

The Earth's inner core is capped by snow made of tiny particles of iron, much heavier than the snowflakes seen in the atmosphere, a study published in the journal JGR Solid Earth finds. The iron-snow falls from the molten outer core and piles up in the inner core of the Earth creating stacks that are up to 320 km thick.



Quick to see

The peregrine falcon, one of the world's most common predatory birds, has the fastest vision in the animal kingdom and can register nearly 130 frames per second, according to a study published in the Journal of Experimental Biology. In comparison, humans see up to a maximum of 50 to 60 blinks per second. This is the first time scientists have studied the speed of vision among birds of prey, calculating how fast they see.



Early immunity

how a brief disruption in the guts of pre-born mice can compromise their adult immunity to rotavirus infection. The study, published in $Science\ Immunology\ showed$ that this prevented a robust antibody response in adult mice to rotavirus. This early disruption limits the ability of the immune system to later trigger and generate production of Immunoglobulin A (IqA) antibodies



The last known settlement of Homo erectus, direct ancestors of modern humans, who disappeared around 4,00,000 years ago, was situated in Ngandong on the Indonesian island of Java, a new study published in Nature finds. According to the researchers. the human ancestors existed on the Indonesian island between 1,08,000 and 1,17,000 years ago.

Mutation in smell gene found to be associated with asthma

Studying a multi-generational Indian family led to the discovery of associated gene variant

R. PRASAD

Based on a study of a four-generation family in Mysuru with high prevalence of asthma, a multi-institutional study by Indian researchers has shown that a variant of an olfactory gene (OR2AG2) is a novel candidate for asthma. This is the first time in India a four-generation large family with high asthma prevalence has been studied for the said purpose.

The gene was validated in a north Indian cohort of 141 children with asthma and 130 controls. About 80% of children with asthma carried a copy of the gene

Twenty individuals representing the four generations were selected. Of the 20 persons studied, 14 had asthma and the rest served as a control group. Whole genome genotyping was undertaken on all the 20 participants and exome sequencing was carried out on five people with asthma and three controls. While whole genome genotyping helps in detecting variations across the genome, the exome sequencing allows variations in the protein-coding region of any gene to be identified.

Several variants were seen after genotyping and exome sequencing. The team led by Anurag Agrawal, Director of the Institute of Genomics and Integrative Biology (CSIR-IGIB), Delhi, turned to computer modelling to narrow down the possible variants that might be responsible for asthma and finally confirmed the genetic variant through conventional sequencing.

"Mutation in the sensory pathway such as olfaction is a plausible mechanism for increased asthma



Inherited: All 14 family members with asthma had one copy of the gene

risk because of inability to mount an appropriate counter response. The inability to mount a counter response could lead to lung damage," says Dr. Agrawal. The inability to smell could be a potential mechanism for lung damage.

Identifying odour

To test this, the researchers evaluated the ability of the 20 participants to smell a sweet odour and the concentration at which they could identify the odour. All 14 family members with asthma had one copy of the gene variant.

"Healthy individuals and those with asthma were able to identify and differentiate different smells, but those with asthma could detect smells only at higher concentrations," he says. "This suggested a defect in their ability to smell. Also, family members with asthma

said they could not smell burning

"Whether olfactory gene was associated with asthma or not was not known till now. Ours is the first study to find such an association." says Dr. Samarpana Chakraborty from CSIR-IGIB and the first author of a paper published in the journal Scientific Reports. "The gene variant may cause olfactory dysfunction in the family members who have asthma."

"By studying the four-generation family alone or the children cohort individually, we couldn't have identified the gene. We needed both groups," Dr. Chakraborty says. "In population-based studies that have been undertaken, it becomes difficult to identify such

'There are three main reasons why we could identify the gene variant – asthmatics in the family had difficulty in smelling, we saw the same variant in the cohort and we were looking for a novel genetic variant," Dr. Agrawal says.

Suppressing expression

But during the validation studies, asthmatic children with or without the variant did not show significant difference in the ability to smell, which was unexpected. "Asthmatic children without the variant too had impaired smell threshold, which made us wonder if asthma-related pathway itself can cause suppression of the gene independent of the genetic variation," he says.

