CAPSULE

Origin of gold
Heavy metals found on earth, such as gold and platinum, probably originated in a supernova explosion, new research from University of Guelph, Canada, claims. Challenging the earlier theories involving colliding blackholes or neutron stars, the study points towards the relatively rare collapsors, which are a heavy-element rich supernova explosion of stars about 30 times as massive as the sun.

Rings around Saturn
Analysing the data given by Cassini probe during its last rendezvous with Saturn, several groups have published their findings in *Science*. Saturn has five small moons located in and around its rings. These accrete ring material and have distinct shapes. The rings are much younger than the planet, giving clues and placing constraints on models of how they formed.

JNCASR finds key protein conferring radiation sensitivity in cancer cells

The immediate medical implication of the finding will be in the treatment of certain cancer patients

R. PRASAD

Researchers at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, have unravelled the molecular mechanism by which autophagy pathway (a pathway recycles unnecessary or dysfunctional cell components) that gets enhanced leading to human cells becoming resistant to radiation. The immediate medical implication of the finding will be in treatment of certain cancer patients. The JNCASR research team led by Tapas K. Kundu from the Molecular Biology and Genetics Unit discovered that absence or downregulation of a particular protein – positive co-activator 4 (PC4) – is responsible for enhanced autophagy.

Mystery unravelled: This is the first time any study has shown that genome organisation is directly responsible for autophagy regulation in cells, say Sweta Sikder (left), Tapas Kundu and Ravi Manjithaya.

DNA damage

When a cell experiences stress, its DNA gets damaged. Cells with damaged DNA can either die or can activate the autophagy pathway and recycle the damaged cell components and survive. Lack of PC4 protein leads to irregular nuclear shape and defects in chromosome distribution in daughter cells. However, these changes do not lead to cell death but enhanced autophagy. The increased level of autophagy allow cells to withstand the stress caused by gamma radiation.

"What we found was that cells despite several defects upon PC4 downregulation not only did not die, they actually displayed increased proliferation. This was not expected," says Sweta Sikder from JNCASR and first author of a paper published in *FEBS Journal*. "When the cells lacking PC4 protein were exposed to gamma radiation for 24 hours, there was greater induction of autophagy. This observation suggests that gamma radiation further triggers the induction of autophagy in the cells, thus allowing cells to survive the effects of radiation."

Studies have shown that in some cancers, resistance to gamma radiation is achieved through enhanced autophagy. So, the team set to investigate if autophagy was indeed enhanced in the cells where the PC4 protein is absent or downregulated. "We did observe enhanced autophagy in the cells that had depleted levels of PC4 protein. We now know how the cells survived gamma radiation," says Ravi Manjithaya from JNCASR and one of the authors of the paper.

Validation

To validate increased autophagy in cells that had depleted PC4, the researchers used inhibitors of autophagy pathway. "The inhibitors reduced autophagy and the cells that lacked PC4 protein started to die when exposed to gamma radiation," says Prof. Kundu, who is currently the Director of CSIR-Central Drug Research Institute, Lucknow. The team also silenced the gene responsible for autophagy induction to revalidate the findings. Even in this case, the proliferation rate reduced drastically.

The final validation was by restoring (or rescuing) the protein expression in the PC4 knockdown cells. When the PC4 protein was restored to normal levels, autophagy reduced. The team thus confirmed that in cells with depleted PC4 protein the autophagy is enhanced making the cells not only to survive but to also proliferate at an increased rate and also become resistant to gamma radiation.

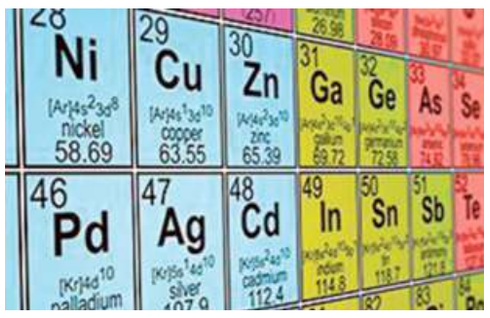
"This is the first time any study has shown that genome organisation is directly responsible for autophagy regulation in cells," says Prof. Kundu.

"We found that in cancers cells that are relatively less malignant, the PC4 level is normal and autophagy is low. But in such cells, if the PC4 is depleted then the cells become highly aggressive," explains Prof. Kundu. "And if you inhibit the autophagy in such cells, the proliferation comes down."

