SNAPSHOTS

Helpful parrots
A paper in *Current Biology* describes how African Grey Parrots like apes and humans offer help to others wishing to achieve a goal. In an experiment involving African Grey Parrots and Blue-headed Macaws, where a token could be traded for a nut, only African Grey Parrots would lend their token to a neighbour to help them get the nut instead.

Climate goals
With several coastal cities facing threat of flooding due to sea-level rise, a new study published in *Science Advances* developed an integrated assessment model. This model suggests that climate policies designed to directly tackle sea-level rise may be more effective than those targeting temperature rise. These may be more sustainable and less expensive.

Hominins in Asia
The first arrival of hominins at Sangiran, an archaeological site in the island of Java in Indonesia, is important in understanding the arrival and evolution of humans in Asia. A new study published in *Science* indicates that *Homo erectus* first arrived here 1.3 million years ago. The researchers used a combination of dating methods on hominin-bearing sediments.

VR and visual memory
Researchers have found that virtual reality (VR) - a computer-generated simulation of a three-dimensional image or environment - may interfere with visual memory. According to the study published in *Frontiers in Psychology*, VR may interfere with visual memory due to the way it moves images in conjunction with user movement.

New method better estimates melting of debris-covered Himalayan glaciers

The debris partially insulates the glacier from the warm exterior thereby slowing down the melting

SHUBASHREE DESIKAN

A study of the Satopanth glacier in order to model the melting of debris-covered glaciers has been carried out by a group of Indian researchers. Their new method gives a better estimate of the glacier's melting than existing ones. Studying debris-laden Himalayan glaciers is important from the point of view of how climate change affects them. About 20% of Himalayan glaciers are debris-laden, and their dynamics are very different from the ones without debris cover. The study was published in *Journal of Glaciology*.

Handy tool: To study the melting of the glacier the researchers planted 60 bamboo stakes below 4,600 metres elevation.

Effect of debris

In glaciers without a debris cover, the rate of melting increases as the elevation decreases. However, in glaciers covered with debris, the thick cover partially insulates the glacier from the warm exterior and thereby slows down the melting. The thickness of the debris cover, by and large, increases as the glacier flows down. This works against the general trend that the lower the elevation, the higher the rate of melting. Matters are further complicated because the thickness of the debris cover is not uniform but fluctuates randomly.

This line of research was initiated by H.C. Nainwal of the Geology Department, Hemwati Nandan Bahuguna Garhwal University, in 2004. Initially it constituted studies of paleoglaciation and monitoring the fronts of Satopanth and Bhagirath Kharak glaciers. "Full scale glaciological observations began in 2013," says R Shankar of The Institute of Mathematical Sciences, Chennai, and an author of the paper.

Prof. Shankar and Argha Banerjee, now with IISER Pune, are interested in developing a model to describe the dynamics of debris-laden glaciers like the Satopanth. The collaboration happened almost by chance: "I was planning a motorcycling trip in Garhwal, including a visit to Gangotri in 2007. I came across a paper by [Harish Chandra] Nainwal in *Current Science* on the geomorphology of Gangotri valley and took a copy along to see what it was like on the field," says Prof. Shankar. This brought them, and Dr Banerjee, together to discuss Satopanth. Along the way, they realised that it was an important problem to model the dynamics of debris-covered glaciers.

Studying Satopanth

Satopanth glacier is located in Garhwal in Central Himalaya, in Uttarakhand. It is the origin of the river Alaknanda, one of the two main tributaries of the Ganga. The other tributary is Bhagirathi, which originates from the Gangotri glacier. These two rivers join at Devprayag, around 70 km upstream of Rishikesh. Downstream of Devprayag, the river is called Ganga.

To study the melting, the team planted nearly 60 bamboo stakes in the Satopanth glacier, most of which were placed in ten transverse lines below 4,600 metres elevation. The initial depth of the bamboo stakes was noted down, and periodic measurements were made over the course of three years to assess how much ice had melted. Nearly 1,000 measurements were made, mainly by Sunil Singh Shah, the first author of the paper.

Better estimate

They computed the sub-debris melting of the glacier by interpolating the collected data as a function of thickness of the debris and averaging over debris thickness distribution over different parts of the glacier. This is to be contrasted with the conventional method where the collected data is interpolated as a function of elevation. The new method introduced by the group worked better at estimating the dynamics of the glacier than the conventional method.

