

nature india

SEEKING HIGHER GROUND

In protecting shared borders, the Himalayas could be a point of cooperation and mutual gain

Twist in the Cheshire cat tale
Separated photons can swap their spin

A new chapter of knowledge
Open-access policy could change publishing game

Barriers for women
Gender gap in healthcare treatment



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S. Priyadarshini

From the editor

The year 2020 was defined by the global pandemic. Throughout the long, difficult year, disease and death came in tragic waves, testing the limits of healthcare systems, especially in countries with limited resources. In India, one of the worst affected countries, significant outbreaks continue in 2021.

A positive outcome, however, has been the triumph of science. In record time, scientists rushed to sequence the genome of the virus and its variants, created affordable diagnostic and treatment solutions, and produced multiple vaccine and drug candidates to control the pandemic. We have been covering the pandemic in India and the subcontinent in depth through the lens of science. Besides our regular coverage, we produced two special issues on the COVID-19 crisis in India – one on how the pandemic was affecting life in a country of 1.3 billion people, and the other on affordable engineering solutions being developed in haste by India's scientists to confront the virus. In our quest to disseminate trusted information during a global public health emergency, the pages of *Nature India* were filled with resources on SARS-CoV-2 and COVID-19.

Meanwhile, despite challenges thrown up by a series of lockdowns and funding issues, science in other disciplines unrelated to the pandemic has continued to flourish. One criticism of scholarly publishers and scientific journals has been that their overwhelming engagement with the pandemic (public health, medicine, virology and epidemiology) squeezed out other disciplines during 2020. In this annual volume, therefore, we are highlighting *Nature India's* coverage of all sciences, efforts around which quietly continued through 2020.

The biodiverse Himalayan region, straddling the borders of many countries in Asia, including India and China, offers immense potential for collaborative scientific research. However, the inhospitable terrain and geopolitical strife in the region, have created obstacles to a joined-up research approach. Our cover story tells of the growing call by researchers in the two countries to go beyond political differences and make the Himalayan region a hub for scientific collaborations.

Also highlighted in this issue are migratory birds from across the region coming into India, and the need for heronries to protect them.

The country is weighing the challenges and opportunities of an ambitious 'one nation one subscription' policy that aims to make scholarly knowledge freely accessible to everyone in the country, and we analyse the merits of this proposed plan.

The pandemic is never far from the immediate consciousness of everyone, and our annual photo competition on the theme brought inspired images of this era, where masks, sanitation, immunisation, and innovative solutions to health needs are paramount, and the focus of our daily lives.

We hope you enjoy reading.

Subhra Priyadarshini
Editor-in-chief

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Research highlights

DIABETES ALARM FOR METROPOLITAN INDIA

More than half of men and two-thirds of women above the age of 20 in India's cities are likely to develop diabetes during their lifetime, a study suggests.

Prevention of diabetes, especially in young urban populations, should be a national priority for India, says lead author, Shammi Luhar, at the University of Cambridge, UK.

The assessment is based on data from the Centre for Cardiometabolic Risk Reduction in South Asia (CARRS) Cohort Study – a community-based health survey project in Delhi and Chennai in India and Karachi in Pakistan – the Indian Council for Medical Research and government reports on age, sex, and urban-specific mortality rates.

Results are much closer to estimates of lifetime risk of diabetes among black and Hispanic populations in the United States, the authors say.

Muthuswamy Balasubramanyam, a disease-biologist and associate dean of medical research at the SRM Institute of Science and Technology in Chennai, says the greater risk among Indians of developing diabetes implies a role of accelerated ageing. This needs expanded research, prevention strategies and health policy interventions.

Diabetologia (2020)



AIRBORNE FUNGI THREATENS CROPS

Airborne fungi cause more crop diseases and damage to major crops, such as rice, potato, tomato and ginger, than bacteria and viruses, according to a study at the Indian Institute of Technology Madras.

Rising temperatures might increase the prevalence of fungal diseases, which are likely to extend to the Himalayan regions and the Western Ghats, where rare and important medicinal plants grow.

Microorganisms spread as suspended particles in the air. The roles of airborne fungi in crop diseases, however, are largely unexplored. Using media and government reports, and local observations between 1998 and 2018, scientists generated a data set of more than 4,000 records of fungi-related crop diseases in India.

They found that 69 fungal attacks harmed 39 different crops over the past 20 years. During this period, the fungal species *Puccinia striiformis* affected wheat crops on 12 occasions, along with other disease-causing fungal species. Nine different fungal species, including *Pyricularia oryzae*, were found to affect rice crops.

Prevalence has been linked to the mixing of surface air with upper-boundary layer air, increasing the fungi-containing bioaerosol concentration.

Environ. Sci. Pollut. Res. (2020)

BLOOD-CLOTTING MATERIAL MIMICS MARINE MUSSELS

A biocompatible and biodegradable peptide-based hybrid material can help stop bleeding, a study shows. The material mimics the blood-clotting properties of fibrin and the adhesiveness of specific proteins in the base pad of marine mussels.

Applied to rabbit wounds, the material accelerated blood clotting and wound healing with less blood loss than fibrin, found a team from the Indian Institute of Science Education and Research, and the West Bengal University of Animal and Fishery Sciences, both in Kolkata.

The researchers, led by Rituparna Sinha Roy and Samit Kumar Nandi, then tested the efficiency of their peptide-based sealant in rabbits. They found that the sealant stopped bleeding from a rabbit liver wound, without a suture, within about 100 seconds. It also closed wounds more efficiently than the fibrin, suture and stapler without adverse reactions.

The sealant-treated wounds showed the growth of thick, mature and organized collagen bundles. The sealant's mechanism doesn't depend on the body's own blood-clotting process, making it potentially useful for treating patients with haemophilia.

ACS. Biomater. Eng. Sci. (2020)



A SEISMIC SEARCH FOR DIAMONDS

Earth scientists at the Indian Institute of Science Education and Research (IISER) in Pune have proposed using seismic imaging of the Earth's crust for identifying regions in which diamonds might be found.

Formed in the mantle of the earth, diamonds reach the surface via volcanic rocks, such as kimberlites. To identify kimberlites, the IISER team uses a seismic image of the lithosphere, exploiting a strange behaviour of the 'shear waves' generated by earthquakes.

Unlike surface waves, shear waves move through the body of an object. According to the researchers, while shear waves travel at a speed of 4.5 kilometres per second (km/s) through most parts of India, their speed increases to 4.7 km/s-plus when passing through India's diamond corridor, a 1200-km stretch of eastern Dharwar, Bastar and Singhbhum blocks in the south-east.

The study presents a new geologic model that explains the distribution of 'diamondiferous kimberlites', and suggests that the seismic image of the lithosphere can be a guide for exploration of diamonds. Through high-resolution seismic imaging of the lithospheric mantle, the scientists are further analysing the actual size of the diamond fields needed to explain the observed difference shear wave velocities.

J. Earth Syst. Sci. (2019)



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TRACING THE ORIGIN OF THE INDIAN CHEETAH



Seeking answers about the long-extinct Indian cheetah

Scientists have gained fresh insights into the origins and divergence of the Indian cheetah, hunted to extinction in the mid-20th century. They suggest that the most recent common ancestor of all cheetahs lived almost twice as long ago as previously reported.

Genetic analyses reveal that Indian cheetahs are more closely related to south-east African cheetahs than those from north-east Africa. The scientists, including some from the CSIR Centre for Cellular and Molecular Biology in Hyderabad, and the Birbal Sahni Institute of Palaeosciences in Lucknow, took mitochondrial DNA (mDNA) from a museum specimen of Indian cheetah and two African cheetahs, one modern and the other historic, imported to India at different times.

They then sequenced their mDNA and compared them with

mDNA samples of 118 cheetahs from various parts of Africa and Asia.

Led by Kuamarasamy Thangaraj and Guy Jacobs, the researchers found that the Indian cheetah diverged from the south-east African cheetah (*Acinonyx jubatus jubatus*) about 72,000 years ago. The north-east African cheetahs, they report, parted company with both south-east African and Asiatic cheetahs between 100,000 and 200,000 years ago.

Since offspring get their mDNA from mothers, scanning this allowed the researchers to refine the maternal picture of cheetah divergence.

Sci. Rep. (2020)

TRACING OUR FOOTSTEPS TO SEE HOW WE WALK TALL

The stiff foot was critical in the evolution of the human upright gait. A study now explains how arches helped achieve this, results which could help the design of artificial limbs and robotic feet.

Until now, researchers have mostly studied the medial longitudinal arch (MLA), which runs from the heel to the ball of the foot, ignoring the role of the transverse tarsal arch (TTA), which runs across the foot.

Studying mechanical mimics of the midfoot, human cadaveric feet and fossil foot bones, the researchers tried to find out the TTA's contribution to stiffness of human feet. The scientists, including some from the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, performed three-point bending tests on these models. They found that the TTA is responsible for more than 40% of the stiffness in our feet.

Tracking the growth and evolution of primate feet, including that of extinct human ancestors, the researchers found that only the genus *Homo* had fully developed arches (MLA and TTA). Together, these arches contribute to the stiffness of human foot, they report.

Nature (2020)



HIMALAYAN GLACIER ADVANCING, NOT RECEDING

Researchers have reported historical evidence of the advancing of a glacier above Leh in Northwest Himalaya. The Puche glacier, they say, has made three advances – the first around 30,000 years ago, and the most recent one thought to be 12,000 years ago, in the Holocene age.

The study, at Physical Research Laboratory, Ahmedabad, found morphological, sedimentological and chronological evidence from glacial deposits (moraines).

Earlier studies to determine the moraines' age, based on the concentration of radio-nuclides, estimated the age of Puche glacier to be 90,000-110,000 years, suggesting the role of the Indian Summer Monsoon (ISM) in its advancement. The team used the 'optically stimulated luminescence' dating technique to measure the concentration of trapped electrons in quartz crystals extracted from the moraines. They found the moraines are only 30,000-20,000-years-old, corresponding to a period during which moisture originating in the Mediterranean region was the major feeder for glacier growth, not the ISM. The study has implications in the role of the ISM in the glaciers of Ladakh and Karakoram.

Palaeogeogr. Palaeoclimatol. (2020)

Research highlights



EVIDENCE OF A SINGLE GUT MESENTERY

The long debate about whether the 'gut mesentery', a fan-shaped, double-layered membrane in the human abdominal cavity, is a single entity, has been settled. Using a revised method of dissection, an international research team has now proved that it is.

The researchers found a continuous mesentery along all parts of the intestine and have presented an anatomical specimen description of the continuity of the membrane in unprecedented detail – extending from the duodenum, a part of the small intestine, to the rectum, a part of the large intestine.

They have also provided a novel technique to dissect the intact mesentery that could be of great use for surgeons.

Attached to the posterior abdominal wall, the gut mesentery holds parts of small intestines and also contains blood vessels, nerves, lymph nodes and fat. Mesentery in humans was never known to exist in the duodenum, says lead author, Ashutosh Kumar, a human anatomy expert at the All India Institute of Medical Sciences in Patna.

Knowledge of a continuous mesentery will simplify surgical approaches, Kumar says, as it will be easier to access a targeted part of the gut tube. Immune cells in the mesentery play a role in the pathogenesis of certain intestinal diseases such as Crohn's disease.

Front. Surg. (2020)

LASER BEAM SENDS MESSAGES THROUGH THE AIR

Physicists have designed a communication system that can send data in the form of voice, text and images over long distances using light.

The system can send data through the air without fibre-optic cables, the researchers from the Indian Institute of Technology in Guwahati, India, have demonstrated. This mode of data transmission is free from the effects of atmospheric turbulence, the researchers say.

Previous work had tested vortex beams, a specific type of light beam, to send data through the air, but transmission was distorted by wind. To overcome this, the IIT scientists used a specific type of laser beam and tested its efficiency in sending data through the air between two stations.

They sent data by modulating the phase profile of the laser beam, and a specially designed sensor decoded the laser beam encoded with user information at a receiving station. This process can transmit user information even through a turbulent atmosphere.

It can be used for high-speed and secure communication between two people, inside or outside.

Comm. Phys. 3:203. (2020)

INDIAN COBRA GENOME MAPPED



The Indian cobra's venom can disrupt a bite victim's heart function.

Mapping the genome of the Indian cobra (*Naja naja*), researchers have identified specific genes that encode different venom toxins in multiple snake tissues. Knowledge of such venom toxin genes, they say, may help in the development of effective antivenom therapies.

Using a combination of gene-sequencing techniques, an international research team, including scientists from the SciGenom Research Foundation in Bangalore and SciGenom Labs in Kochi, predicted the presence of 23,248 protein-coding genes in 14 different tissues of the Indian cobra.

They identified 139 genes, which belong to 33 toxin gene families. Of these, 19 toxin genes

are expressed exclusively in the venom glands. Comparing the cobra genome with that of the prairie rattlesnake, they narrowed their search to 15 toxin gene families that were unique to the cobra.

The researchers say that it is likely that these genes encode proteins that form the core toxic components of the venom. The toxin-packed venom disrupts the activity of the heart, muscle, paralyses, and can trigger nausea, blurred vision and bleeding.

This information of genes can be used to rapidly synthesise and identify toxin-neutralizing antibodies for the generation of synthetic antivenoms.

Nat. Genet. (2020)

MULTI-DRUG RESISTANT TB CASES DECLINING



Adult females have a more robust immune response to TB.