Implications

Explaining the possible medical implication of their study, Prof. Kundu says that in some cancers the autophagy gets enhanced. And this is seen only in the cancer cells and not in normal cells of the cancer patients suggesting that future cancer therapies may involve supplementation with autophagy inhibitors.

"In the present study, we generated a stable PC4 knockdown cell line for screening autophagy inhibitors. We are in the process of licensing the cell line," Prof. Kundu says.



An ode to Mendeleev and his periodic table of elements

The periodic table symbolises the logical cogency, principled rationality of all science

SPEAKING OF SCIENCE

D. BALASUBRAMANIAN

Mankind has known materials such as gold, silver, mercury, iron, phosphorous, sulphur and others since antiquity. Alchemists tried making gold out of "base" metals – with no success. But we had to wait until the English school teacher John Dalton who in 1808 came up with his "new system of chemical philosophy", where he proposed that chemical elements are made of atoms; any given element is made entirely of one kind of atom and that each atom has a characteristic weight; chemical reactions occur when atoms of different elements interact with one another. Dalton and Thomas Thomson from England and Berzelius from Europe defined the weight of a hydrogen atom as one, and the atomic weights of other elements were measured using this standard. By the 1860s, the atomic weights of a large number of elements were published.

The question that captured the minds of chemists at that time was: is there any pattern or logic that one can derive by looking at the similarity in the properties of certain classes of atoms (say, lithium, sodium and potassium) on one hand, and their atomic weights on the other? Johann Dobereiner of Germany in 1817 found that, if he took a triad of elements with similar properties, the atomic weight of the middle element is roughly midway between those of the other two [e.g., sodium with atomic weight 23 is midway between lithium (3) and potassium (39), or bromine (80) between chlorine (35) and iodine (127)]. And in 1865, the English chemist John Newlands stated his "law of octaves": if elements are arranged in increasing atomic weight order, those with similar properties occur after each interval of seven elements (for example, lithium and sodium, or carbon and silicon), much as the notes in music.

It was against this background that we meet Professor Dimitri Mendeleev at St. Petersburg, Russia, in 1865. Not satisfied with existing text books, he wrote his own. In doing so, he had to organise the elements and arrange them in a logical order. Dr Tom Siegfried writes in ScienceNews on 9-1-2019 that Mendeleev wrote each of the 69 then known elements with their properties on a note card, arranged the cards in vertical columns from lower to higher atomic weights, and found that elements arranged according to the size of their atomic weights show clear periodic properties, and more importantly "the size of the atomic weight determines the nature of the elements". He presented this discovery before the Russian Chemical Society on March 1, 1869. The periodic table was born. (Incidentally, Siegfried's lucid essay: "How the periodic table went from a sketch to an enduring masterpiece", mentioned above, is a free access article, highly recommended for reading).

Predictive power

This periodic table of Mendeleev not only confirmed the works of Dobereiner and Newlands (that every eighth element in the table resembles the first), but could go further. Given this repetition rule, he could predict that an element (he named it eka-silicon) will be discovered which will resemble silicon and have an atomic weight of 72. Sure enough it was found in 1886, and was named germanium. Likewise, his prediction of eka-aluminium too came true; gallium discovered in 1875 had all properties predicted by Mendeleev. Siegfried writes: "His [Mendeleev's] table finished the transformation of chemical science from the medieval magical mysticism of alchemy to the realm of modern scientific rigor. The periodic table symbolizes not merely the constituents of matter, but the logical cogency and principled rationality of all science."

While Dalton and Mendeleev believed that the atom is the ultimate indivisible particle of an element, modern physics, by the turn of the century, showed that atoms themselves are made up of a central nucleus, inside which "protons" (with a single positive charge and weighing that of a hydrogen atom) and often also of "neutrons" (no charge but mass of a hydrogen atom) reside, and "electrons" (of negligible mass, but a single negative charge) spinning around the nucleus at various well-defined orbits of increasing radius, somewhat akin to the sun and its planets. This idea enabled chemists to arrange elements in such atomic models, and in orbits of increasing levels corresponding to the atomic number (protons in the nucleus). The electrons in the outermost orbits in an atom govern the chemical properties of the element.