They also repeated the estimation after leaving out several of the data points and restricting the data to about 25 stakes. They could still get better results than the conventional method. "This established a clear advantage of the new method. The estimates were seen to be more robust when a reduction in the number of stakes was applied," says Prof. Shankar. Using a more detailed measurement of the debris thickness variation would make the estimate more accurate, the authors write in the paper.

Species-rich forests offer stable carbon capture

Teak, eucalyptus plantations had 43% and 55% less carbon storage than natural forests, respectively

ASWATHI PACHA

Spending over six months conducting surveys inside Anamalai Tiger Reserve and using satellite data from multiple locations in the Western Ghats, an international team of researchers has shown that carbon storage was highest in species-rich evergreen forest. The paper published in *Environmental Research Letters* adds that the rate of carbon capture was more stable across years in forests than in plantations, and carbon capture by forests was more resilient to drought.

Varied terrain

The study was done in natural evergreen and deciduous forests, and in teak and eucalyptus plantations. The studied eucalyptus plantations had comparatively lower carbon storage, while teak plantations stored nearly as much carbon as deciduous forests.

The team identified the trees, measured their girth and height in 250 square plots inside the Anamalai Tiger Reserve, and used the measurements to estimate carbon storage in different forests and plantation types. They then used satellite data from Parambikulam Tiger Reserve, Rajiv Gandhi Tiger Reserve, Wayanad Wildlife Sanctuary and Bhadra Tiger Reserve, along with Anamalai to assess the rate of carbon capture and how they varied across years (2000-2018). All the study areas used to be exploited for timber and for raising plantations of commercially important trees in the past, but are now strictly protected as wildlife reserves. Annual rainfall and stressors like drought were all taken into consideration for the study.

The results showed that the species-rich evergreen forests stored carbon at approximately 300 tons per hectare. The storage in teak and eucalyptus plantations was 43% and 55% less, respectively. The researchers also found that the rates of carbon capture remained nearly the same year after year in natural forests compared with plantations.

Carbon sink: The team found that species-rich evergreen forests stored carbon at approximately 300 tons per hectare. ▪ ANAND OSURI

"This study can help transform reforestation policies. Currently, according to government data, over half of compensatory afforestation plantations use five species or less, which is way lower than in natural forests and totally inadequate. We know that this is not good for biodiversity, and now this study has shown that it is not great for the stability of carbon capture too," explains one of the authors, T.R. Shankar Raman from the Nature Conservation Foundation in Mysuru.

He adds that we also need to think about where the afforestation measures are being carried out. Grasslands help in carbon capture themselves and planting trees there can cause more harm than good.

Long-term effects

The first author of the paper Dr. Anand Osuri says: "Our findings suggest that protecting and regenerating natural forests comprising a diverse mix of native tree species is more reliable in the long term than raising monoculture or species-poor plantations as a strategy for mitigating climate change." He was a postdoctoral scientist at Columbia University during the study and is presently a scientist with Nature Conservation Foundation.

Ruth DeFries, one of the authors from Columbia University, US adds: "Species-rich forests are beneficial for biodiversity as they also provide habitat to many other components – insects, birds, etc. Previous studies have shown that species-rich forests are also resistant to diseases."

Keeping the Australian fires in mind, when asked if species-rich forests have better resistance to fire, she said that different trees have varying degrees of fire resistance depending on the thickness of the bark. Also, the ability to regenerate the seeds differ across species and so a multi-species forest would likely show greater resilience in case of a fire.

IIT-M designs room temperature sodium sulphur battery

The battery was able to achieve higher charge storage capacity and nearly zero self-discharge when not in use

R. PRASAD

While conventional sodium sulphur batteries require very high temperature (300 degree C) for operation, researchers at the Indian Institute of technology (IIT) Madras have designed a new sodium sulphur battery that can be operated at room temperature. By operating the battery at room temperature, the team was able to achieve higher charge storage capacity (technically called the specific capacity) and nearly zero self-discharge when the battery is not being used.

Storage and retention

While high temperature sodium sulphur batteries have charge storage capacity of about 558 mAh per gram, the battery designed by the IIT Madras team was able to achieve as much as 1,034 mAh per gram at a current density of 50 mA per gram.

The battery also showed 83% retention of capacity even at the end of 500 cycles of charging and discharging.

