CAPSULE

Unlocking plant growth
Researchers have unveiled the structure of one of the key components of photosynthesis. This is cytochrome b6f, a protein complex that significantly influences plant growth by means of photosynthesis. With this understanding and further research, larger plants that yield more food can be developed. The study was published in *Nature*.

Ritual secrets from DNA
There are doubt as to whether ancient Egyptians, for ritual use, domesticated the Sacred Ibis. A study published in *PLOS* argues that the genetic diversity of DNA from mummified specimens is similar to that from modern Sacred Ibises. If they had been tamed, there would be less diversity. Thus, the birds were caught just for mummification.

Monkey embryo cultured
A study published in *Science* reports that cynomolgus monkey embryos were cultured in the lab and studied up to 19 days post-fertilisation. This is a feat as mammalian embryos attach themselves to the uterine wall and develop there. Along with ethical issues, this makes it difficult to grow them outside. The study may guide ones on human embryos.

Carbon capture ways
A study published in *Nature* investigates the potential scale and cost of 10 different ways of capturing and reusing carbon dioxide, such as in fuels, chemicals, plastics and building material. On average, 0.5 gigatonnes of carbon that may escape into the atmosphere could be used by each pathway.

Ghost imaging
A paper in *Optics Letters* describes how a moving object may be imaged using unconventional techniques known as ghost imaging. Moving objects appear blurry when imaged. The researchers combined the data on the position of the moving object with the blurry images to produce a clear picture. -

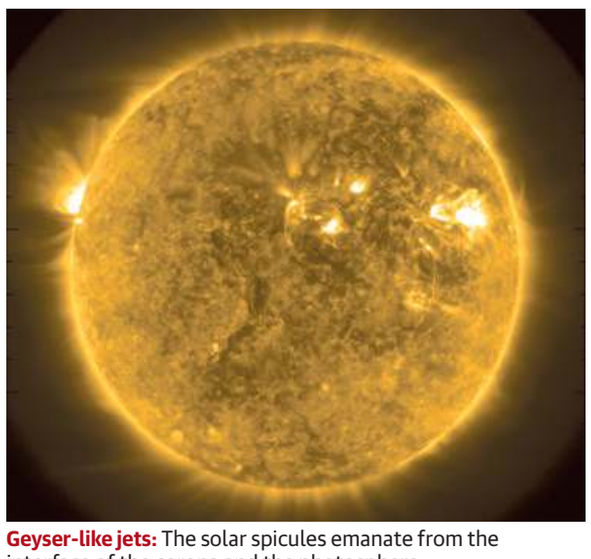
Long-standing conundrum on the Sun's atmosphere solved

The study used high-resolution and high cadence images

SHUBASHREE DESIKAN

The Sun is one of the most familiar celestial objects - it is on the sky everyday. Yet, it harbours many a puzzle for the solar physicist. One of the puzzles concerns its surface and atmospheric temperature. An international team of researchers including one at Indian Institute of Astrophysics, Bengaluru, has had a go at this question. These observations may have unravelled why the Sun's atmosphere is hotter than its surface.

The temperature at the core of the Sun is nearly 15 million degrees Celsius, while that at its surface layer, known as the photosphere, is merely 5,700 degrees C. The natural thing to expect is that still further outwards, in its atmosphere, known as the corona, the temperatures would be comparable to that at the surface (photosphere). However, the temperature of the corona is much higher. It starts increasing outside the photosphere, reaching a value of about one million degrees or more in the corona.



Geyser-like jets: The solar spicules emanate from the interface of the corona and the photosphere. ▪ TANMOY SAMANTA

Coronal heating puzzle

One would expect that as there are no extra sources of heat, when you move away from a hot object, the temperature steadily decreases. However, with respect to the Sun, after dropping to a low, the temperature again rises to one million degrees in the corona which stretches over several million kilometres from the surface of the Sun. This implies there should be a source heating the corona.

The puzzle of coronal heating has been tackled by many theories. Now, in a paper published in *Science,* the team of solar physicists has made observations and matched it with an analysis that explains this conundrum.