Scientists report a decline in the prevalence of multi-drug resistant tuberculosis (MDR-TB) in south India from 8.4% in 2015 to 1.3% in 2018.

Resistance to the two first-line anti-TB drugs – Rifampicin and Isoniazid – also decreased from 2015 onwards, pointing to the effectiveness of India's Revised National TB Control Program, according to the authors of the study, collaborating from multiple hospitals.

Their study involved a retrospective analysis (for drug resistance) of 20,245 specimens obtained from presumptive TB patients in the southern states of Tamil Nadu and Puducherry between 2013 to 2018. They also examined associations between

age, gender, previous treatment/failure, HIV status and drug resistance.

The researchers found a positive association of MDR-TB for females, and negative association with old age indicative of the mechanisms by which the immune system and sex hormones may be involved in the pathogenesis of MDR-TB. These aspects could be studied further for innovative approaches to target MDR-TB, the researchers say.

There is an inherent male bias in the incidence of TB and adult females tend to mount a more robust immune response, the researchers say.

Sci. Rep. (2020)

KERALA MOSQUITO SPECIES GETS ITS OWN NAME

A mosquito species from Kerala got a new name almost 50 years after living with the name of one of its close cousins.

The species has now been named *Heizmannia rajagopalani* after medicinal entomologist Pyllore Rajagopalan, known for his work on the Kysanur Forest Disease (Monkey Fever).

The subgenus *Heizmannia* of the genus *Heizmannia Ludlow* comprises a group of 33 mosquito species widely distributed in East Asia. When the first specimens of the mosquito were collected in Kerala in the 1970s, they were misidentified as *Heizmannia metallica*, a species found in Malaysia.

Researchers from the ICMR-Vector Control Research Centre (VCRC) in Puducherry collected and reared the mosquito larvae from fallen cocoa shells and discarded tyres in Kottayam and Idukki Districts of Kerala. Upon taxonomic examination, they found that the specimens differed distinctly from the Malaysian species *Heizmannia metallica*.

The Indian species is medium-sized with metallic iridescent and snow-white markings on the head and thorax, they report.

Zootaxa (2020)



GENOME OF PABDA FISH DECODED

Researchers from the All India Institute of Medical Sciences in New Delhi have sequenced the genome of the Pabda fish, which could help in its conservation and captive breeding.

Catfish such as the Pabda fish are an excellent source of fatty acids, vitamins and minerals. In recent years, overfishing, habitat losses and the rampant use of pesticides have drastically reduced Pabda stocks, once common in India, Bangladesh, Pakistan and Nepal.

Taking Pabda fish from the Ganges, the researchers, led by Subhradip Karmakar, sequenced its genome, and found 21,371 genes. Its genome was found to be comparable to the genomes of the channel catfish and the striped catfish.

The first-ever genome of the Pabda fish, they say, will also help understand its evolution, migration patterns and immune systems. The work might shed light on the closeness between humans and fish, thereby designing conservation-related development programs for this fish and other vertebrates.

BMC. Res. Notes. (2019)

Research highlights

WEB RESOURCE FOR DISEASE VECTORS

Biologists have created a digital repository of important vectors that carry and transmit pathogens to humans and livestock in India.

The database, called VectorInfo, contains biological information such as genes and genome sequences, proteins and metabolic pathways of about 53 species of vectors found in India.

Scientists from the Vector Control Research Centre and the Pondicherry University, both in Puducherry, developed VectorInfo by collecting data from sources such as the research literature, reference books, manually curated databases and data from the National Centre for Biotechnology Information.

The online database has seven sections, including biology, genomics, transcriptomics, proteomics, enzymes and their pathways, immune-specific genes and insecticides.

It offers 2,500 pieces of omics data that correspond to global analyses of proteins, genes, metabolites, lipids, DNA and modified proteins in chromosomes related to the vectors. The site has information about insecticides that are used to kill disease-carrying insects such as mosquitoes, flies, fleas, ticks and mites.

The insecticide section outlines the list of chemicals and medicinal-plant-derived insecticides that targets multiple life stages of vectors.

Acta. Tropica (2020)

PITCHER PLANT INSPIRES A WATER HARVESTER

A printer paper coated with a sponge-like porous polymer material can harvest water from an artificial fog or vapour-laden air. The polymer coating helps generate water-loving spots on the paper surface, which mimics the surface of an insect-eating pitcher plant.

The study's authors, from the Indian Institute of Technology in Guwahati, explain that the technique could be used to harvest water from air without the need for a cooling apparatus.

The IIT scientists designed a water-loving slippery liquid-infused porous (SLIP) surface using a polymer and a natural and edible oil on printer paper. They then tested the efficiency of this paper in harvesting water from artificial fog or vapour-laden air.

They found that the specially designed surface facilitated faster pooling of water droplets, and rapid shedding of those droplets, compared with other nature-inspired interfaces.

The hydrophilic paper surface started shedding water droplets after an exposure of 107 seconds to the artificial fog. A slight modification of the pattern of the water-loving surface further accelerated the shedding of the water droplets, the researchers found.

The polymer coat on the paper remained intact even after being exposed to acidic and basic solutions, artificial seawater, river water and ultraviolet light, for 30 days.

J. Mater. Chem. A. (2020)



READING VOLCANIC ERUPTIONS



Volcanic activities affect large-scale precipitation dynamics.

Large volcanic eruptions offer a novel path for monsoon predictions and for anticipating the strength of seasonal rainfall in the Indian subcontinent, a study by a team of Indian and German researchers says.

Accurate forecast of the seasonal summer monsoon rainfall is critical for the agrarian economy. Prediction of the monsoon rainfall over India is closely connected to the evolution El Niño/Southern Oscillation (ENSO) – a dominant climatic phenomenon in the tropical Pacific Ocean.

Year-to-year variations in the monsoon are tied to large-scale patterns of sea surface temperature and sea level pressure variations with the El Niño phenomenon. However, the ENSO-Indian Monsoon (ENSO-IM) relationship has weakened during the past few decades, the study says,

Large volcanic eruptions have the potential to couple the phases of the ENSO and monsoon oscillatory systems, says corresponding author Raghavan Krishnan of the

Indian Institute of Tropical Meteorology (IITM) in Pune.

Ash, particulates and gases ejected by volcanoes enter the stratosphere and block the solar radiation reaching the Earth's surface. "Less sunshine means less warmth and hence a change of temperature differences between the northern and southern hemispheres," says Krishnan. "The preferential cooling of the northern hemisphere induces an El Niño-like anomaly in the tropical Pacific Ocean and alters the large-scale precipitation dynamics."

The volcanically forced ENSO-IM coupling enhances the predictability of the monsoon due to a stronger coupling between the monsoon over large parts of South and South-East Asia and the El Niño phenomenon after an eruption, the report says.

Science Adv. (2020)

Discovering Purpose, Exploring Passions



Ashoka University is a leading not-for-profit private university built on the principles of **collective public philanthropy**. It has been given an overall diamond rating by QS I.GAUGE, and was ranked as the second-best private university in India in Education World 2019-20 Rankings. Ashoka aspires to be globally recognised as a **pre-eminent institution of learning** that secures India's front-ranking position in the creation of knowledge, produces future leaders, and simultaneously transforms society.

Teaching and research are done through programmes in Natural Sciences, Social Sciences and Humanities, Computing and Data Sciences, and multiple Centres focused in key areas that cut across disciplines.

Ashoka's education is unique. Built on the foundations of liberal arts, all students are taught fundamental principles of **physics** in a way that brings in both the elegance of principles of natural world and the complexity that still needs to be unraveled. Subsequently, students are introduced to **chemical, biological and human worlds**, not as independent disciplines, but as a continuum of physical world. **Mathematics** is taught as a language that connects all these disciplines of science and also as an abstract method by which we understand our surroundings.

In addition to classical and emerging areas of **Computer Science**, students have an opportunity to study interdisciplinary areas like computational biology, social and information networks, digital humanities and data-driven journalism.

The **Trivedi Centre for Political Data (TCPD)** and **Centre for Economic Data and Analysis (CEDA)** are using big data to facilitate informed debates about economic, social and political developments in India.

“**Ashoka education prepares students to be ethical leaders in a diverse and complex world.**

Prof. L S Shashidhara,
Dean (Research), Ashoka University

The **Center for Health Metrics (CHM)** will focus on accurate collection, curation, analysis and reporting of health data, information and trends in India and eventually will cover the whole of South East Asia for providing unbiased and evidence-based health trends to facilitate effective policies and enable timely and effective funding of health-care projects.

The **Centre for Climate Change and Sustainability (3CS)** at Ashoka is truly a trans-disciplinary initiative led by world-class researchers and teachers, who are passionate about changing the way we engage with climate change.

The research in the **Trivedi School of Biosciences (TSB)** focuses on emerging and frontier areas of Biosciences. This includes three interconnected and interdisciplinary research centers – **Center for Disease Biology, Center for Inflammation Biology and Center for Synthetic Biology** – that will carry out cutting edge research and support the training of future leaders.

The **Centre for Interdisciplinary Archaeological Research** aims to create a state-of-the-art facility that brings archaeology and the sciences together to offer new perspectives that will deepen study of the Indian past.

Ashoka, with its strengths in humanities and social sciences, is developing a strong program on **Science policy**. Ashoka plans to float interdisciplinary postgraduate degree programs to meet the highly skilled human resources needs of the industry, the fast expanding discovery science sector and development of new and sustainable technology. In addition, certificate courses would be offered in instrumentation, big data and computational methods, AI and ML as tools for discovery sciences, environmental chemistry, science policy, etc.



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BORDERS WORTH PROTECTING

Scientific collaborations between researchers in India and China could become part of a wider dialogue to improve troubled regional relations. **By Jacob Dreyer and Subhra Priyadarshini**





The complex geopolitical dynamics between India and China have long created barriers to sustained scientific collaboration. But scientists on both sides of the border say environmental degradation is posing an increasingly grave threat to billions of people in south Asia. They are calling for renewed efforts to protect and nurture research partnerships between the world's most populous countries.

Scientific teamwork could lay foundations for shared spaces, offering environmental benefits, and openings for diplomatic commonality, particularly in current areas of conflict.

The border landscape between the two countries is the most biodiverse in the region. It straddles the remote terrain of the Himalayas, vast swathes of connecting dense forests, and cradles south Asia's largest transboundary rivers. It is also the subject of a long history of territorial disputes between the military forces of both countries that escalated last year in a clash in the Galwan Valley of the Himalayas.

"Geopolitics and jingoism have been the bane of scientific collaborations between the two countries," says Maharaj Pandit, a professor of Environmental Studies at the University of Delhi. Because of a paucity of research, a 2007 report by the United Nations' Intergovernmental Panel on Climate Change referred to the Himalayan region as a "black hole for data". The COVID-19 pandemic has only deepened this hole in data generation and sharing, Pandit says.

But, problems such as water diversion from shared rivers, extreme weather events, dwindling numbers of endangered animal species, and energy insecurity urgently require discussion and joint action between scientists.

Biodiversity and climate

Scientists and conservationists increasingly point to biodiversity preservation as the central plank in necessary measures for addressing the impact of climate change in the region. "There is enough evidence for us to push for action," says Pema Gyamtsho, Director General of the Kathmandu-based International Centre for Integrated Mountain Development (ICIMOD). ICIMOD's objective is to promote regional conservation and development initiatives through a transboundary landscape approach. It covers an area of 71,452 square kilometres in Myanmar (66%), China (22%) and India (12%). While ICIMOD's efforts are limited by an imperative to avoid the overlapping territories in the "line of control" disputed areas, in October 2020, ICIMOD hosted a ministerial summit of all eight Himalayan countries, including India and China, where government representatives pledged to reduce greenhouse gas emissions and promote ecologically smart alternatives, among other measures. "It is time to walk the talk," Gyamtsho says.

S. PRIYADASHINI

Cover story

Wang Jinnan, head of the Chinese Academy of Environmental Planning in the country's Ministry of Ecology and Environment, recently made headlines by suggesting that Qinghai, home to the Sanjiangyuan National Park, should become a demonstration province for carbon neutrality. Sanjiangyuan (meaning source of the three rivers Yangtze, Yellow and Mekong) is a showcase of how sustainable water use, electricity generation, and agricultural methods can become vehicles for new relationships.

However, the road to decarbonization has many hurdles. "The single-minded focus on reducing global carbon emissions gives China a perfect alibi for pressing ahead with hydro-power projects," says Li Yifei, an assistant professor of environmental studies at New York University Shanghai.

Researchers in India and Nepal have expressed concerns about the negative environmental impacts of a proposed dam on Yarlung Tsangpo, a Tibetan river, which downstream in India is called Brahmaputra. In line with these concerns, Chinese researchers earlier recommended that the Yarlung Tsangpo canyon be designated a national park.

Transboundary water issues have long been a point of contention between India and China and the Yarlung Tsangpo dam proposal represents a test case for multinational communication and collaboration, says Li. A national park or protection zone could allay regional concerns about China's dam-building, and at the same time, preserve the natural heritage of the region. It also creates potential avenues for balancing decarbonization strategies with respect for biodiversity and indigenous communities. While mining and hydroelectric



Reserves are vital for preserving biodiversity.

projects developed by both countries in biodiversity hotspots of the western and eastern Himalayas have had an adverse impact, most of these ecologically sensitive areas have been under military control since the Indo-China war of 1962. Intensive military operations have forced indigenous people to flee.