Preventing leakage: The shielding layer helps significantly reduce self-discharge of the battery, say (from left) Ajay Piriya, Ramaprabhu Sundara and Kamaraj Muthusamy

To assess the capacity retention, the researchers used higher current density of 500 mA per gram. "The charge storage capacity was 650 mAh per gram to start with and after 100 cycles it reduced to 570 mAh per gram, at the end of 500 cycles, the charge storage capacity was 499 mAh per gram," says Ajay Piriya from IIT Madras and first author of a paper published in the journal *Advanced Materials Interfaces*.

The first step that the team led by Ramaprabhu Sundara from the Department of Physics at IIT Madras took to operate the battery at room temperature was by changing the electrolyte used.

Novel electrolyte

Conventionally, sodium sulphur batteries use a solid electrolyte (sodium beta alumina), which by default reduces the diffusion of sodium ions from the anode to the cathode at room temperature. It is to increase the diffusion of sodium ions that the temperature is raised to about 300 degree C.

So in place of a solid electrolyte the researchers used a glass fibre separator soaked in ether-based electrolyte that allows the battery to be operated at room temperature.

"Changing the electrolyte alone is not sufficient to improve battery performance as there are other problems with sodium sulphur batteries," says Prof. Sundara. Sodium is supposed to react with sulphur and produce stable sodium sulphide through intermediate steps. Each of the intermediate step produces different sodium polysuphides. "The intermediate sodium polysuphides are unstable and get dissolved into the electrolyte. The dissolved polysuphides cause twin problems that reduce the capacity and durability of the battery," he explains.

The first problem is that with increasing amount of polysuphides getting dissolved into the electrolyte, there is a net loss in the cathode sulphur. In addition, the dissolved polysuphides move towards the anode and form a coating over it. This reduces the performance of the battery.

Shielding layer

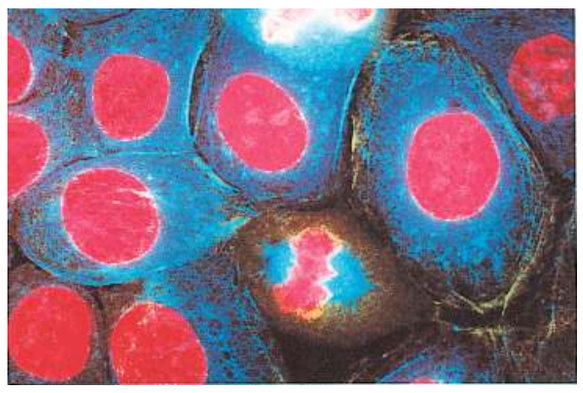
To address the twin problem, the team added a shielding layer very close to the cathode. The shielding layer is made of white graphite mixed in a polymer matrix.

"The polymer allows the sodium ions to pass through while the white graphite added to the polymer matrix prevents the migration of polysuphides to the anode," says Kamaraj Muthusamy from the Department of Metallurgical and Materials Engineering at IIT Madras and a co-author of the paper. The boron and nitrogen present in the layered structure of the white graphite act as binding sites for the polysuphides. The polysuphides that are chemically bound by the polymer composite react with sodium and produce sodium sulphide.

"Nearly all of the sulphur gets converted into sodium suphide when we used the shielding layer between the cathode and the separator," Ms. Piriya says. "Since the migration of the polysuphides to the sodium anode is prevented by the shielding layer, self-discharge of the battery is significantly reduced."

The battery was tested for self-discharge by measuring the open circuit potential of a fully charged battery for 16 continuous days. They found the potential remaining constant at 2.35 volt when the shielding layer was used; the voltage dropped without the shielding layer.

While conductive carbons are added to the sulphur to make it electrically conductive in conventional sulphur batteries, the researchers used partially exfoliated multiwalled carbon nanotubes.



Formidable challenge: Multidrug-resistant germs sicken almost three million people across the world every year

India should lead in the fight against multidrug-resistant pathogens

SPEAKING OF SCIENCE

D. BALASUBRAMANIAN

A recent headline in *The New York Times* (December 28) was titled: "Lifelines at risk as bankruptcies stall antibiotics - a health crisis looms: scant profits in fighting drug-resistant bugs sours investors." This refers to the growing menace of disease-causing germs such as bacteria and fungi, for example, *pseudomonas, E.coli, klebsiella, salmonella* and TB, which no longer respond to the conventionally used antibiotic drugs. These emerging Multi-Drug- Resistant (MDR) germs sicken almost 3 million people across the world every year, and the UNO states that if we do not find drugs to fight and kill these MDR-germs quickly enough, the global death toll could soar to 10 million people by 2050.