Note that orbits arranged in increasing well-defined levels. This periodicity indeed concurs with Mendeleev's periodic table arrangement and its predictions. In a sense, Mendeleev was "prescient." This was his grand plan to arrange elements, whose 150th year we celebrate in 2019.

A poetic tribute to the Periodic Table has been written by Dr. Alok K. R. Paul, Principal Scientist at the Central Electrochemical Research Institute, Chennai Unit. This "ode to the periodic table" can be accessed at https://euroscientist.com/ode-to-the-periodic-table/. Read it and enjoy it!

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Clues from crickets: Can temperature influence our body clock?

Circadian machinery of crickets shows both drosophila and mammal-like traits

ASWATHI PACHA

Cricket, the tiny insect, is not just good at making spooky noises at night; it has now helped researchers understand more about the body's sleep-wake cycle or the circadian rhythm.

The team from Okayama University in Japan and Indian Institute of Science Education and Research (IISER) Thiruvananthapuram, looked at how changes in atmospheric temperature can affect the behaviour and molecular mechanism of the clock genes.

Studying crickets: It helped us understand the diversification of insect clocks and how it has evolved across the animal kingdom, says.Nisha Kannan (sitting).

Dark environment

They locked up a few adult crickets in a totally dark environment and exposed the insects to 30 degree C for 12 hours and 25 degree C for the remaining 12 hours. They found that the activity of the insects increased when the temperature dropped. In fact, the activity started one hour before the transition period. "The insects being nocturnal perceived the drop in temperature as evening setting and started its activity," explains Nisha N Kannan from IISER Thiruvananthapuram and first author of the paper published in *Zoological Science*.

Till now, drosophila or fruit fly has been considered as a model organism and have been used in many studies. So why cricket? According to Dr. Nisha, the circadian machinery of crickets shows both drosophila and mammal-like traits. "Studying crickets would help us understand the diversification of insect clocks and how it has evolved across the kingdom," she says.

The team also studied the clock genes – period, timeless, cryptochrome2 and cycle – to see if the temperature changes altered them.

Optical lobe

The team looked at the optical lobe of the cricket to decode whether the change in activity is mediated through the expression levels of the clock genes. "In drosophila, the body clock control is in the brain scattered across 150 neurons and in humans, we have the suprachiasmatic nucleus region in the brain composed of thousands of neurons that control our circadian rhythm. Similarly, in crickets, it has been found that the optical lobe (located in the anterior segment of the brain), which receives the visual information from the retina, houses the clock controls," adds Dr. Nisha.

Changes were seen in the period and timeless mRNA expression indicating these are the initial clock gene components that respond to changes in the external environmental temperature.

The case of mammals

Will this hold true for humans? In mammals, in addition to the master clock present in the brain, peripheral circadian clocks too operate, which means that the cells and tissues throughout our body have their own individual clocks.

Dr. Nisha explains that this peripheral circadian clock can be affected by temperature changes but our master clock in the brain is resistant to temperature changes.

Our brain has evolved to even override the peripheral circadian clock, so, fortunately, temperature changes (unless very extreme) cannot affect our body clock.

NIT Rourkela: Converting fruit waste to ethanol

Marine bacteria isolated from Digha and Shankarpur waters were used

GREESHMA P

With finite supply of combustible and natural energy sources, there is a demand for alternative energy sources. This has led to increased focus on biofuels. Now, researchers from the Department of Biotechnology and Medical Engineering at the National Institute of Technology (NIT) Rourkela, Odisha, have discovered a marine bacterial strain (*Citrobacter* species) that can produce ethanol directly from fruit waste.

Tolerant strains

The *Citrobacter* species was isolated from the marine water near Digha and Shankarpur seashore of West Bengal. Ten strains were found to be highly tolerant to ethanol. The strains were tested with various waste materials including kitchen, paper, fruit and garden waste for their ability to produce ethanol.

"We wanted a more eco-friendly and cost-efficient method apart from the usual fermentation processes for the production of bioethanol," says Angana Sarkar from NIT Rourkela, the corresponding author of the paper published in the journal *Process Safety and Environment Protection*.

Of the ten ethanol-resistant strains screened, a particular species (*Citrobacter* sp. E4) was found to directly convert fruit waste into ethanol without any pretreatment.