To validate the hypothesis, the researchers directly measured the gene expression in lung samples of those with asthma and normal subjects. In people with asthma, there was significant reduction in the expression of the gene.

They also carried out cell culture studies. When the cultured human cells were treated with IL13 cytokine, which is associated with allergy, there was suppression of OR2AG2 gene expression.

"So there is either a genetic defect in the OR2AG2 gene at birth leading to suppressed expression or there is acquired suppression of gene expression later in life due to inflammation or environmental factors," he says. "This supports our hypothesis that the gene may be a convergence point for asthma pathways at the lung level."

Carbon dots help detect herbicide pollution

ASWATHI PACHA

In an extraordinary waste-towealth feat, researchers from Assam have used the commonly found invasive plant water hyacinth to produce carbon nanoparticles. These extremely tiny (less than 10 nanometre) particles can be used for detecting a commonly used herbicide - pretilachlor. The nanoparticles were found to be selective and sensitive for the detection of the herbicide.

"At the biodiversity hub of our institute we have been trying to figure out how to convert this weed into a value-added product. Here in Assam, every water body is infested with water hyacinth, and it was an easy and cheap option to explore. Some teams are exploring if its fibre can be used to make furniture. We are also working on making activated carbon using the plant and these carbon dots were one of the innovations born in our lab," explains Devasish Chowdhury from the Material Nanochemistry lab at the Institute of Advanced Study in Science and Technology, Assam. He is the corresponding author of the work published in Heliyon.

Leaves to carbon

The team harvested water hyacinth leaves, removed the chlorophyll, dried and powdered it. The sieved powder underwent several treatments including heating at 150 degree Celsius to convert it to carbon dots. "When a nanoparticle is less than 10 nanometre we call it a dot or nanodot. Our carbon dots were able to give a green fluorescence under UV light. The extremely small oxygen functional groups on the surface of the dot are responsible for the fluorescence," explains the first author of the paper Ma-



Waste to wealth: Water hyacinth was used to produce carbon nanoparticles. • M. KARUNAKARAN

nash Jyoti Deka.

The herbicide pretilachlor is mixed with water and carbon dots, and studied using special equipment. The fluorescence intensity increases in the presence of the herbicide. The team also tested using different pesticides and other compounds having similar chemical structure and found that the carbon dot was extremely sensitive to pretilachlor and could detect even very small quantity of the herbicide. After successful testing in the laboratory conditions, the team collected soil samples from different places across the State and proved the efficiency of the carbon dots in detecting pretilachor in soil sam-

Fluorescence enhancement

The paper also describes the mechanism by which electron transfer happens between the dot and the herbicide which enables the fluorescence enhancement. Dr. Chowdhury adds that this will be a commercially viable option when compared with the sensors currently available in the market, as the raw material for the construction of the sensor the water hvacinth – is readily available and is practically a waste material. Based on this study, the group is now developing a paper strip-based sensor for onsite detection of pretilachlor.

IIT Hyderabad team uses plant extract, heat to kill cancer cells

The nanoparticles, which encapsulate the extract, had no adverse effect on mice, indicating their biocompatibility

R. PRASAD

Lipid-based nanoparticles encapsulating chlorophyllrich extract of a medicinal plant Anthocephalus cadamba and a near-infrared dye has been found to selectively kill cancer cells when exposed to near-infrared light.

Unlike the conventional photothermal therapy that relies on heat to kill cancerous cells, a multi-institutional team led by researchers from the Indian Institute of Technology (IIT) Hyderabad used heat generated by the dye when exposed to light to destroy the encapsulation

and release the extract. Through in vitro studies, the team led by Aravind Kumar Rengan from the Department of Biomedical Engineering at IIT Hyderabad found that the extract generated excess amount of reac-

tive oxygen species, which caused cell death through autophagy (body's way of removing damaged cells).