How did these MDR-bugs come about? Since penicillin and similar antibiotics (erythromycin, floxins) were introduced about 60-70 years ago, we have been using them with success, because each such conventional drug effectively kills millions of germs. Yet a tiny population of them had survived, thanks to some escape routes such as slight change in their genes, leading to pathways that stop the drug from entering their cells or pathways that pump out the entered drug molecules. Such escapees started growing and multiplying into millions over months and years, and became resistant to all the common antibiotics- these are the MDR-germs.

What is needed in this scenario is for scientists and drug firms to do basic, fundamental research into the biology of MDR germs and develop effective drugs to fight and win over them. This often takes a decade or more to bring out the product and make them available in the market. Indeed, it was precisely such an R&D effort that has brought about the discovery and marketing of many drugs against chronic diseases such as diabetes, arthritis, blood disorders and cancer. And the amount of investment for R &D in each one of them has been billions of dollars, and the company expects to gain billions of dollars each year. It is here that the problem lies in the case of investing in drugs against MDR bugs. As Andrew Jacob points out in the above article, major drug firms have shied away from work on MDR-germs, since unlike chronic diseases which are prescribed for long terms (months and years), antibiotic drugs are prescribed for days and at best for weeks, and so no long term profit is made!

Public spirited players

To do research and development and come out with drugs against MDR-germs, too, is no different, and this also requires long-term effort and involves billions of dollars input. And it is here that some private firms have pitched in. Happily enough, they have been getting R&D funds as grants from private foundations and governmental sources. The article describes how the biotech company Achaogen succeeded in obtaining a billion-dollar grant from the US government's Biomedical Advanced Research and Development Authority (BARDA), spent 15 years of research and development work and came out with the drug called Zemdri, effective against hard-to-treat urinary tract infections. Zemdri was approved by the Food and Drug Administration (FDA) and the WHO. Sadly, Achaogen could not make any sustained profit, the investors were unhappy and the firm went bankrupt. Similarly, the firm called Tetraphase, which obtained a major grant from a nonprofit group and produced the drug Xerava, which is effective against some MDR-bugs, had to cut down its staff and its plans to conduct further R & D efforts since its stock price was plummeting. And so was a third firm, Melinta Therapeutics, which has successfully produced Baxdela, an FDA-approved drug for drug-resistant pneumonia.

It is of interest to note that the firm Achaogen was bought over by CIPLA-USA, which is the US arm of the Indian public-spirited drug company CIPLA. This involved buying all the equipment and the rights to acquire the technology and to make and sell the drug Zemdri across the world.

CIPLA's move in this area holds out an example for other Indians and firms to enter the field. They may likewise interact with other such firms in the US, acquiring them, or as partners or owners (even set up labs in India), gain the hard-earned technology of making drugs active against MRD-germs, and make these available for use by the needy not only in India but across the world. Note that a recent paper on the mortality burden of MDR-pathogens in India (S. Gandra et al., *Clinical Infectious Diseases* 2019; 69(4):563-70) which studied 10 hospitals across the country for MDR pathogens and the patient mortality outcomes shows that 13% is the overall rate of death. If this be for hospital-based deaths, we can imagine the millions affected and dying across the towns and villages of India. And surely such a situation would be true in parts of Africa, southeast Asia and other low-income, high-population countries. R&D efforts by Indian scientists will thus be of public health and economic value.

Fortunately, Indian government and its funding agencies are keen in offering grants in this Focal Theme area to researchers in government-operated R&D institutions and universities, as well as to private non-governmental research institutions, and drug companies. Private non-profit foundations in India should also open up their purses (not just the Wellcome Trust of the UK or the Bill and Melinda Gates Foundation of the US).

Many of us in our own country do not realise that India has become the major vaccine provider for children across the world. Just a handful of vaccine-makers across India now provide about 35% of childhood vaccines globally, through their R&D efforts. There is thus no reason why India cannot be a major player in offering good health to the 7 billion people across the world through our efforts in the area of fighting infection by traditional, MDR-type and other emerging disease-causing germs.

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