The path forward

Geopolitical tensions make for difficult dialogue between researchers, but shared biodiversity conservation goals can identify common ground in disputes. "Authorities and scientists from India and China need to strengthen communication with indigenous people and increase survey efforts on threats

to biodiversity," says Sambandam Sandilyan, a researcher of invasive species, and former fellow of the Centre for Biodiversity Policy and Law, at the Indian National Biodiversity Authority. "Researchers should respect the policies and laws of each country before starting conservation operations, and follow strict biosafety measures during surveys and sample collection," he says. The UNESCO guidelines for jointly run research stations could be applied.

India and China have already signed several accords including the Sino-India collaboration agreement on the environment in 1993, and on agriculture and afforestation in 2009. But international intervention would help. Inter-governmental organizations such as ICIMOD, the Global Tiger Forum, the United Nations Development Programme (UNDP) and the UN Environment Programme (UNEP), need to take the lead to establish a conducive environment for cooperative research, says Sandilyan.

Communication blockages between scientists are not impossible to overcome, according to Peng Kui, manager for Beijing-based Global Environment Institute (GEI)'s Ecosystem Conservation and Community Development Program. Peng, who works on ecological protection zones on the border with South-east Asian countries, including Myanmar and Laos, says building links between researchers and parks on both sides of the India-China border would be a good start. He hopes to initiate collaborative discussions at a forum he is to co-host at the 15th Conference of Parties (COP15) of the Convention on Biological Diversity in Yunnan's capital, Kunming, this October.

Peng says scientists and policymakers must be proactive in identifying nature reserves on the borders for collaborative research, such as Xishuangbanna Biosphere Reserve in the south-western Chinese province of Yunnan, bordering Myanmar, and in south Tibet.

Other examples of scientific collaborations include China and Russia's ecological protection zone for the critically endangered Amur leopard on their borderlands; and the Gaoligong National Park, where it is proposed that elephants should roam freely between China, Laos and Myanmar. In December 2013, the Chinese government laid out ambitious plans for a number of national parks in the border region, a move that saw the Sanjiangyuan national park in the Tibetan plateau become a research hub, led by the Chinese Academy of Sciences.

China's ambition is to make its national parks programme a significant push for the preservation of biodiversity. The country has earmarked four more areas for protection, to be run collaboratively with the Tibet Autonomous region administration in the Qinghai-Tibet plateau. Three of these are in the Himalayas.

With the stakes so high, the argument for territorial-neutral ecological research areas and multilateral collaborations is being made on both sides of the border.



The Pangong-tso lake is shared between India and China.

EPIDEMIC PREPAREDNESS: IND-CEPI ON A MISSION TO ADVANCE VACCINE DEVELOPMENT, INCREASE CAPACITY, IMPROVE INFRASTRUCTURE

The Government of India

partnered with global initiative Coalition for Epidemic Preparedness Innovations (CEPI) in March 2019 to accelerate India's vaccine manufacturing program which proved to be a timely initiative. As COVID-19 ravaged the country and the world, the Ind-CEPI initiative enabled the launch of a rapid response against the pandemic.

Led by the Department of Biotechnology, the Rs 312.9 crore Ind-CEPI mission partnership has been at the forefront of the fight against the virus and is supporting India's only RNA vaccine candidate being developed by Genovva Biopharmaceuticals.

Since inception, Ind-CEPI has worked on multiple fronts to secure a vaccine infrastructure and capabilities to help not just India but neighbouring countries too. Development, up to phase-two testing, of two to three vaccines in five years leads the pack of initiatives to tackle potential outbreak threats.

The mRNA vaccine candidate under development with the support of Ind-CEPI is designed to be thermo-tolerable. It can be transported at temperatures of 4°C to 8°C, thus making its last-mile delivery in any South Asian country more efficient.

This is the partnership's essence — a goal to build a coordinated preparedness in the Indian public health system and vaccine industry to address existing and emergent infectious threats in India.

Ind-CEPI is also backing development of a potential Chikungunya vaccine by Bharat Biotech International. An effective vaccine candidate against chikungunya is a long-standing need to immunize millions throughout the world, especially in developing countries.

The vaccine development objectives are being implemented via a program management unit at DBT's Biotechnology Industry Research Assistance Council (BIRAC). It facilitates pathways for vaccine development and assessment — all developed in consultation with CEPI.

The NABL Accredited Bioassay Laboratory at THSTI supported under the Ind-CEPI programme has been recognized by CEPI as one of the 7 global network of laboratories for harmonized assays for vaccine development. The laboratory offered services to several vaccine manufacturers by providing validated assays for testing COVID-19 vaccine immunogenicity and efficacy

Vaccine development is incomplete without a robust **academia-industry interface**. For Ind-CEPI, creating that bedrock is priority. Helping in **capacity building** and **skill development** a major focus area, the Ind-CEPI mission also recognises the critical need to strengthen **surveillance and logistics frameworks** for new vaccines as and where required.

All this requires **inter-ministerial coordination** to fill the gaps in R&D for vaccine development, create pathways for improved manufacturing, and harmonize regulatory requirements and vaccine storage with equitable distribution.

Ind-CEPI recognises the need for **regional cooperation and collaboration** to meet the challenges posed by a pandemic or disease outbreak. To that end, it has successfully expanded its reach in the neighborhood and region.

A case in point are its multi-nation eCourses. In the little over two years of its partnership, Ind-CEPI has been lauded for its eCourse series, ably implemented in the middle of the pandemic.

The first, 'Strengthening Clinical Trial Research Capacity in Neighbouring Countries', included 771 participants from Afghanistan, Bangladesh, Bhutan, Maldives, Mauritius, Nepal and Sri Lanka.

Organised from October 9 to December 4, 2020, the series in ten sessions and four programs covered good clinical practice, ethical considerations in clinical research, good clinical laboratory practice, and novel vaccine development and immunization policy in a pandemic. All participants were certified after assessment.



Dr Renu Swarup,
Secretary, Department of
Biotechnology
Ministry of Science & Technology
Government of India

“ This is an important Mission Program being implemented under the Atal Jai Anusandhan Biotech Mission for establishing integrated preparedness for epidemic threats and international coordination and cooperation. Partnership with CEPI has been important and Ind-CEPI has contributed to the acceleration of our vaccine development.”

The second eCourse, 'Strengthening Clinical Trial Research Capacity in India's Friendly Countries', from February 5 to April 30, 2021, had 1,731 participants from Bhutan, Nepal, Bahrain, Kenya, Myanmar, Oman, Somalia and Vietnam.

Aligned with CEPI's global initiatives, Ind-CEPI's scientific leadership in regional networking and its championing a vaccine infrastructure is on target to ensure the country is equipped to adapt to epidemics in the future, and help its neighbourhood too.

For more information on Ind-CEPI's initiative, please visit www.birac.nic.in.

Office address: PMU Ind-CEPI, BIRAC, 1st Floor, MTNL Building, 9, CGO Complex, Lodhi Road, New Delhi-110003



<p>Mission</p> <p>Epidemic preparedness through rapid vaccine development: Support of Indian vaccine development aligned with the global initiative of the Coalition for Epidemic Preparedness Innovations (CEPI)</p> <ul style="list-style-type: none"> Department of Biotechnology's flagship program being implemented at BIRAC Approved with a total cost INR 312.92 Crore. 	<p>Supporting Vaccine Development</p> <p>Currently supported: CHICK SARS-CoV-2</p> <p>Infrastructure Support</p> <p>EOI Published: Quality Management Systems</p> <p>Internal inter-ministerial co-ordination for rapid vaccine development</p> <p>Vaccine diplomacy initiatives, Bilateral-Multilateral Co-operation</p> <p>Skill Development</p> <p>E-Course Series: Strengthening Clinical Trial Research Capacity in Neighbouring & Friendly Countries</p>	<p>Future Efforts</p> <ul style="list-style-type: none"> Vaccines to control epidemic outbreaks of infectious disease at an early stage to prevent spread, including engagement with LMICs Novel Platform technologies Development of ethical and regulatory frameworks, surveillance and logistics for use of new vaccines.
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MAKE THE HIMALAYAS A ZONE FOR MEETING MUTUAL GOALS

Maharaj K. Pandit*



Conservation could be part of the toolkit for diplomacy between China and India.

Thirty-five years ago, at the beginning of my research career, I walked for weeks to study populations of the endangered Himalayan goldthread or mishmi teeta (*Coptis teeta*), an endemic plant in Arunachal Pradesh in the Eastern Himalayas that is used as a potent antimalarial drug by local communities. Himalayan species are



intriguing. Like isolated islands, mountain peaks reveal how evolution works: by knowing where unique species concentrate, we can learn how speciation occurs.

It would be hard for researchers across the Himalayas to do research treks today. Hundreds of thousands of soldiers are now stationed across the high Himalaya. June 2020, saw the worst clash in 45 years, when India–China disengagement talks were followed by a fatal brawl that left at least 20 people dead, several from falls into a river gorge. It is the latest episode in a border conflict between two nuclear powers, and it is happening in a unique and fragile ecosystem.

The Himalayas, which straddle seven nations, already has one of the world's highest rates of deforestation as a result of logging, agricultural expansion, a burgeoning human population, and the building of dams and other infrastructure. It is also thought to be the most rapidly warming mountain range on Earth. Alongside the animal species, Himalayan alpine meadows boast a wealth of herbaceous flowering plants – strange, colourful and delicate – often with medicinal properties. Nowhere else are so many native plant species found at such high elevations.

I have been studying this region for decades, mainly investigating the effects of dams, deforestation, land-use changes, conservation and policy. Roads and buildings to accommodate troops are encroaching on this fragile territory. Pangong Tso Lake, at an altitude of 4,280 metres, saw a military face-off in May 2020. It is only one of many unique Himalayan ecosystems being trampled. The lake is a specialized saline water body surrounded by alpine meadows. Militarisation, land-use changes, and habitat destruction and fragmentation across the Himalayas are likely to push several species with small populations to extinction. Diplomacy is their only hope.

Here is my idealistic aim for this region. Alongside other multilateral strategies, the mountain range, or at least those areas between 2,600 and 4,600 metres high – whose famous inhabitants include the snow leopard and its prey, the Himalayan blue sheep – should be designated a nature reserve. I propose calling it the Himalayas-one-Nature-one-Reserve, or HONOR. It would ideally encompass much of the Himalayan biodiversity hotspot in the Eastern and Western Himalaya, about 740,000 square kilometres.

My dream is not as far-fetched as it seems. In Antarctica, the Ross Sea Marine Protected Area covers at least 1.5 million square kilometres under a 25-nation agreement. The largest land-based protected area, Northeast Greenland National Park, is 972,000 square kilometres.

I am also inspired by other conservation efforts. The Mekong River Commission includes the governments of Cambodia, Laos, Thailand and Vietnam. A similar Himalayan

River Commission, involving all the Himalayan head-water and downstream nations, needs to be explored. In the Himalaya, fledgling transnational conservation efforts and proposals, such as the Kailash Sacred Landscape Conservation and Development Initiative, and the Kangchenjunga Landscape Conservation and Development Initiative, should be ratified and strengthened.

These ideas need to be on the table now, while tensions are so alarmingly high. None of the Himalayan countries wants war, so some sort of stand-down will happen – and conservation should come into the discussions. There is a de-facto code for military engagements at this border to avoid the use of firearms. Surely, not building more infrastructure is as feasible as soldiers not using guns.

Military infrastructure built so far in fragile parts of the Himalaya includes thousands of kilometres of roads. The Chinese-backed US\$75-billion China–Pakistan Economic Corridor is a 3,000-kilometre-long route comprising roads, a railway and oil pipelines. India's Border Roads Organisation has been empowered to build 3,400 kilometres of strategic border roads, 61 in total, to cater for far-flung communities, pilgrims and border security.

Transporting fuel to inaccessible terrains to melt bitumen for the road surface is expensive and arduous. Woody plants such as rhododendrons, oaks and conifers, including extremely slow-growing shrubs such as Juniperus, are regularly used as fuelwood. A Belt and Road initiative of the Chinese government, which India is not involved in, passes through the most fragile Himalayan landscapes.

As the grasses and herbaceous plants disappear from these alpine valleys, so will a way of life. With no public-healthcare system, fragile medicinal herbs are the only source of medicine, and the only source of cash for highland marginal communities. The semi-domesticated yak in the Himalayan highlands, on which the people depend, cannot graze on the shrubs that are fast invading the meadows under the impact of global warming. I dream instead of the highlands transformed into a peaceful nature reserve, and that the huge public funds squandered on managing conflict are invested instead in infrastructure for health care, education, conservation and welfare. Perhaps this vision will inspire those trying to bring peace to the roof of the world.

**Director, Centre for Inter-Disciplinary Studies of Mountain & Hill Environment and at the University of Delhi. He is the author of Life in the Himalaya: An Ecosystem at Risk.*

SERVICING THE PIT STOPS OF MIGRATORY BIRDS

Open-pit mining in eastern India has carved out unique water havens that must be conserved. **By Richa Malhotra**

Every winter, migratory birds descend upon the Indian sub-continent from distant lands in search of warmer climes. During these long flights, the birds stop by wetlands to rest and refuel. Scores of 'pit lakes', formed as a result of open-pit mining in West Bengal and Jharkhand, offer the avian guests a stopover venue, new research suggests¹.