Collaborative effort

Researchers from the University of Hyderabad, IIT Bombay and Bose Institute, Kolkata, were part of the study and the results were published in the journal Nanos-

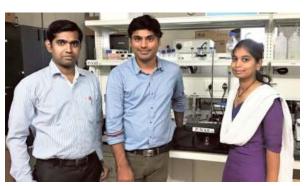
The extract showed selectivity in killing only cancer cells; the extract released inside normal cells caused insignificant cell death. The reason: the extract did not increase the amount of reactive oxygen species generated inside normal cells thus not causing them through autophagy.

"In our study, heat is used mainly to destabilise the lipid nanoparticle encapsulation and release the extract," says Prof. Rengan. "We optimised the amount of dye used and the duration of illumination so that the thermal effect is mainly for triggering the release of the

Potent mechanism

The lethal effect of the extract to kill the cancer cells when exposed to thermal energy was already demonstrated by the team a couple of year ago. But the mechanism through which the extract killed the cancer cells was not known then. "Based on studies using breast cancer cell lines we found that the extract increased the generation of reactive oxygen species, which enhanced autophagy-mediated death of cancer cells," he says.

When photothermal therapy alone was used, nearly 50% cancer cells died in



Targeted killing: The extract showed selectivity in killing only cancer cells, says Aravind Kumar Rengan (left)

about 24 hours. But 45% cancer cells grew back in about a day. "But there was no significant growth (about 7.5%) of cancer cells even 48 hours when photothermal therapy was used along with the extract. The extract was able to restrict cancer cell growth," says Tejaswini Appidi from IIT Hyderabad and one of the first authors of the paper.

Autophagy-mediated cell death was confirmed by using a particular protein that serves as an autophagy marker. "When cancer cells were treated with the extract, the amount of protein marker generated showed an increase. The protein marker produced varied depending on the amount of extract used," says Deepak BharadHyderabad and the other first author of the paper.

Pemmaraju from IIT

Reactive oxygen

Since the extract increased the amount of both reactive oxygen species and autophagy, the researchers set out to explore the link between the two. They used a known generation of reactive oxvgen species and then treated the cancer cells with the extract. "Cells where the ROS generation is inhibited showed negligible cell death due to reduced autophagy" says Appidi. "This helped confirm the role of reactive oxygen species in causing cell death."

Similarly, the researchers used an inhibitor to prevent autophagy and treated the cells with the extract. "We saw significant reduction in

cell death in the presence of the extract when autophagy was inhibited. This helped confirm the role of autophagy in causing death of cancer cells," says Pemmaraju. "These two experiments helped confirm that the cell deaths that occurred could be due to ROS-mediated autophagy."

The efficacy of the nanoparticles containing the plant extract and dye was tested in mouse model with breast cancer. The tumour volume reduced significantly when treated with the extract along with photothermal therapy compared with controls and cells treated with the extract alone. "But the nanoparticles had no adverse effect on the body weight of mice, indicating the biocompatibility of the nanoparticles," says Pemma-

Ramanujan's legacy used in signal processing, black hole physics

Due to the remarkable originality and power of Ramanujan's genius, the ideas he created a century ago are now finding applications in diverse contexts

SHUBASHREE DESIKAN

There is no question about the fact that mathematical genius Srinivasa Ramanujan has left behind a rich legacy of problems in pure mathematics. What is surprising is that his mathematics, done over a hundred years ago, finds applications today in areas other than pure mathematics, which were not even established during his time (22 December 1887 - 26 April 1920). Two among these are signal processing and black hole physics.

Signal processing

Examples of signals that are processed digitally include obvious ones like speech and music to more researchoriented ones such as DNA and protein sequences. These all have certain patterns that repeat over and over again and are called periodic patterns. In reality, complex repeating patterns may need to be identified as they bear significance to health conditions. So in signal processing, one thing we are interested in is extracting and identifying such periodic information.

much less known.

"A Ramanujan Sum is a sequence like c(1), c(2), c(3) ... This sequence repeats periodically... It was thought by a number of authors before me to be useful in identifying periodic components in signals, much the same as sines and cosines are used in Fourier ananlysis," says P.P. Vaidyanathan who has developed these ideas over the last decade. He is the Kiyo and Eiko Tomiyasu Professor of Electrical Engineering at the California Institute of Technology, U.S.