Spicules in the Sun

The key to the puzzle lies in geyser-like jets known as solar spicules that emanate from the interface of the corona and the photosphere. While in a photograph these look like tiny hairlike projections, they are in fact 200-500 kilometres wide and shoot up to heights of about 5,000 km above the solar surface.

It has been suspected that these spicules act as conduits through which mass and energy from the lower atmosphere bypass the photosphere and reach the corona. The present study, led by Tanmoy Samanta and Hui Tian of Peking University, China, has deciphered how these spicules form and also shows that they act as conduits through which hot plasma is carried into the corona region.

"Our observations show that these spicules heat up while propagating upward, reaching the coronal temperature. They are made of plasma - a mixture of positive ions and negatively charged electrons," says Dr Samanta. Objects at different temperatures emit light of different wavelengths. "The coronal plasma emits light in extreme ultraviolet. We find an increase in coronal intensity (emission) as spicules propagate upwards," he explains.

The team did their observations using the 1.6-metre Goode Solar Telescope at the Big Bear Solar Observatory (BBSO), the world's largest solar telescope, with the NIRIS instrument. "This is a high-precision instrument and can measure magnetic fields with high sensitivity," says Dipankar Banerjee, from Indian Institute of Astrophysics and one of the authors of the paper. The researchers also matched these observations with simultaneous observations form the Atmospheric Imaging Assembly in NASA's Solar Dynamic Observatory spacecraft.

Frequent images

The research involved taking many high-spatial-resolution images of the same region of the Sun within a short time. This is known as high-cadence. "Since spicules have a very short lifetime - from 10 to 100 seconds - to understand their dynamics, we need a higher cadence. This is also a limiting factor of many solar telescopes," says Dr Samanta.

The key findings are that bursts of spicules originate from the boundaries of web like networks of magnetic structures in the surface. Near their footpoints, there emerge magnetic elements that have opposite polarity to the existing magnetic network. When the structures with opposing polarity run into each other, they cancel out. This was seen at the footpoints of some spicules. "Exactly at the time of cancellation, we found the presence of spicules, which are also responsible for heating the upper atmosphere," says Dr Samanta, explaining how the spicules originate as per their observations.

SeeTB: new diagnostic tool for detecting tuberculosis

Device shows better sensitivity than existing methods

ASWATHI PACHA

Accounting for over a million deaths in 2018, tuberculosis (TB) remains a major healthcare burden for most developing countries, and India still leads the list with the largest number of cases. "The World Health Organization has aimed at eliminating TB by 2035, and the Indian government has vouched to do this by 2025. If this ambitious plan has to succeed, we should be concentrating on not missing out on any case," says Dr. Sayed E. Hasnain from Jamia Hamdard University in New Delhi.

With this aim in mind, he and his collaborators have developed a small device that can be attached to a simple optical microscope to convert it into a fluorescence microscope, thus enabling better TB diagnosis at the point-of-care.

Handy and fast: The device is battery operated and allows for quick identification of the bacteria.

> **CLR-SeeTB [combination] is a highly economical platform and is most suited for a country like India which has a high TB burden.**
> NASREEN Z EHTESHAM
> National Institute of Pathology

Battery-operated device

Named SeeTB, the device is battery operated and allows quick identification of the bacteria. The team has also developed a clearing reagent called CLR which helps in thinning the collected sputum thus enhancing the bacteria detection. A patent has been filed for both the reagent and the device.

"CLR-SeeTB is a highly economical platform and is most suited for a country like India which has a high TB burden," adds Dr. Nasreen Z Ehtesham, Director-in-Charge at the Indian Council of Medical Research-National Institute of Pathology and one of the authors of the paper published in *Scientific Reports*.

"Also, the currently used fluorescence microscopy requires infrastructure, an air-conditioned room, trained professionals and is functional only in tertiary health care centers. SeeTB can be used at the primary health care centres in the villages, and once diagnosed, the treatment can be started."

The device was used to test more than 300 suspected pulmonary patients. The results showed that compared to fluorescence microscopy, the CLR-SeeTB system had higher sensitivity.

Relative performance

Against bacterial culture studies, fluorescence microscopy showed 63.38% sensitivity while SeeTB system showed improved sensitivity of 76.05%.