The rich habitat of these pit lakes also attracts a number of local bird species, and therefore it is important to conserve them, according to researchers from the Salim Ali Centre for Ornithology and Natural History (SACON) in Coimbatore, Tamil Nadu.

Pit lakes are formed when groundwater and rains fill mining dug-outs. New pit lakes may have poor water quality, but over time, some develop into healthy ecosystems, harbouring wildlife and supporting local communities.

SACON's Santanu Gupta prepared an inventory of 62 such pit lakes in the Eastern Coalfields Limited's (ECL) mining operations in West Bengal and Jharkhand. Some of these lakes are more than 50 years old². Using a combination of mathematical models and field visits, Gupta and colleagues assessed 20 lakes to see how suitable they are for birds. They found

three pit lakes to be highly favourable for the species they chose to study – the long-distance migrants, bar-headed goose and red-crested pochard, and the locally dispersing cotton teal (also called pygmy-goose).

The researchers mapped the three pit lakes and divided each into three conservation zones – a 'conservation priority site' with the restored lake at its core; a 'habitat development zone' where trees have been planted; and an 'eco-overlap zone' criss-crossed by farms, homes and roads.

The priority site of the lakes can be protected as they are, says Snehangshu Das, a master's student at Shivaji University in Maharashtra, and co-author of the study. In the habitat development zone, non-indigenous trees planted by ECL to rehabilitate the land will need to be replaced by indigenous varieties, Das says. All human activities, he adds, should be restricted to the eco-overlap zone.

During their survey of the 20 pit lakes, the researchers counted 41 resident and 10 migratory bird species. They also found nests of some resident bird species.

However, despite being important bird habitats and a source of water for communities,



A cotton teal in its pit lake habitat.

pit lakes are not mentioned in state or national wetland policies such as the West Bengal Wetlands and Water Bodies Conservation Policy or the National Plan for Conservation of Aquatic Eco-systems.

These unrecognized lakes also face the threats of pollution and infilling. According to Gupta, at least five pit lakes have been entirely or partially filled with either coal ash waste from thermal power plants or debris from active coal mines nearby. The flattened land is repurposed for housing and other development activities, Gupta says.

Gupta and team hold ECL, a subsidiary of the government-owned Coal India Limited, accountable for not fulfilling their corporate social responsibility (CSR). Between 2017 and 2018, the company spent³ most of its CSR funds on activities unrelated to the environment, and left a balance from its allocations unspent. ECL must take responsibility in protecting the biodiversity of the pit lakes, the researchers say.

1. Das, S. et al. Spatial prioritization of selected mining pitlakes from Eastern Coalfields region, India: A species distribution modelling approach, *Conserv. Sci. Practice* (2020) doi: 10.1111/csp2.216

2. Gupta, S. Ecological exploration and socioeconomic valuation of pitlakes in Eastern Coalfields, India: Implications for conservation and sustainable use. Annual Progress Report (1). Submitted to DST, Gol (2018)

3. ECL Annual Report 2017-18, 64-72 (2018)



Pit lakes attract long-distance migrants and local residents.



AHMAD MASOOD/REUTERS/ALAMY STOCK PHOTO

Researchers have found that fertilizer consumption is directly linked to the amount of ammonia in the air.

INDO-GANGETIC PLAINS WORLD'S AMMONIA HOTSPOT

Emissions correlated with fertilizer use and stubble burning.

By K. S. Jayaraman

The Indo-Gangetic Plains (IGP) in India have become a global hotspot of ammonia emission, thanks to intense agricultural activities and a large concentration of fertiliser industries, according to research at the Indian Institute of Technology-Kharagpur¹.

Atmospheric ammonia over India has reached 'record high levels', particularly over the IGP region, where its level is higher than anywhere on the globe. This makes the north India river plain region one of the largest and most rapidly growing ammonia hotspots of the world, the researchers say.

Ammonia is a gaseous compound of nitrogen that combines with other pollutants in the air

to form aerosols that affect public health and the climate. Agriculture contributes significantly to the atmospheric emission of gaseous ammonia, says the report by Jayanarayanan Kuttippurath and his colleagues.

Using satellite observations, the researchers found that fertilizer consumption was directly linked to the amount of ammonia in the air. An increasing trend in atmospheric ammonia during the *khari*f agriculture season (June-September) established this link between agricultural activities and ammonia release.

As party to the Paris Agreement to combat climate change, India faces the challenge of meeting the growing demand for food while

keeping a check on atmospheric emissions. One way to do this, the researchers suggest, is to regulate the fertilizers used in cropping seasons by adopting precision farming. Such methods observe the actual demand of a plant for fertilizers rather than using conventional blanket fertilisation levels.

The findings seem to concur with insights from the Indian Nitrogen Assessment, which revealed that chemical fertilisers are the largest contributors to nitrogen emission, says Nandula Raghuram, professor of biotechnology at Guru Gobind Singh Indraprastha University in Delhi, and Chair of the International Nitrogen Initiative.

"Ammonia emissions are clearly correlated with urea fertiliser use and stubble burning," he told *Nature India*. Raghuram says while governments are encouraging moderation of fertilisers and crop diversification, farmers have not sufficiently adopted these ideas.

"Soil amendments for prevention of alkalinization in Punjab, Haryana, and possibly western Uttar Pradesh, may be another important intervention to reduce ammonia emissions in these states."

While it is easy to attribute ammonia levels to the readily available fertiliser data, more rigorous analysis of ammonia emissions from solid and liquid waste, and their trends over time, are needed, he adds.

1. Kuttippurath, J. *et al.* Record high levels of atmospheric ammonia over India: Spatial and temporal analyses. *Sci. Total Env.* **740** (2020) doi: 10.1016/j.scitotenv.2020.139986

METEORITE CONFIRMED AS CAUSE OF RAJASTHAN CRATER

Spectacular site becomes the third reported impact crater in India. **By K. S. Jayaraman**

A much studied crater in the sleepy village of Ramgarh in Rajasthan has finally been confirmed as an asteroid impact spot by two separate international teams of geologists. However, the exact size of the crater is still a matter of debate.

This makes the Ramgarh crater, studied for more than five decades for its spectacular geomorphic features, the third impact structure in India. The now-eroded crater in the Vindhyan Supergroup of sedimentary rocks dates back to the Mesoproterozoic age (roughly 1600 to 1000 million years ago).

The scientists, including a group from the Physical Research Laboratory (PRL) in Ahmedabad, analysed the chemical composition of rocks at the impact site to conclude that the crater was created by the impact of a copper-rich iron meteorite. A meteorite is a fragment of an asteroid. The mineralogical and geochemical characteristics of the millimetre-sized, iron-rich spherule-like particles, which they recovered from the alluvium inside the crater, also bore signatures of a meteorite impact. The absence of nearby known volcanic structures strengthens the theory.

The magnetic particles, which the scientists recovered from the rim of the Ramgarh structure, shows presence of coesite, a high-pressure polymorph of silicon dioxide, “one of the most diagnostic indicators of impact origin”, says Dwijesh Ray of PRL and lead author of one of the studies. “The presence of a possible central peak and its current crater diameter/depth ratio of -12 well corroborate the range of terrestrial complex asteroid impact craters,” Ray tells *Nature India*.

Earlier, Thomas Kenkmann, with colleagues Gerwin Wulf at the University of Freiburg, in Germany, and Amar Agarwal from the Indian Institute of Technology Kanpur, documented the “planar deformation features, planar fractures and feather features” in quartz grains from the centre of the Ramgarh structure, to confirm its origins in an asteroid impact.

Roughly rectangular, the Ramgarh crater resembles the well-known Barringer Crater



The size of the Ramgarh crater is a matter of debate.

CHETAN K. JAIN

in the United States. Worldwide, 204 impact craters have been reported, two of which are in India: the Lonar Crater (Maharashtra) in the Deccan Traps, and the Dhala Structure in Bundelkhand (Madhya Pradesh). The Ramgarh structure was first discovered by the Geological Survey of India in 1869. The Geological Society of London identified it as a crater in 1960.

Impact cratering is a geological process that shapes the surfaces of the terrestrial planets when high-velocity asteroids or comets hit them. Imprints of past impacts on the Earth are poorly preserved because of the continued action of mountain building due to plate tectonics, weathering and erosion. Therefore, identifying new asteroid impact structures on Earth is challenging for palaeontologists.

“Only recently has concrete evidence emerged in the form of documentation of shock metamorphosed minerals in the target rocks of Ramgarh structure,” says Senthil Kumar, principal scientist at the National

Geophysical Research Institute in Hyderabad.

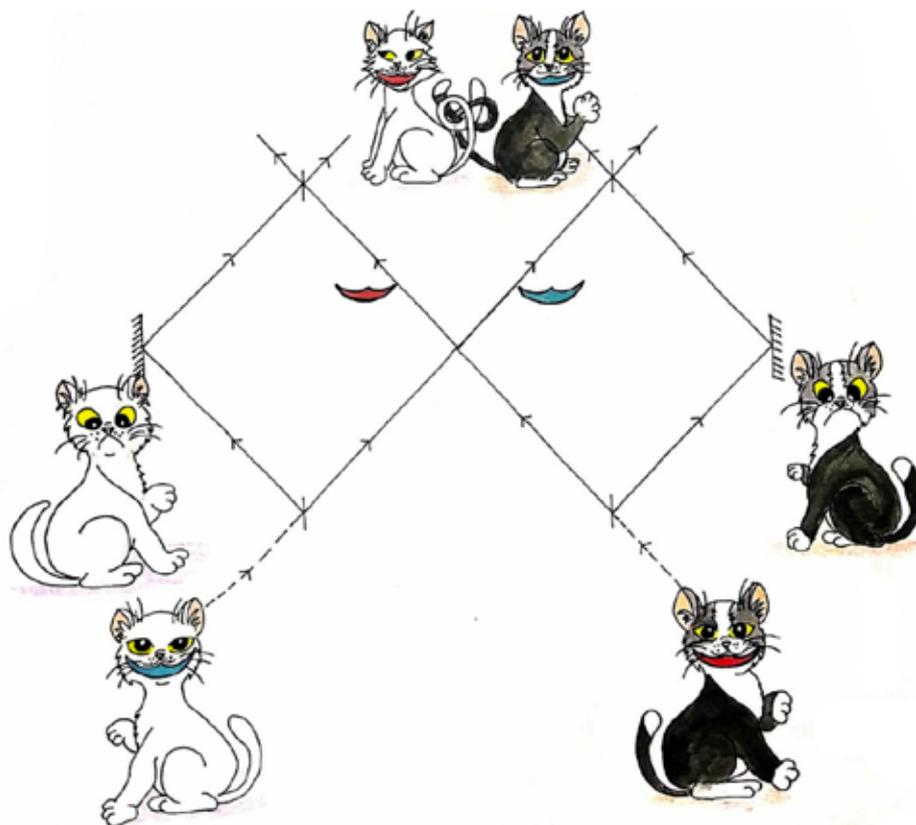
Kumar says this requires further investigation since the two studies differ in their estimation of the size of the Ramgarh crater. While Kenkmann and colleagues consider the Ramgarh structure to be a large complex crater 10 km across, Ray and team have described it as a crater of 2.4 km rim to rim.

Ray concedes that the precise size of the Ramgarh structure is still a matter of debate. “While Kenkmann and team estimated the size based on the remote sensing survey, we hope there is still scope to find the exact size of the impact structure through field-based survey using geophysical techniques,” he says.

Kenkmann explains that the PRL study took the topographically apparent ring-like structure of the Ramgarh crater and interpreted it as the uplifted crater rim. “We demonstrate that the topographic ring (collar) is the remnant of a central uplift, which is a typical feature of larger craters that make up more than 60% of craters on Earth,” he adds.

QUANTUM CHESHIRE CATS

A physics trick that separates the feline from its grin. By K. S. Jayaraman



The exchange of grins in a double Quantum Cheshire Cat setup using weak measurement.

In a world governed by classical physics, an object cannot be separated from its properties. For instance, a smile and the resultant dimples on the cheeks cannot be segregated from a person's body.

But it is not always so in the quantum world, where the physical properties of a particle may not belong to the particle itself.

Quantum physicists Arun Kumar Pati and Debamalya Das, from the Harish-Chandra Research Institute (HRI) in Allahabad, now prove that a quantum object can permanently discard a physical property and obtain a new one it did not initially have¹.

"This sounds strange, but it can have profound implications for our understanding of the quantum world," Pati told *Nature India*.

In quantum physics terms, separating an object from its own properties is called the

Quantum Cheshire Cat (QCC) effect, in reference to Lewis Carroll's *Alice in Wonderland*, in which Alice is wonderstruck by a magical cat that appears and disappears at will, leaving its grin behind.

In 2013, Israeli physicist Yakir Aharonov and his colleagues showed the possibility of separating an object from its own properties using the concept of quantum weak measurement, supporting the QCC effect theory².

Pati and Das now propose that two photons can swap their circular polarizations, or spin, even if they are not at the same site – the photons being analogous to Cheshire cats, and their circular polarisations to the grins.

They revealed this separation of the body and the grin of the 'elementary Cheshire cats' by taking two sets of weak measurements of the particles – one to establish the location of

the particle and the other to locate its circular polarisation.