Prof. Vaidyanathan came across this work in an inter-

The mathematical opera-

tion of identifying and separating the periodic portion is much like using a sieve to separate particles of different sizes. Some of the best known methods to extract periodic components in signals involve Fourier analysis. Using Ramanujan Sums is

have a Ramanujan-Fourier



relevant: Srinivasa Ramanujan's mathematics now finds applications in areas not during his lifetime. ■ M. SRINATH

Still

esting process that illustrates the role of friendly connections in the development of science. Several years ago, mathematicians H. Gopalakrishna Gadiyar and R. Padma, from VIT, Vellore, were studying the twin prime problem when they observed that some arithmetical function which captures the properties of the primes should

They sent their paper to Bhaskar Ramamurthi, Director of IIT Madras, who in turn forwarded the paper to Prof. Vaidyanathan, a friend from his graduate days. Intrigued by the Ramanujan Sum mentioned in the paper, Prof. Vaidyanathan delved deep into it and developed the concept of "Ramanujan subspaces"

These ideas were further developed by his doctoral student Srikanth Tenneti who showed that using these gave a method that worked better than Fourier analysis when the region of periodicity is short. "A number of extensions using two- and higher-dimensional generalisations for images

and video, and extensions for non-integer (non-whole number) periods," are on the cards according to Prof. Vaidhayanathan.

Partitions of a number Ramanuian was famously interested in the number of

ways one can partition an integer (a whole number). For instance 3 can be written as 1+1+1 or 2+1. As the number to be partitioned gets larger and larger, the number of ways to partition it becomes difficult to compute. The seemingly simple mathematical calculation is related to a very sophisticated method to

Our work has had unexpected applications such as **Umbral** Moonshine', quite unrelated to black

holes

ATISH DABHOLKAR ICTP, Italy

reveal the properties of black holes, as has been established by physicist Atish Dabholkar, who is now Director, International Centre for Theoretical Physics in Trieste, Italy. Ramanujan related this

counting problem to some

special functions called "modular forms". A modular form is symmetric, in the sense that it does not change, under a set of mathematical operations called "modular symmetry". "A geometric analogy for such a function would be a circle which does not change its shape under the 'circular symmetry' of rotations," explains Prof. Dabholkar. "Using this symmetry, Ramanujan and G.H. Hardy found a beautiful formula to compute the number of partitions of any integer."

Nearly modular

In his famous letter to Hardy in 1919, Ramanujan introduced the "mock theta functions" and observed that they were "almost modular". "A geometric analogy would

nearly circular but with a small blip," explains Prof. Dabholkar. "It is not easy to explain precisely what a 'blip' is, similarly, 'almost modular' remained a mystery for close to a century," he adds.

be a 'mock circle' that is

Following the work of mathematician S. P. Zwegers in 2002, in which he intro-"mock modular forms," giving a precise definition of what "almost modular" means, Prof Dabholkar's paper with Sameer Murthy and Don Zagier made the connection between mock modular forms and Black Hole physics.

Black Hole entropy

A separate concept in physics, entropy, explains why heat flows from a hot body to a cold body and not the other way around. The results of Ramanujan and Hardy on partitions and his subsequent work on what are called mock theta functions have come to play an important role in understanding the very quantum structure of spacetime - in particular the quantum entropy of a type of Black Hole in string theory, according to Prof. Dabholkar.

Stephen Hawking showed that when quantum effects are taken into account, a Black Hole is not quite black, it is rather like a hot piece of metal that is emitting Hawking radiation slowly. Thus one can associate thermodynamic quantities like temperature and entropy to a Black

"Mock modular forms are beginning to appear more and more in many areas of physics... Our work has also had unexpected applications in new topics in mathematics such as 'Umbral Moonshine', which are quite unrelated to black holes," adds Prof. Dabholkar.

"It is a tribute to the remarkable originality and power of Ramanujan's genius that the ideas he created a century ago are now finding applications in such diverse contexts," he says.