoy Chatterjee, a PhD student at the institute. He is the first author of the paper published in *Journal of Experimental Biology*.

"Previously, there was no easy way to dissociate the waggle dance activity of honey bee foragers from their foraging activity. Our experiments now provide us with the means to dissociate them, an essential first step towards understanding the mechanisms underlying the conversion of flight information to waggle dance information", adds co-author Ebi George, another PhD student at the institute.

Reversible superglue inspired by snail epiphragm

Snails secrete a mucous film which dries to forms a glassy structure that fixes them to the substrate

SHUBASHREE DESIKAN

A hydrogel-based adhesive that combines strength and reversibility has been developed by a collaboration of researchers based in the U.S. and Korea. This combination is not easily found in adhesives. The group has drawn inspiration from snails in developing this adhesive.

Snail mucous

When snails are startled or encounter discomfort, they shrink into their shells. They secrete a mucous film around the opening of their shell, which on drying forms a glassy structure that both seals them in and fixes them strongly to the object they are sitting on. This structure formed by the dry mucous is called an epiphragm.

The strength of this epiphragm stems from the fact that before it dries it penetrates into the microscopic crevices on the surface the



Firm grip: To demonstrate this, we used two 2-square-centimetre pieces of the adhesive to suspend me (85 kg) in the air, says Jolly. *SPECIAL ARRANGEMENT

Similarly, the hydrogel developed by the group hardens from its wet state with a modulus of 100 pascals to a dry state value of 2.3 gigapascals.

"The ability to go from being as soft as Jello to being 1,000 times stiffer when dried, that is, hard as a bottle cap, and to do so without shrinking significantly in the process, is what makes our adhesive special and strong," says Jason Christopher Jolly, a PhD student in the School of Engineering and Applied Science, University of Pennsylvania, and an author of the paper published in *Proceedings of the National Academy of Sciences*.

Soft hydrogel

Unlike commercially available wood glues (such as Fevicol) or superglues that are liquids when applied and solidify to perform the adhesive role, the PHEMA adhesive developed by the

group is like a solid that in its hydrated state is soft, wet and squishy. "In this state it is able to flow into and fill micro- and nanoscale surface grooves and pores, following which it can be dried to lock itself in place," explains Jolly in an email to *The Hindu*.

Strong adhesive

PHEMA, which stands for poly(2-hydroxyethyl methacrylate), has a remarkable adhesive strength. According to the researchers, a 1 x 1 cm square sample of the adhesive can hold an object weighing 91 kg. To compare this to a commonly used reversible adhesive, a strong 1 cm square of Velcro can support a weight of 12.2 kg.

"To demonstrate this, we used two 2 square centimetre pieces of the adhesive to suspend myself (85 kg) in the air," says Jolly.

The group ran into PHEMA rather serendipitously when Gaoxiang Wu, co-first

author of the paper, was cleaning out some old samples from his desk that were thin films of patterned PHEMA on slides he had prepared for another project. The idea was born when he found that the slides were stuck together and he could not separate them even with great effort.

The group has filed for patents for the technology. Further, while the adhesive shows strength and reversibility, it is still limited to use in relatively dry environments, as its switching mechanism relies on water. "It is limited to applications that don't require very fast switching," says Jolly.

"Our plan is to tweak the chemistry so as to not be water-based but to use organic solvents. We are also working on engineering more adhesives of this class that can be switched on with different stimuli such as light, heat or electrical pulses," he adds.

IISER Mohali finds that zebrafish use landmarks for navigation

The presence of colourful landmarks, visible even in turbid conditions, plays an important role in improving foraging success

R. PRASAD

Low to extremely turbid water conditions are quite common in areas that humans inhabit. Under such conditions, it is a challenge for fish to forage food as they rely on vision to navigate and find food. Now, in a study carried out using zebrafish, researchers at the Indian Institute of Science Education and Research (IISER) Mohali have found hard evidence to support how turbidity negatively affects foraging efficiency and how they learn to cope with it. The study was done in collaboration with IISER Kolkata.

The team led by Dr. Manjari Jain from the Department



Smart fish: The zebrafish used visual cues and landmarks to navigate to foraging sites. *NAKUL RAJ

termining success in foraging food. The results of the study were published in the journal *Biology Letters*.

Colourful landmarks

In addition to acclimatisation, the presence of colourful landmarks that are visible even in extremely turbid conditions plays an important role in improving foraging success. The study could conclusively show that zebrafish use visual cues to navigate to foraging sites especially when turbidity is high and visibility is low.

"The cornerstone of the study is the visual learning capability of zebrafish. We found the wild freshwater zebrafish (*Danio rerio*) are cap-

able of using familiar visual landmarks to find food locations even when vision is compromised," says Dr. Jai

"This is the first study to show the ability of zebrafish to use any landmark for navigation," she says. The study highlights the important role of behavioural plasticity and spatial learning to cope with altered sensory environments, which in this case is increased turbidity of the water they live in.

Effect of turbidity

"Here we demonstrate the detrimental effect of turbidity on zebrafish with respect to foraging. Turbidity is likely to increase the metabolic cost associated with foraging

behaviour," Dr. Jain stresses. "But what is unique is that within one month of acclimatisation they seem to deal with it. The foraging ability improves drastically. It highlights the importance of acclimatisation."

If zebrafish do indeed learn to cope with turbidity and find food in a matter of one month, should the effect of turbidity on zebrafish matter at all? "Just because they are able to cope with turbidity in a month does not mean that chronic exposure to turbid water is not going to affect them. The resilience to survive in turbid water has not been studied," she warns.

"If one of the sensory mo-

dalities is compromised in some species they are capable of switching over to another. But in the case of zebrafish we found they continue to use visual sensory to locate food," Dr. Jain says.

For the study, the researchers collected 160 zebrafish from a clear stream near Kolkata. The fishes kept in tanks were fed fish pellets and *Artemia* (genus of aquatic crustaceans). They were trained for two weeks to navigate and locate food. After training fish to find food, 75 fishes were split into three groups and the different groups were acclimatised for a month in clear, low turbid and high turbid conditions. The low turbid condition

mimicked coastal water and high turbidity mimicked an estuary mouth.

Acclimatisation

The researchers found that one month of acclimatisation was sufficient for fishes to forage food even when the turbidity was high.

Even during training, the researchers did find that zebrafish in turbid water did learn to use colourful stones as proxy for food locations. During the tests, even in highly turbid conditions, the ability to locate food was superior when there landmarks. Their ability to locate food was compromised when the landmarks were not present.