"Physical attributes are not real and may not belong to a system," explains Pati regarding their observations. The thing at play here was quantum entanglement, meaning the inextricable linking of two particles where whatever happens to one immediately affects the other. "Entanglement plays a crucial role in the realization of this exchange process," Pati says. This means that it is possible to swap the polarisations of two photons without their being close to each other.

The QCC effect has opened up a new window for the understanding of quantum systems in quantum information as well as in technological applications, adds Pati. It pertains not only to photons and their polarizations but can, in principle, be observed with any quantum system and its property, such as a neutron and its magnetic moment, and an electron and its charge.

Dipankar Home, a quantum physicist at Bose Institute in Kolkata, says implications of the QCC effect are much debated and an unambiguous empirical demonstration of this effect still remains to be seen. "This work is a stimulating twist and its implications need to be further explored," he told *Nature India*.

Pati says the spin swapping by photons predicted by his group has now been experimentally observed and reported³ by researchers in China.

Jingling Chen of Nankai University, one of the authors of that study, says their experiment, a demonstration of two photons exchanging their spins without classically meeting each other, would help foster new research in the area of quantum information. The apparent separation of physical properties from quantum objects and the exchanges of these properties "lucidly exhibit the genuine quantum feature of the quantum Cheshire cats".

Quantum physicist Eliahu Cohen, from Israel's Bar-Ilan University, says Pati and Das' work has not only separated two photons from their polarizations, but also let them take each other's polarization. The conceptual implication could relate to the question of what inherently characterises a particle. "... the practical implication would be to attempt to utilize the proposed effect in quantum communication and computation," he says.

1. Das, D. & Pati, A. K. Can two quantum Cheshire cats exchange grins? *New J. Phys.* **22**, 063032 (2020). doi: 10.1088/1367-2630/ab8e5a
2. Aharonov, Y. et al. Quantum Cheshire cats. *New J. Phys.* **15**, 113015 (2013). doi: 10.1088/1367-2630/15/11/113015
3. Liu, Z-H. et al. Experimental exchange of grins between quantum Cheshire cats. *Nat. Commun.* **11**, 3006 (2020). doi: 10.1038/s41467-020-16761-0



JAMES WAINSCOTT/UNSPASH

A single nanoscale sensing device is based on the ability of swarms of insects to avoid collision.

CRASH DETECTOR CHIP DRAWS ON INSECT VISION

Scientists replicate mechanism that insects use to avoid collision in flight. **By K. S. Jayaraman**

How do billions of desert locusts, flying in swarms across the sky to attack crops, avoid crashing into one another? They deploy their ‘insect vision’, the unusual ability that helps these pests undertake long collision-free flights.

A team of Indian scientists at the Pennsylvania State University (PSU) in the United States is now trying to mimic this unique ability to build collision detectors¹, which can help robots, drones, and even self-driving cars detect a potential collision and steer away from it.

“Insect vision offers an ideal model system for task-specific visual information processing circuits such as collision avoidance,” says Saptarshi Das, assistant professor of engineering at PSU, who, with his colleagues started

looking at how this works in locusts.

The researchers found that locusts were able to avoid collisions by quickly changing direction using a single, specialized neuron, called the Lobula Giant Movement Detector (LGMD). The neuron receives two different signals: one, the image of an approaching locust (which gets larger as it comes closer) and the other, the angular velocity between itself and the approaching locust. This single neuronal cell expertly computes the changes in the two inputs to quickly figure a diversion response when it senses an imminent collision.

The researchers built a nanoscale collision detector — a chip with an area of 2.25 mm² that mimics the escape response of the LGMD neuron in locusts. They made the compact detector

from a layer of molybdenum disulfide (MoS₂) photodetector stacked on top of a non-volatile and programmable floating gate memory architecture. The detectors used in autonomous automobiles are large and heavy. Their detector, the researchers say, is smart, cheap, task-specific and energy efficient.

They have tested the device only with objects on a direct collision path, and are yet to optimize its response in other practical situations. They are also examining whether multiple devices on the same chip can help avoid collisions in a 3D space.

The team claims this is the first demonstration of “in-memory computing and sensing using a single nanoscale device. Emulating the LGMD neuron using a MoS₂ photodetector is a milestone for bio-mimetic devices, confirms Deblina Sarkar, the founding director of the Nano-Cybernetic Biotrek Research Lab at the Massachusetts Institute of Technology (MIT). It is a fine example of how understanding the computational aspects of information processing in the nervous system can inspire solutions to real-life engineering challenges, according to Fabrizio Gabbiani, from the neuroscience department of Rice University in Houston, Texas.

Das and colleagues are in the process of patenting the technology.

1. Jayachandran, D. et al. A low-power biomimetic collision detector based on in-memory molybdenum disulfide photodetector. *Nat. Electronics* (2020) doi: 10.1038/s41928-020-00466-9

STONE TOOLS REVEAL THAT ANCIENT HUMANS SURVIVED VOLCANIC CATASTROPHE

By Biplab Das



Tools excavated in the middle Son river valley were probably made by modern humans.

Stone tools unearthed from a site in the Son river valley in Central India reveal that modern humans have lived continuously in various pockets of India for the last 80,000 years¹. The toolmakers may also have survived a massive eruption of the Toba volcano in Sumatra, Indonesia around 74,000 years ago, the archaeological finds reveal.

The Toba volcanic eruption blanketed a vast marine and terrestrial area stretching from the Arabian Sea to the South China Sea. India and various regions of South Asia and Europe are thought to have been covered in this thin veil of ash for days to several weeks. The discovery of the stone tools debunks an earlier theory that the eruption nearly decimated all humans in India and in parts of South Asia and Europe.

“The stone tools are more or less identical before and after the Toba eruption, suggesting that the eruption likely had little effect on people living in India at the time,” says the study’s lead author, Chris Clarkson, from the University of Queensland in Australia.

The tools, he says, are very similar to the ones found in Africa and Arabia around the same time. These tools were most likely made

by modern humans, meaning that humans like us lived in India very early on, and according to Clarkson, much earlier than previously thought.

The eruption is believed to have caused an extended volcanic winter that disrupted human dispersal out of Africa, and their arrival in Asia and Australia. Researchers have long debated its deleterious effects on the globe-trotting humans. Fossil finds from key regions such as India have been scarce.

Clarkson, teaming up with researchers from the University of Allahabad, the University of Madras, and the Banaras Hindu University, explored the middle Son river valley in Madhya Pradesh, where very thick deposits of Toba ash are found in the eroding cliffs. They focused on Dhaba, a site on the river bank very close to the thickest and best preserved Toba ash deposits in the valley.

On excavating three sites in Dhaba, they unearthed the stone tools made using the Levallois technology, a method for removing flakes and stone points of predetermined size by careful preparation of the core.

The tools contain predominantly bidirectional and unidirectional cores, flakes, points,

blades, notches and scrapers, and were made between 80,000 and 40,000 years ago, the researchers say.

The toolmakers were hunter-gatherers who extensively used the resources of the river, Clarkson says. “They made wooden tools and most likely hunted with stone-tipped spears.” Presence of red ochre, an iron-based pigment used for cave painting, indicates that they probably practiced symbolic or ceremonial activities. Since no organic artefacts survive at the site, it is difficult to say what they ate or what kinds of organic tools they made, Clarkson explains.

The people living at the site stuck to the same lifestyle before and after the eruption. This indicates that they were not seriously affected by the event. “There may have been some short-term consequences, but we do not see total replacement or big changes in tool kits indicative of a highly altered lifestyle,” he adds.

Kumarasamy Thangaraj, a geneticist from the Centre for Cellular and Molecular Biology in Hyderabad, says, however, that in the absence of any human remains, it is difficult to support the view that the modern humans arrived and settled in North India before the Toba eruption.

Thangaraj says genetic evidence indicates that the skin colour mutation, lactase persistence mutation, and other variations are common between people of North India and Europe. The age of Europeans, he says, has been estimated to be about 40,000 years.

Clarkson, however, is optimistic about the findings. Beyond India, fossil and archaeological evidence from Israel, Greece, Arabia, Sumatra and China reveal that modern humans were living outside Africa for a very long time before their main dispersal about 50,000 years ago, he says. In this context, the Dhaba sites serve as an important bridge linking regions with similar archaeology, he says.

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THE TRUE COST OF SNAKEBITE FOR VICTIMS IN INDIA

New data provide first estimate of the toll snakebites take on survivors. **By Carrie Arnold**

Each year snakebites cost India's citizens the equivalent of three million years of health and productivity. The figure takes into account survivors of bites who are left with debilitating outcomes such as amputation, kidney disease, and severe scarring.

The analysis, by a research team at the Seattle-based University of Washington's Institute for Health Metrics and Evaluation (IHME), provides the first estimate of the toll of snakebites on survivors in India. It also confirms an earlier calculation showing that more than half of the world's snakebite deaths occur in the country — demonstrating the need for greater investment in preventive measures.

Snakebite “is just still really not very well studied or understood at the same level as a lot of these other [tropical] diseases”, says Nick Roberts, who was part of the team. Now a medical student at Weill Cornell Medicine in New York, Roberts presented the research during the November 2020 virtual meeting of the American Society of Tropical Medicine & Hygiene.

A little-recognised disease

The World Health Organisation (WHO) designated poisoning by snakebite a neglected tropical disease in 2017, and last year launched a global initiative to halve the number of deaths and disabilities it causes by 2030. The initiative highlights the need for better data, says Prabhath Jha, director of the Centre for Global Health

Research in Toronto, Canada. “If the goal is to reduce snakebite deaths by half, then you need to know where the problems are.”

Because many people who are bitten by snakes never enter hospitals or healthcare centres, they are not formally recorded, and researchers frequently underestimate the impact of the bites across the world. Snakebite also doesn't receive a lot of attention because it “is a poor man's disease”, affecting mainly farmers and their families in rural areas, according to Kempaiah Kemparaju, a biochemist at the University of Mysore in India who studies snake venom.

The subcontinent is home to nearly 300 species of snake, and 60 are highly venomous, explains Priyanka Kadam, president and founder of the Snakebite Healing and Education Society, an organization in Mumbai. It can also be impossible for those bitten in remote parts of the country to get treatment, because the nearest health clinic might be several hours away, she says. Even then, clinics don't always have anti-venom on hand, and if they do, it might not have been stored properly.

A clearer picture

Because so few of those poisoned by snakebites are treated in hospital, reliable data on the impact of the bites has been challenging to obtain. Global estimates of snakebite deaths have ranged from 50,000 to 125,000; in India alone, they have varied from 11,000 to 50,000¹.





Farmers are at high risk of attack by snakes such as the Russell's viper (*Daboia russelii*).

In 2011, Jha and his colleagues tried to nail down more accurate estimates for snakebite deaths in India¹. He runs the Million Death Study, an effort to clarify causes of death in the country using reports from family and physicians. On the basis of these accounts, Jha calculated that 45,900 snakebite deaths occur each year in India, spurring officials to revise worldwide figures. Today, the WHO gives a range of 81,000 to 138,000 annual snakebite deaths globally.

The IHME analysis provides the first quantitative information on the long-term effects for people who survive snakebites. Such estimates are important, says Kadam, because they can provide insight into healthcare costs and other societal burdens.

The analysis also broadly supports Jha's estimation of the number of snakebite deaths, finding that about 52,000 people died of snakebite in India last year. It used a different data source from Jha, however: the 2019 Global Burden of Disease (GBD) study. This data set, also used by the WHO, provides worldwide estimates on illness and death for 369 diseases and injuries using official vital statistics and verbal autopsy reports, allowing Roberts and other scientists to compare the burden of snakebite between countries.

Jha, however, casts doubt on the accuracy of the latest analysis, contending that the GBD study uses complex and non-transparent models to determine how many people died and how. IHME has also been questioned about the transparency of its COVID-19 models, although those efforts remain separate from the snakebite work.

Roberts acknowledges that the GBD study isn't perfect, but said that "our modelled estimates attempt to use high-quality data, correct possible biases in the data and create accurate estimates at scale". No matter what estimates are used, says Roberts, the WHO's goal to halve snakebite deaths and disabilities by 2030 is "ambitious".

"We're not on track to meet it," he adds, given that snakebite deaths in India have declined only slightly, if at all, over the past decade. (Jha confirmed this trend with a follow-up study² in *eLife*.) The WHO did not respond to *Nature's* request for comment.

Kadam, whose organisation works with scientists and policymakers to reduce the impact of snakebite in India, says the data show an "urgent need for a focused change at the policy level and access to basic health care", particularly in rural areas where many people live. "The government also needs to step up the availability of snakebite treatment in all states."

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GENDER GAP IN HEALTHCARE ACCESS

Large study suggests that women face bigger obstacles in reaching big public health centres.

By Alakananda Dasgupta



Women at either end of the age range, and those living far away from tertiary healthcare centres, are more disadvantaged, research has found.

Women are marginalized when it comes to accessing the highest level of public healthcare in India, according to a study conducted at a large, tertiary hospital, the All India Institute of Medical Sciences (AIIMS) in New Delhi¹.

Older and younger women, and those living significant distances from tertiary healthcare centres, face greater disadvantages, researchers conclude. Although India has seen steady improvement in tertiary healthcare in the past few years, women are still the last to receive treatment.