When the performance was compared against GeneXpert, another diagnosis tool that looks for DNA markers of TB bacteria, SeeTB showed improved sensitivity. Also, while GeneXpert method takes about two hours, SeeTB can help find the bacteria in about 30 minutes.

3D printing

Dr. Ravikrishnan Elangovan from Indian Institute of Technology Delhi and one of the team members explains: "We used 3D printing to rapidly prototype this compact optical platform, and now we are using injection moulding to produce these components in large scale. This can help drastically bring down the cost, thus making it feasible for large scale distributions across the country."

The Indian Council of Medical Research has planned to start large scale validation of the CLR-SeeTB in its primary health research units at different locations in the country.

Collapse of ancient civilisation linked to megadrought

A series of natural events weakened agriculture, amplified conflict

PRESS TRUST OF INDIA

The Neo-Assyrian Empire – that thrived between 800 and 600 BCE centred in northern Iraq, extending to Egypt – may have collapsed due to a 60-year, climate related megadrought, according to a study.

The researchers, including Indian-origin scientist Ashish Sinha at California State University in the U.S., said the Neo-Assyrian Empire was by far the largest empire in the region up to that time, controlling much of the territory from the Persian Gulf to modern day Cyprus.

The study, published in *Science Advances,* noted that climate-related factors contributed to political instability, civil wars, and invasion by outside armies, that ultimately led to the civilisation's collapse.

The researchers said the Neo-Assyrian Empire experienced a series of megadroughts that probably triggered its collapse by weakening agriculture and amplifying conflict.

They analysed fossilised drip water in the Kuna Ba Cave in northern Iraq and assessed the quantities of radioactive isotopes, or variants, of oxygen and carbon atoms present across different layers of the cave formations to infer historical time based on changes in precipitation.

"Because the isotope record went all the way up to 2007 CE, we were able to correlate the stable carbon and oxygen isotope ratios with modern instrumental climate information from the region. This has enabled us to compare the modern isotope data with ancient layers," Adam W. Schneider, study co-author from University of Colorado, Boulder, explained.

The researchers found that the megadroughts that affected the empire started decades earlier than previously thought,

Climate-related factors have contributed to the collapse of several empires in history.

Understanding upside-down landings of flies

Turning around and settling on the ceiling involves four steps

ASWATHI PACHA

"When I was a student, Late Prof. K. S. Krishnan who was on the interview panel asked me, 'how do flies land on the ceiling?' Although seemingly an innocuous question, it turns out to be a really complex phenomenon," says Prof Sanjay Sane from the National Centre for Biological Sciences, Bengaluru. Now, after several years of research using the modern state of the art tools and months of video recordings his team has answered the question. The paper recently published in *Science Advances* notes that the inverted landing "involves a serial sequence of well-coordinated behavioural modules."

Complex task: The data indicates that ceiling landings may be more 'difficult' for a fly. ▪ GETTY IMAGES

Four steps

The international team lists out four steps that take place in the complex process which includes upward acceleration towards the ceiling and then based on visual inputs it begins to rotate - pitch and roll. It then flings all six legs and prepares to land, and in the final stage does a leg-assisted body swing and lands firmly.

Precision landing

The question is how is it possible to do all the four steps so precisely. It involves visual, neurobiological and gyroscopic inputs. The team used video recordings of how blue bottle flies land and by plotting the distance at which landing is initiated and speed at that point, they concluded that they have to initiate deceleration at 40 microseconds speed. For easy comparison, we blink our eyes at about 150 to 200 microseconds. If the fly missed initiating the landing response within this window, it ended up colliding with the substrate.

The team from NCBS had previously compared how houseflies land on the straight wall and inverted ceiling. The results published earlier this year in *PLOS ONE* noted that in both cases, the fly uses the same landing manoeuvres but there are also notable differences in both types of landing.

Difficult task

"To orient itself in an inverted position, a fly can either perform a roll rotation or a pitch rotation or a combination of both," explains Sujay Acharya, the first author of the paper from NCBS in an email to *The Hindu*.