The waste material was powdered to enhance bacterial activity and thereby reduce the time taken to produce ethanol. The powdered waste along with the bacterial strain and mineral salts required for its growth were introduced into the bioreactor. Under optimum temperature (33.2°C) and optimum pH (7.1), a maximum output of 0.30g of ethanol was obtained from 1g of fruit waste. It took over 24 hours to convert waste into ethanol.

Due to the high sugar content, fruit waste was found to be the most favourable, whereas paper waste was the least favourable due to the presence of cellulosic substances. The researchers note that this method is environment-friendly, sustainable and cost-efficient.

The species was further tested and found to be non-pathogenic and antibiotic-resistant against cephalosporin and ampicillin, to name a few.

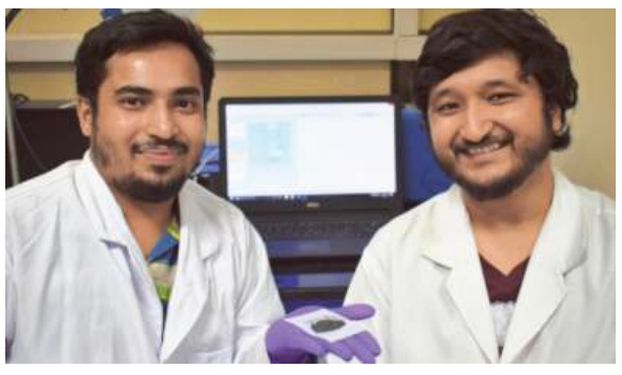
The species could be easily cultured under laboratory conditions. "We are trying to genetically modify the species to increase the amount of ethanol produced," adds Dr. Sarkar.

Novel selenium-graphene catalyst for fuel cells

This catalyst provides a cheap and effective alternative to platinum which is often used in fuel cells

SHUBASHREE DESIKAN

Modern energy technology, for example fuel cells which are used commercially in hydrogen fuel-based cars, require good catalysts that are efficient as well as cost-effective. Now, a multi-institutional team from India has developed a selenium-graphene-based catalyst which is more efficient, costs less and also remains stable for longer than the usual platinum based catalysts. The institutes involved in the work are: Tata Institute of Fundamental Research, Hyderabad (TIFR-H), University of Hyderabad and Indian Institute of Science Education and Research (IISER) Thiruvananthapuram. The research has been published in the journal *ACS: Applied Energy Materials*.



Right chemistry: A small amount of selenium and high amount of graphene, treated right, presented the group with a useful and cheap catalyst.

Normally, fuel cells use expensive platinum-like elements. "These expensive metal-based technologies perform excellently for initial few cycles, but then get degraded in performance due to many reasons," explains T.N. Narayanan of TIFR-H, the corresponding author. As a result, there is a need to change this part of the fuel cell routinely.

The oxygen reduction reaction is a key step in the functioning of the fuel cell. Graphene by itself is a "poor" catalyst of this reaction. In the sense that it involves reduction of oxygen in two steps, each of which consume two electrons. This is not very useful either for fuel cells or metal-air batteries.

Platinum is often used to catalyse this reaction. As a substitute, the group developed the catalyst with selenium and graphene. "Graphene modified with selenium atoms in very low amounts can perform like platinum in a demonstrated reaction," Dr. Narayanan clarifies.

While neither selenium nor graphene can do the trick by themselves, the combination works efficiently. "When you do the right chemistry together with small amount of selenium with high amount of carbon containing graphene, you end up with a very useful catalyst, which is very cheap too," he adds.

Poisoning-resistant

Methanol fuel cells, a common form of fuel cell used, suffer from a "poisoning" effect. This is a part of the process where the methanol reaches the negative electrode and coats it, so that the electrode becomes ineffective after some cycles. This is especially problematic when expensive catalysts like platinum are used, as they often are. "We found that the catalyst we have developed has a high tolerance [to poisoning] while platinum got affected," says Dr Narayanan.

The concept of single-atom catalyst - that category into which this catalyst falls - is not new. But earlier concepts had used heavy metals such as platinum, palladium and gold. Using selenium is a novel idea mooted by this group.

"Such direct water converting oxygen reduction reaction catalyst has enormous applications in other fields too, such as metal-air battery. It is ongoing research for the development of high energy density devices in batteries. This will be far better than the existing lithium ion-based battery," he says.