This apparent disparity in healthcare access led Ambuj Roy, a cardiology professor at the



AIIMS, to look at the number of women visiting the hospital, which receives more than two million patients annually. He teamed up with Mudit Kapoor, an associate professor in the Economics and Planning Unit of the Indian Statistical Institute in New Delhi, to bring together a multidisciplinary group of economists, doctors and epidemiologists.

Researchers analysed records of 2,377,028 outpatients (excluding obstetrics and gynaecology patients) as well as data from AIIMS' hospital information system for 2016. The hospital draws patients from four states: Delhi, Haryana, Uttar Pradesh and Bihar. The team computed the 'missing' female patients for each state, taking the population sex ratio from the 2011 state censuses as the yardstick.

The difference between the actual number of women who presented at AIIMS and the number that would be expected to, compared with men, was disproportionate with the population sex ratio of these states – this, they considered as the 'missing' number. They found that the overall ratio of patient visits was 1.69 men to every woman (63% men and 37% women), whereas the overall sex ratio of the population of the four states was 1.09. In total, they found 402,722 women missing tertiary healthcare access from this population alone.

Younger and older female patients, they report, were poorly represented, compared with middle-aged women. The figures also pointed to a correlation between the women's relative distance from the hospital and their access to healthcare – those living farther away from the facility were less likely to visit the hospital. This ratio of males to females was 1.41 for Delhi, 1.70 for Haryana, 1.98 for Uttar Pradesh and 2.37 for the farthest state, Bihar.

The study differs from similar studies conducted earlier because of the large size of its data set, and the diversity of patient groups. Roy told Nature India that they hope to create awareness of the gender imbalance so that more women-specific health programmes beyond just maternal health could be created. "We emphasize that improving local health infrastructure would help women much more," he says.

Improving infrastructure may not be the solution to gender disparity in healthcare, says Jacob Creswell, head of innovation and grants at the Stop TB Partnership in Geneva, Switzerland. Deeper cultural and societal biases are at play here, he says.

The authors concede that the study has some limitations. It was conducted in a single tertiary hospital, so there's need to replicate it in all public hospitals, Kapoor says. "That's possible as data is increasingly becoming available digitally," he says.

Siwan Anderson, a professor at the Vancouver School of Economics in Canada, points to another possible limitation. The difference in the number of visits by gender for a certain age



Improving infrastructure may not be the only solution to the gender imbalance.

group does not necessarily imply discrimination, she says. "There are differences by gender and age in the incidence of different diseases. And, men and women may make different decisions with regards to going to a hospital," she says. The opportunity cost of being ill is higher for higher-income earners, typically the men in the families, Anderson points out.

The concept of 'missing women' was earlier proposed by Nobel-Prize-winning economist Amartya Sen when he reported that, in certain countries, including India and China, the ratio of women to men getting healthcare was alarmingly low^{2,3}. Sen attributed this imbalance to inequality and neglect that leads to higher female mortality.

Literacy and economic development measures, directed only at girls or women, are not enough to address the paradox of missing girls, according to a similar study⁴. India needs evidence-based multimodal approaches to combat the preference for male children and gender-based neglect. Besides community education, introduction of gender-related dialogues between boys and girls in school curricula using mobile technology would also help, they say.

A 1996 World Bank report⁵ on women's health issues in India noted that lack of knowledge, motivation, ability to pay, social status, and availability and quality of services may be blocking access to healthcare.

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KEEPING A BIRD'S-EYE VIEW ON HERONRIES

Monitoring populations of storks, ibises, spoonbills and cormorants needs investment, and citizen scientists. **By Abdul Jamil Urfi***



The Keoladeo National Park, a UNESCO World Heritage site in India's Rajasthan state, looked enchanting once upon a time. In its heyday, this picturesque site featured in the 1972 Hollywood film *Siddhartha*. Today it is a depleted version of its former glory.

One of the park's distinctive features was the presence of extensive heronries – nesting colonies of storks, ibises, spoonbills, herons and cormorants. Spread across many blocks of the 2,873-hectare mosaic of wetland, swamp, forest and scrub, the park also hosted thousands of migratory waterfowl, including the endangered Siberian crane *Leucogeranus leucogeranus*, during winter.

There were close to 2,500 nests of just one species, the painted stork (*Mycteria leucocephala*), in the middle of the 20th century¹. Now, only about a few hundred nests per year can be counted, and they are restricted to just a few blocks.

Delhi's resilient painted stork colony

Just a couple of hundred kilometres away, in

India's capital, Delhi, some painted storks began building a colony inside the National Zoological Park around 1960. The storks thrived on islands of mesquite trees in the zoo's open ponds. This nesting colony, strangely sandwiched between the historical monuments of Old Fort and Humayun's Tomb, came up quite organically.

In the ensuing years, Delhi has seen unimaginable growth, its feeder river Yamuna is murky with pollution, and the river's floodplains are overwhelmed by human settlement. Surprisingly, these adverse conditions have done nothing to the zoo colony, to which the painted storks continue to add almost 200 nests every year.

These two sites present a strangely contrasting picture. While in a natural site such as the Keoladeo bird sanctuary, the colonies of painted stork are much depleted; their populations have remained stable in urban Delhi despite environmental degradation and loss of foraging habitats near the zoo premises.

In the Keoladeo sanctuary, changes in water regulation policies by the Rajasthan state government have decreased the quantity and quality of water supply needed in the park for rejuvenation of the aquatic food webs. In Delhi

zoo, however, the security of the park premises could explain why painted stork and other species of heronry birds continue to prefer it as a nesting site, as foraging habitats are lost outside the premises.

Lack of long-term data

A more significant issue is the lack of long-term records of populations or nesting parameters to be able to understand the effects of environmental change on biodiversity. In both cases cited above¹, I had to extract nesting records from old books, sporadic reports in journals and even student dissertations.

In other words, there is a strong need for conservation monitoring programmes that can be sustained over long periods, with mechanisms in place to ensure regular data gathering by trained personnel.

The monitoring of birds with a long-term, conservation perspective, often supported by citizen science, has paid rich dividends in basic and applied ecological research. For instance, among the initial studies to demonstrate the effect of global climate change on bird nesting patterns in Europe, the investigators relied



A colony of painted storks and black-headed ibises at a wetland near Delhi.

upon long-term population records maintained by various agencies^{2,3}.

The heronry census in the United Kingdom, which gathered nesting records of the grey heron (*Ardea cinerea*) for more than 100 years, is often used as a textbook example of how abiotic factors (winter temperatures in this case) regulate population trends over the long term.

Despite the known benefits of ongoing population monitoring, most agencies are reluctant to invest, given that it requires a continuous supply of funds, commitment to science, strict adherence to a protocol and coordination activities. India's programmes for monitoring biodiversity have a mixed record, with some of its wildlife monitoring schemes coming under a cloud. For instance, the accuracy of the tiger census has been challenged over methodological issues since its inception in the 1970s.

With respect to birds, a significant start was made with the Asian Waterfowl Census (AWC) in 1982 by international agencies such as the Waterfowl Trust and Wetlands International (and later taken over by Indian NGOs such as the Bombay Natural History Society). The

AWC⁴ has yielded many positive outcomes over the years. But it has also faced challenges that come with crowd-sourced biodiversity data-gathering programmes, such as misidentification of bird species by untrained amateur volunteers, deviations from protocol, and data gathering concentrated around urban and semi-urban regions.



MONITORING SCHEMES FOCUS ON CONTENTS OF THE NEST.

Showcasing the nesting phase, heronries offer a great educational opportunity, so a monitoring programme involving students and researchers can be beneficial for both.

Apex predators

However, unlike bird-counting programmes, heronry programmes place emphasis on nests – stationary structures unlike their makers. The focus in monitoring programmes is on the contents of the nest – eggs and nestlings – besides information on parent birds in attendance. By repeated visits to the same nest, one obtains estimates of nest success – an important parameter in conservation biology that helps accurately understand how birds respond to change in their habitat. Now, with specialized software, some agencies have started programmes to monitor nest success through volunteer efforts. The Nest watch programme of the Cornell Lab of Ornithology is a case in point.

Having a monitoring programme for heronry birds, which include species of storks, ibises, spoonbills, herons and cormorants, is vital in India because of its relevance for conservation⁵. Several species in this group, listed as threatened taxa, are also colonial nesters.

Many of the fish-eating heronry birds are apex predators in aquatic food chains. Therefore, any fluctuation in their principal food source fish (for instance, due to climate change) is likely to be picked up in monitoring exercises, alongside changes in their foraging habitat due to urbanization⁶ and pollution (especially pesticides).

Heronries can be monitored relatively easily. Many of them are located in accessible urban areas. Besides the painted stork colony at the Delhi zoo, many nesting colonies or heronries have become permanent fixtures in other Indian cities, such as Mysuru and Bhavnagar.

**Associate Professor at the Department of Environmental Studies, University of Delhi.*

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THROWING OPEN THE SCHOLARLY LITERATURE

Researchers recommend an open-access policy that promotes research being shared in online repositories. **By Smriti Mallapaty**



DINODIA PHOTOS / ALAMY STOCK PHOTO

India could become the largest country to strike deals that give access to paywalled articles to all its citizens — more than 1.3 billion people .

The Indian government is pushing a bold proposal that would make scholarly literature accessible and free to everyone in the country. The government wants to negotiate with the world's biggest scientific publishers to set up nationwide subscriptions, rather than many agreements with individual institutions that only scholars can use, say researchers consulting for the government.

The proposal is expected to be part of the government's latest science, technology and innovation policy, which is being developed by the Office of the Principal Scientific Adviser to

the Government of India and the Department of Science and Technology. A draft release is pending approval by the cabinet, and feedback has been sought by all stakeholders.

The success of the proposal is also heavily dependent on publishers' willingness to negotiate nationwide subscriptions. But if successful, India would become the largest country to strike deals that give access to paywalled articles to all citizens — more than 1.3 billion people — say researchers. "If India could do it, and make it cheaper, many countries will be interested," says Peter Suber, the director of the Harvard Office for Scholarly Communication in Cambridge, Massachusetts.

In some other countries, such as Uruguay, research institutions have subscriptions that allow all citizens to read international research, and in nations including Germany there are nationwide subscriptions between academic institutions and big publishers. Under the German 'read and publish' deals, researchers can also publish under open-access terms so that anyone can read their work for free.

India is not proposing the same open-access terms for articles that its researchers publish. Instead, the researchers advising the government want authors to archive their accepted manuscripts in public online repositories. This is often described as 'green' open access, which

differs from the 'gold' route of publishing in open-access journals.

This proposal emerged from discussions about whether the country should join Plan S, a global open-access initiative backed by more than 20 national funding agencies and international organizations, most of them in Europe, which comes into effect in 2021. The plan mandates that the work of researchers funded by these agencies is free to read – in journals or on other platforms – immediately on publication.

But open-access advocates in India say Plan S doesn't work for the nation because many open-access journals impose up-front article-processing charges (APCs). "Paying to publish is not good for countries like India, where resources for research are scarce," says Madhan Muthu, a librarian at Azim Premji University in Bengaluru, who is part of the advisory group. Krishnaswamy VijayRaghavan, the principal scientific adviser to the government, has previously said that India will not be joining Plan S.

Although the latest proposal favours 'green' open access, some members of the advisory group want the government to pay APCs for reputable open-access journals so that researchers who currently can't afford such fees can publish in them. But other group members argue against that use of public funding.

Low- and middle-income nations will be watching the country's next move closely. India was the third-largest producer of science and engineering articles in 2018, publishing more than 135,000 documents, according to data compiled by the US National Science Foundation. As a large research producer, the country's position might carry more weight in negotiations with publishers than smaller nations that produce less, says Suber.

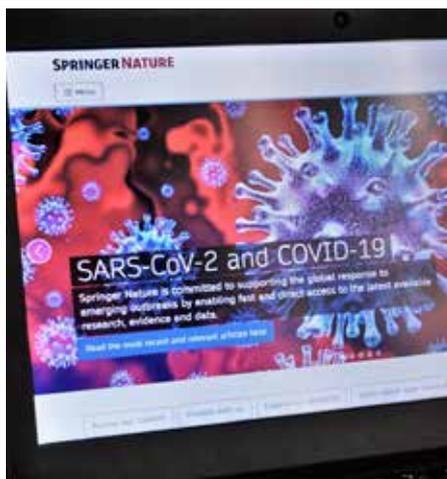
'One nation, one subscription'

Rough estimates suggest that research institutes in India spend at least 15 billion rupees (US\$200 million) on subscriptions to pay-walled scholarly literature each year.

By clubbing together to negotiate with publishers, members of the advisory group say, the government could significantly reduce these costs, and expand access to all Indians.

But the success of the 'one nation, one subscription' proposal will depend on whether publishers agree to discounted rates. One of the biggest scholarly publishers, Elsevier, said it looked forward to working with the research community, but did not comment on whether they would be willing to negotiate such a deal, while Springer Nature, which publishes *Nature*, said it was also open to discussions but had yet to receive a proposal regarding a country-level subscription so it would be difficult to comment. (*Nature's* news team is editorially independent of its publisher.)

Heather Joseph, executive director of the Scholarly Publishing and Academic Resources



Springer Nature is 'open to discussion'.

Coalition in Washington DC, says that a nationwide subscription is not likely to reduce costs significantly, "unless publishers suddenly diverge wildly from the deals they've agreed to so far". Publishers might also refuse such a big deal because of the technical challenges of providing access to a population the size of India, says Suber.