"Vertical landings on the other hand are highly stereotyped. As the fly approaches the wall, it pitches up before contact. Our data also indicates that ceiling landings may be more 'difficult' for a fly. We observed that in close to half the cases, a fly landing on a ceiling bumped into it. Whereas, we did not observe such collisions for vertical landings."

Prof. Sane adds that, "This study will help us gain insights into how the nervous system acquires and integrates inputs from multiple sensory modalities to execute a fast but precise behaviour." He also explains that these flies belong to the Dipteran order which means they have only one pair of wings and their hind wings are modified into special structures called halteres, which helps in body orientation and alerts them when they are involuntarily pitching or rolling.

Inspired by nature

"We look at nature for inspiration. This helps drive the fundamental science of engineering, to understand how flies are able to solve these problems so we can apply them to future technologies," explains Prof. Jean-Michel Mongeau, one of the authors from Pennsylvania State University in a release. "This work reiterates how fast these [manoeuvres] are executed within an extremely small nervous system. This data can lead to new hypotheses for understanding how brains function."

Weeding out black hole mimickers by looking at gravitational waves

The universe contains not just black holes but many exotic objects, such as gravastars and boson stars

SHUBASHREE DESIKAN

In September 2015, the LIGO detectors in the US made history by directly detecting for the first time the merging of two black holes. Since then, LIGO, joined by other detectors around the world, has gone on to detect eleven events of which one is the merger of two neutron stars and the remaining ten, of pairs of black holes (binary black holes).

As they spiralled in towards each other and merged, the binary black holes let off characteristic gravitational wave signals. The properties of the merging black holes, namely the masses and spins could be arrived at by looking at the initial part of the signal waveform. Similarly, by carefully looking at the tail end - also known as the ring down part of the signal, the mass and spin of the final merged state (black hole) can be inferred.

Remote objects: The properties of merging black holes can be calculated from the initial part of the signal waveform. ▪ LIGO

> **There are not many ways to look for exotic objects, and gravitational waves could be one...**
> K.G. ARUN
> CMI, Chennai

The question emerges - whether other exotic objects exist that may act as black hole mimickers and give off similar signals. And if so, how is one to distinguish between such spinning black holes and exotic objects?

Theoretically, there are possibilities such as the so-called gravastars and boson stars which are black hole mimickers. For instance, a gravastar is a strange object that would have a core of exotic matter resembling dark energy with an external shell of normal star-like matter. "There are no observational evidences for their existence till date, but then, there were not too many ways in which one could look for them. Gravitational waves could be one..." says K. G. Arun, Chennai Mathematical Institute, Chennai, who led the study.

Gravastars spinning

The spinning of the compact object has a different effect on it whether it is a black hole or, for instance, a gravastar. Since the gravastar is filled with dark energy, it exerts a negative pressure on the outside. So when it spins it behaves differently from normal stars and black holes. When a normal star spins about an axis, it tends to bulge about the equator and get compressed at the poles. However, for a gravastar this effect is just reversed - It gets compressed near the equator and bulges out at the poles. Thus their shapes change differently when spinning.

"Any compact object, in general, can undergo deformations due to its spinning motion and these deformations are expressed in terms of what is called spin-induced multipole moments," says M. Saleem an author of the paper published in *Physical Review D,* who is a post-doctoral fellow at CMI.

"For black holes, due to the existence of event horizon, any property we measure from outside will depend on only its mass and spin, unlike other compact objects. This is the fact which we make use in our proposed test," he explains.

One property that can distinguish between a black hole and exotic object is known as spin-induced quadrupole moment. This parameter takes the value 1 for a black hole. "For other compact objects, the value ... of this parameter is different from 1 and will vary depending on the internal structure," says N. V. Krishnendu, the first author, formerly a PhD student at CMI, and now a post-doctoral researcher at Albert Einstein University, Hannover.

The researchers, including C.K. Mishra of IIT Madras, tested out their ideas on the events detected so far and found that the events of 2015, December and 2017, June were indeed just binary black hole mergers. These were the "low-mass" events for which their method is applicable. Further development of the idea can be used as a tool to discover exotic objects.