Proponents of the open-access movement outside India think the national subscription plan goes against the spirit of open access. Such schemes do little to remove global barriers to accessing knowledge, says Juan Pablo Alperin, who studies scholarly communication at Simon Fraser University in Vancouver, Canada. They "encourage everyone to fend for themselves", he says.

Rahul Siddharthan, a computational biologist at the Institute of Mathematical Sciences in Chennai, India, and a member of the advisory group, agrees that subscriptions aren't ideal. He says that India should be part of a global movement to reform the publishing system – but if a national agreement can negotiate access for its inhabitants at a fair price, that would be a good thing.

Green open access

To make paywalled research accessible globally, Muthu says, researchers in India should be encouraged to post their author-accepted, peer-reviewed manuscript in an open-access repository as soon as it has been accepted in a journal. This is called a post-print.

But again, publishers could pose a barrier. Before publication, many publishers require authors to sign copyright agreements that impose an embargo period – ranging from months to years – before authors can make post-prints available.

A growing number of institutions, including Harvard University, have introduced 'rights-retention' policies that ensure researchers keep the right to share their work in repositories without breaching copyright agreements, says

Suber. And in July, funding agencies behind Plan S announced a similar rights-retention policy.

But existing repositories in India aren't very popular, so there's a risk researchers won't get behind green open access unless policies are enforced, says Siddharthan. In 2014, India's Department of Science and Technology, and Department of Biotechnology announced that all research they fund had to be uploaded and made available in institutional or central repositories after the journal embargo lifts. However, only a fraction of that research has been uploaded so far.

Conflict on APCs

The advisory group is divided on how to handle open-access journals that charge APCs. The fees can range from a few hundred to a few thousand US dollars, which is out of reach of many researchers.

Siddharthan says that if the government were to pay, it would give such researchers the opportunity to publish in respected open-access journals. He supports establishing a central government fund to pay APCs for reputable open-access journals.

However, Muthu and Arul Scaria, an intellectual-property researcher at the National Law University in New Delhi and an advisory group member, argue that public funding should not be spent on publishing fees, in addition to subscription costs. A central fund would incentivise researchers to submit articles to journals that charge these fees, funnelling more money to publishing companies in the United Kingdom, the United States and Europe, says Muthu. "Science may be global, but when it comes to science communication, the revenue is not shared among many countries," he says.

The growth of APCs has become an increasing concern to researchers in low- and middle-income countries, says Dominique Babini, an open-access advocate with the Latin American Council of Social Sciences in Buenos Aires. Funding agencies should invest more in local and regional open-access journals that do not require authors to pay to publish, which make up about 70% of those listed in the international Directory of Open Access Journals, says Babini.

Given the ongoing debate in India, it is not clear what position the draft policy will take on APCs. VijayRaghavan said in a public consultation on the policy on 12 June that quality journals need to charge these fees to survive, but the costs are disproportionately high for places such as India. "We are actually negotiating in a nationwide level and I am sure that very soon the time will come when both access and the ability to publish at reasonable cost are available," he says.

Nature **586**, 181-182 (2020)

Comment



IITB

According to Scopus data, India is in sixth position globally for number of OA publications.

India's open-access future

Manju Naika* and Sandeep Kumar Pathak** analyse the policy around access to scholarly knowledge.

A consultative group on the new policy has recommended a 'one nation one subscription' formula for India. This means the government will aim to negotiate with leading publishers of science journals a country-wide open access policy.

A new approach will be similar to Germany's open-access policy, but in India, access to scholarly knowledge will not be restricted to the research or academic community. If this policy is adopted, anyone in the country will be able to access scholarly literature without having to pay for it.

The other significant recommendation, which is yet to be ratified by all members of the expert group drafting the policy, is that authors of scholarly literature will be permitted to pay article processing charges (APCs) through grants available to them in order to get their articles published in reputed journals. The experts have proposed further negotiations to

remove the burden of APCs on the researchers, either via a system of invoicing to the government or through a 'subscription rights' mechanism via a centralised portal.

The policy will recommend a central payment system for APCs for all reputed APC-based journals. Predatory publishers will be strictly excluded from this system.

In the run-up to these recommendations, during a public consultation in June 2020, India's Principal Scientific Adviser, Krishnaswamy VijayRaghavan, proposed this open access (OA) model for the country. "Publicly-funded research must be accessible to the public. Users should not have to pay again and again to access scholarly communication – that

fortress has to crumble," he said.

"Those APCs are disproportionately high for a country like India. This makes it difficult for scientists to publish in quality journals."

The government is also looking at broadening an existing OA policy of the Department of Science and Technology (DST) and Department of Biotechnology (DBT) that mandates all publicly funded research to be made freely available.

The new open access policy of India will not just open up scholarly knowledge but also access to research data and research infrastructure, according to VijayRaghavan.

Current trends

It is essential to understand the current trends of OA in India to design a sustainable policy that can provide researchers access to high-quality global peer-reviewed research publications and an opportunity for them to contribute to such publications. The global ranking of Indian universities is tied to research productivity, which can be increased by encouraging and incentivising researchers to publish in reputed publications.

Open access to scholarly communication in India has evolved slowly since the early 2000s, with the government trying to accelerate the growth of OA resources. The government allocates only 1% of GDP to research but has roughly 900 universities and other research institutions, and thus considers OA essential.

There are about 0.34 million researchers (full-time or equivalent) in India. Several studies show that OA publications are cited more frequently than non-OA publications and thus confer greater visibility on their authors. While advances in technology have led to an exponential growth of scientific literature, the cost of electronic journals has increased rapidly. Only a few institutions in the world have access to all the journals they want. Many institutes are deprived of such unfettered access to scientific knowledge. Most Indian universities do not have the budget to appoint a full-time and qualified librarian. As such, giving all university researchers access to scholarly journals of their choice is a distant dream.

However, after the launch of Plan S by the coalition of German funding agencies in 2018, the OA movement has begun to attract worldwide interest. It is worth analysing the share of OA papers in published research output from India to identify factors responsible for the growth of OA resources in India, compared with the rest of the world.

Institutional repositories collect and preserve in electronic format the scholarly output of institutions and make them freely accessible

and discoverable by the public. The repository stores research articles, review papers, theses and dissertations, reports, preprints and post-prints. As of April 2020, the UK-based Directory of Open Access Repositories (Open DOAR) listed 92 such repositories in India. Besides institute-level repositories, India has set up several national ones to promote OA. They include Shodhganga, India's national repository of doctoral theses managed by the Information and Library Network (INFLIBNET). Another is the National Virtual Library of India (NVLI), a comprehensive collection of digital resources giving information about India. The collections are OA and multilingual, in the form of documents, books, images, audio and video files, and other forms.

The National Digital Library of India (NDLI) is an initiative of the Ministry of Human Resource Development (now Ministry of Education) as part of the National Mission on Education through Information and Communication Technology (NMEICT). The library's pilot project is to develop a framework for a virtual repository of learning resources with a single-window search facility. As of April 2020, the NDLI had 47,898,772 digital items. The library's pilot project is to develop a framework for a virtual repository of resources with a single-window search facility.

Science-Central is India's centralized hosting service for all 42 institutional repositories of institutions that are part of the DST and the DBT, as well as a harvester service for those repositories. A centralized harvester gathers data from all the institutional repositories to support OA to publications from projects funded by the DST or the DBT. Seventeen institutional repositories are hosted on the Science-Central platform, and data are harvested from 42 more.

Open-access journals

Journals providing full text of articles to anyone without any charge or restrictions are of three kinds: Green OA (no publishing charges, authors can self-archive the article in an institutional/central repository for free access); Gold OA (articles are freely accessible on the journal's website after publication, usually authors pay to publish; and Hybrid (a mix of green and gold where some articles are free to access and some are behind a paywall).

As of April 2020, 282 Indian journals were listed in the independent online community-curated Directory of Open Access Journals (DOAJ). The J-Gate database, launched in 2001 by a private enterprise Informatics India Ltd, features 3,552 Green OA and 341 Hybrid OA

journals from India. This gateway provides fee-based access to global e-journal literature.

Analysing the Scopus database reveals that between 2015 and 2019, the world's research output in the form of published papers exceeded 15 million, split between global OA publications (25.2%) and non-OA publications (74.8%), the annual average being a little over three million. The output grew by 3.2% annually during that time, whereas the rate for India was 7%.

Although India's contribution to OA publications (4%) was lower than the world average (25%), the annual growth rate of OA publications from India was approximately 12.5%. Between 2015 and 2019, India's share in the world's total output was 5.3%, with more than 0.8 million papers.

Going by Scopus data, India is in fifth position in terms of the total number of publications and sixth in terms of OA publications in the world after the United States, China, United Kingdom, Germany and Japan. Despite less than 1% GDP allocation for research and the lack of APC funding in India, and without any clear mandatory OA policies at the institutional and national level, India seems to be contributing significantly to open access publishing.

Major contributors to OA papers

The 23 Indian Institutes of Technology account for the highest number of OA papers – 11,021 or 7% – in the country's total contribution, followed by the All India Institutes of Medical Sciences (AIIMS) with 4,153 publications, and the Indian Institute of Science (IISc), Bengaluru, with 2,718 publications. All these are public institutes – the first two are groups of institutes and IISc is a single institute.

The top funding agencies publishing OA papers are the Council of Scientific and Industrial Research (3,155 publications) followed by the DST of Kerala (2,995 publications) and the University Grants Commission (2,518 publications). It is noteworthy that the DST of Kerala, one of the smallest states in India, is a key publisher and may well serve as a role model for other states in the country. Incidentally, Kerala also tops in literacy rates in India. Private companies, private universities or other major public-sector institutions are conspicuous by their absence in this list.

Policy-making bodies and funding agencies should take note of the contributions of these institutions and provide incentives to others to increase their OA contributions.

**Chief Library Officer, IIT Bombay and
**Librarian, IISER Bhopal.*

Infection research in India must become more relevant to humans

Surat Parvatam* and Karishma Kaushik**



Only 37% of animal studies were replicable in human clinical trials, according to an analysis.

Those working in the field of tuberculosis (TB) research will know that mice samples infected with *Mycobacterium tuberculosis*, the bacteria that causes TB, are widely used to study how the disease spreads in their lungs.

Mice are the animal of choice to study TB, constituting almost 61% of all models globally¹. In India, the preference for mice models is higher, at 84% (Fig.1). However, these rodents are not the natural hosts of *Mycobacterium tuberculosis*, and do not show lung cavitation, a key feature in human TB where lung cells cave in and die. Therefore, anti-TB drugs developed using animal models may not work in human clinical trials².

This is true for many other infections such as cystic fibrosis, a genetic disease that makes the lungs susceptible to life-threatening bacterial pneumonias³. Genetically modified mice with cystic fibrosis do not develop lung infections, unlike humans⁴. Pigs, on the other hand,

recapitulate most human manifestations of such lung infections, but are difficult to work with because of their size, cost and ethics.

Similarly, results of skin wound infection studies on mice may not be replicable in humans. The way wounds heal in mice is fundamentally different from that in humans. In mice, skin defects heal by contraction. In humans, new tissues regrow and proliferate in the wound bed. Infections of the wound bed typically occur in this proliferative stage, and understanding this is important to study wound infections.

Besides these fundamental differences, animal studies are also plagued with issues of reproducibility⁵, costs, and translation.

According to an analysis, only 37% of animal studies were replicable in human clinical trials⁶. Eighty five per cent of animal studies fail during early clinical trials, and only half of the studies that make it to Phase III are finally approved. Major ethical concerns with animal research have led to mandates, including the

4Rs – replacement, reduction, refinement and rehabilitation – limiting the scope for such experimental studies.

Globally, scientists are increasingly advocating for biologically relevant laboratory models that are not only reproducible, cost-effective and ethical but also closely mimic human biology. In September 2019, the U.S. Environmental Protection Agency (EPA) announced that it would stop funding studies on mammals by 2035, making it the first federal agency to set a firm timeline to phase out animal research.

This discussion has gained substantial traction, with a recent publication outlining a roadmap to develop non-animal technologies. This is critical because of the multiple issues surrounding animal research brought to the fore by a 2003 report by the Indian government's Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA). The report highlighted the deplorable conditions across 400 animal facilities in the country.

There are concerns around pre-existing infections or diseases confounding results of the experimental infection. Researchers will also have to be vigilant about transmission of pathogens to other animals in the facility, and the accidental escape of infected animals.

Alternatives to animals

Organoids, or three-dimensional miniature organ-like structures, are emerging as an exciting area of research (Fig. 2a). They overcome the drawback of classical laboratory cultures, which flatten cells into two dimensions, leading to loss of tissue structure and form.

To make organoids, embryonic cells or stem cells created from adult human samples (called induced pluripotent stem cells – iPSCs), or even primary human cells, are grown in the laboratory. These cells are given specific growth factors that coax them to form organ-like micro-structures. Several organoids have been created, including the brain, stomach, gastrointestinal, kidney, liver, lung and skin, by scientists around the world. These organoids resemble human tissues in terms of structure and gene expression profile^{7,8}.

In 2016, a study reported that the growth of brain organoids exposed to the Zika virus was reduced by 40% compared with unexposed organoids. This resembled microcephaly, or small head (brain) size, a birth defect that cripples Zika-infected infants.

The alternative to animal models is organ-on-a-chip platforms. These are memory-stick-size clear polymers with two parallel hollow channels lined with different types of human cells, and separated by a porous membrane to enable cell communication (Fig 2b).

For instance, a gut-on-a-chip device consists of intestinal epithelial and capillary cells, mimicking the intestine-blood vessel interface⁹. In this platform, intestinal cells could differentiate

into villi, and be stably cultured with an assortment of gut microbes, enabling exploration of the role of gut microbes in various diseases.

This organ-on-a-chip approach has led to miniaturized versions of lungs, bones, liver, placenta and the like. The U.S. National Institute of Health is currently funding a Tissue Chip Program to develop 3D tissue chips that can model human diseases.

The logical extension of an organ-on-a-chip is an infection-on-a-chip platform that uses 3D tissue models to replicate human infections. In 2018, a liver-on-chip was infected with the Hepatitis B virus (HBV) and maintained for at least 40 days. The system could recapitulate all stages of the virus life cycle, and also elicit an immune response much like the human liver.

This is important, given that the pathogen-immunity interactions are critical to infection states.

While hugely promising, these model systems require additional components and further refinements. Most organoids lack relevant

microenvironmental factors such as blood vessels and immune cells.

Studies have tried to overcome this by co-culturing different types of cells, including immune cells, and by expressing proteins that aid vascular development^{10,11}.

Human-relevant infection research

While regulations governing cosmetic and pesticide testing in India recognize human-cell-based alternatives, the field of human-relevant disease and infection biology is still nascent.

The Indian Council of Medical Research (ICMR) has recommended capacity building among various stakeholders, fostering Centres of Excellence to validate non-animal methods. In 2019, the ICMR announced plans to establish a Centre of Excellence in Human-Pathway-Based Biomedicine and Risk Assessment in Hyderabad which will aim to develop alternatives to animal testing. A science policy think-tank, the Centre for Predictive Human Model Systems, also promotes human-relevant

methodologies. The centre is a collaborative effort between the Atal Incubation Centre-Centre for Cellular and Molecular Biology (AIC-CCMB) at Hyderabad and the Humane Society International-India.

In the past four years, human-relevant technologies received around 0.2 per cent of India's Department of Biotechnology's total funding. Increasing funding will enable the regulatory acceptance for these new methodologies. Besides, improving awareness, training, and engaging regulators during the early stages of development will also help.

Building on human-relevant models to mimic infection states could provide unprecedented insights into infection pathophysiology and accelerate the development of novel therapeutics. Leading research in this area, which promises to have a major impact on the future of medicine, could be an opportunity for India. It also underscores India's commitment to animal welfare and ethical science.

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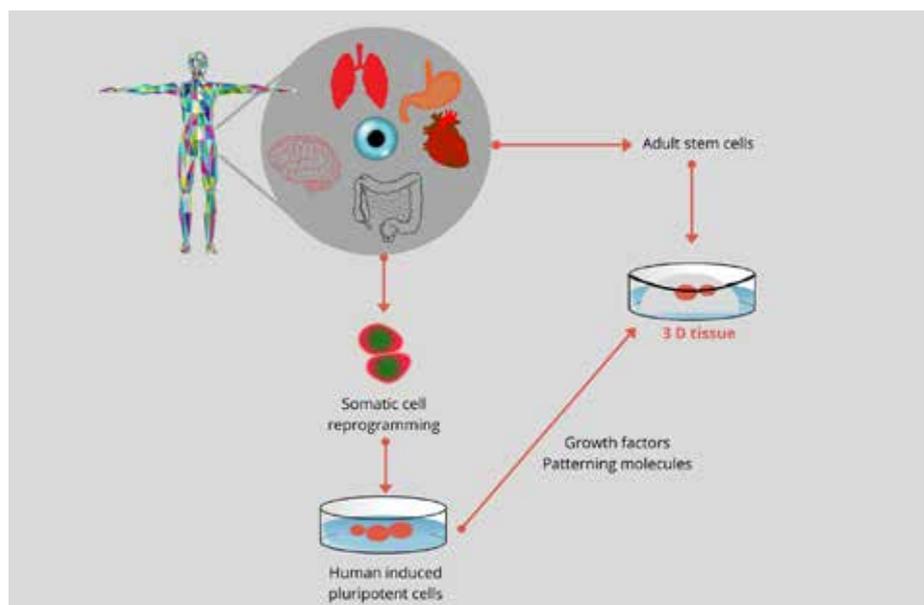


Fig. 2a: Strategies for creating 3D tissues or organoids.

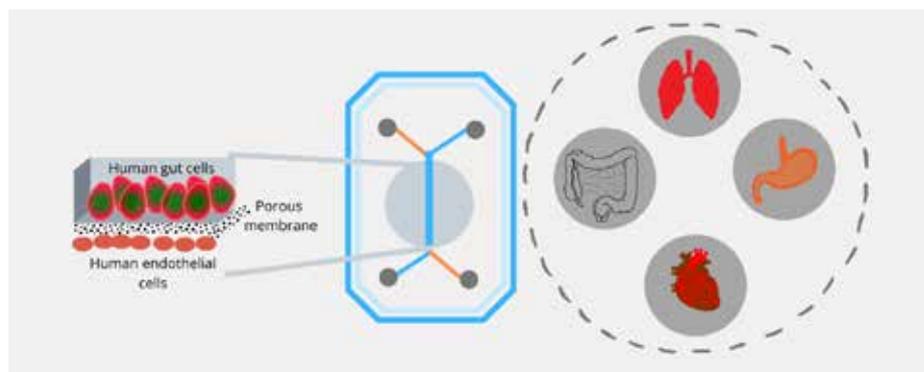


Fig. 2b: Organ-on-a-chip: (left panel) Inside architecture of a gut-on-a-chip; (right panel) tissue-on-a-chip for various organs.

Ananda Mohan Chakrabarty

(1938 – 2020)

A force for change in biotechnology and law

Neil Davey*, Randall Ray Rader** & Debabrata Chakravarti***

On 10 July 2020, the biotech world lost one of its pioneers. Ananda Mohan Chakrabarty – or Al, as he was known – was a brilliant microbiologist who in 1981 obtained the first US patent on a living organism, shaping legal opinion around ownership of genetically engineered organisms and spurring unprecedented levels of biotech innovation and commercialisation for years to come. The US biotech industry would not be where it is today without Chakrabarty's work.

Chakrabarty was born in Sainthia, West Bengal. He received his MSc and PhD in the emerging discipline of biochemistry from Calcutta University under the tutelage of Sailesh Chandra Roy. Chakrabarty published his PhD work in the *Biochemical Journal*.

In 1965, Irwin Gunsalus from the University of Illinois at Urbana-Champaign read his papers and offered him a postdoctoral position. In Gunny's lab, Chakrabarty learned about the pathways of hydrocarbon degradation in *Pseudomonas* bacteria. He remained so loyal to this genus that he was heard to say: "I only have one email address, and it is pseudomo@uic.edu."

Al's scientific journey continued for another 50 years. As a research scientist at General Electric's Research & Development Center, he did not enjoy his initial project: to convert cow manure to more proteinaceous cattle feed using bacteria. In his own time he began studying degradative pathways of hydrocarbons in *Pseudomonas* with the hope that one day a genetically modified form of the bacteria would help clean up oil spills.

By inserting into the bacteria multiple circular DNA molecules (known as plasmids), each with genes encoding different enzymatic functions in hydrocarbon degradation, he and his team were able to create a new variety of *Pseudomonas* that could degrade crude oil in Petri dishes. This was a eureka moment, and Chakrabarty was excited to present his findings at conferences. But his GE bosses had a different idea. Compelled by the potential commercial application of Chakrabarty's discovery, they wanted him to file a patent on his bacteria. Chakrabarty filed a patent application in 1972 with the help of GE attorney Leo MaLossi, knowing well that the US Patent & Trademark Office had never before granted a patent on a living organism.

After an eight-year legal battle, the US



Chakrabaty galvanized the biotech sector.

Supreme Court ruled that his invention was patent eligible, granting him the first-ever US patent on a living organism. The Patent & Trademark Office commissioner argued that Chakrabarty's bacteria could not be intellectual property because "naturally occurring articles" were not considered patentable as per statute (35 U.S.C. § 101). The Supreme Court, however, decided in 1980 in *Diamond v. Chakrabarty* that living things are patent eligible so long as there is sufficient human intervention to alter them. Though his bacteria were never used to clean oil spills, his discovery changed the interface of biotech and intellectual property law forever.

Diamond v. Chakrabarty galvanized the US biotech sector at a time when European and Asian counterparts were taking a more heavy-handed approach to regulating novel biotechnologies. With the ability to patent-protect modified living organisms, US biotech firms have flourished and life-saving treatments have been commercialized.

From General Electric, Chakrabarty was recruited to the University of Illinois at Chicago Medical School, where he stayed until his retirement in 2018 as a Distinguished University Professor. Chakrabarty's laboratory developed plasmid-based technology for the biodegradation of toxic chemicals, such as Agent Orange, and investigated how pseudomonads contribute to diseases such as cystic fibrosis. He and his colleagues discovered that the azurin toxin from this bacteria could effectively kill cancer cells via apoptosis

by binding and stabilizing the tumour suppressor protein p53; subsequent clinical trials have demonstrated that a derivative of azurin called p28 shows favourable safety and anticancer activity. Chakrabarty cofounded two biotech startups, CDG and Amrita Therapeutics, that aimed to develop bacterial peptides as anti-cancer drug candidates.

Chakrabarty published more than 250 research, review and commentary articles. He was also the lead author of two science-based works of fiction aimed at better informing non-scientists about cancer. He has received numerous awards and recognitions. To name a few, he was selected as the Scientist of the Year by the Industrial Research Organization in 1975, recognized as a Distinguished Scientist by the US Environmental Protection Agency and the US Army, given the prestigious MERIT (Method to Extend Research in Time) award by the US National Institutes of Health, and honoured by Procter and Gamble with the Environmental Biotechnology Award.

Outside the US, Chakrabarty received the European Union's Golden Eurydice Award, as well as the Padma Shri (the fourth-highest civilian award) from the Indian government in 2007. He was a founding member of the United Nations Industrial Development Organisation committee that proposed the International Center for Genetic Engineering & Biotechnology in 1983, a Scientific Advisory Committee member of the Indian government's Department of Biotechnology, on the Board of Biology for the US National Academy of Sciences, and on the advisory boards of many academic institutions.

Chakrabarty was the quintessential example of a professor who loved to teach. He was the quintessential example of an inventor who moved humankind forward through his creative spirit.

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Narender Kumar Sehgal

(1940 – 2020)

Brought science to the people

Kinkini Dasgupta Misra*

Narender Kumar Sehgal, who passed away on 7 September 2020 at the age of 79, was widely recognized as the doyen of science communication and popularisation in India.

His pioneering role in institutionalizing communication and building robust national networks to take science to the people made him a trailblazer and a mentor to successive generations of science communicators.

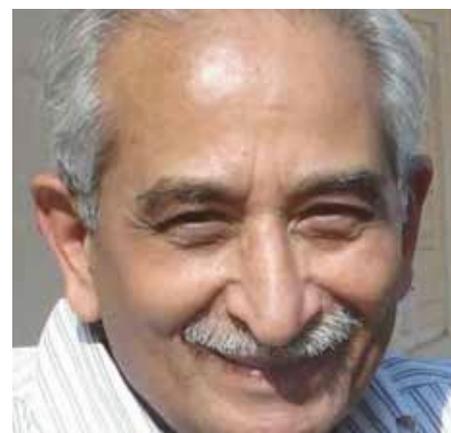
A particle physicist by training, Sehgal worked in theoretical reactor physics and taught at the Somali National University in Mogadishu, Somalia (East Africa), before returning to India in 1978.

Sehgal worked at the Indian Space Research Organisation in Ahmedabad before joining the

Department of Science and Technology (DST) in 1981.

India founded a National Council of Science and Technology Communication (NCSTC) in the DST and chose Sehgal to head it. In 1989, he founded Vigyan Prasar, a national-level autonomous institution of DST mandated for science communication and popularization.

His social experiments with science popularisation were massive in scale, considering they had to be rolled in a country the size of India. For instance, in 1987 with the “Bharat Jana Vigyan Jatha”, and then the “Bharat Jana Gyan Vigyan Jatha” in 1992, he spread science to more than 10 million people; conceived the annual National Children’s Science Congress in 1993; and harnessed the reach and power of national



PIB

television for science popularization.

Indian listeners fondly remember the radio serials ‘Vigyan Vidhi’ (Method of Science) and ‘Manav ka Vikas’ (Human Evolution), which he conceived in 16 Indian languages. The television serials *Kyon Aur Kaise* (Why and How?) and *Kudrat Nama* are also considered ground-breaking efforts in bringing science to the masses.

Sehgal was instrumental in making 28 February a National Science Day for India, to mark the discovery of the Raman Effect by physicist C. V. Raman. In 1988, he created the NCSTC network as a people’s science movement in India.

He founded and edited the quarterly journal *Scientific Opinion* between 1972 and 1976 for discussions on issues and problems relating to science, technology, education, society and development. It was among the earliest journals for science communication in India. Sehgal also contributed to *Nature* during this time.

His multi-pronged science outreach activities earned him the UNESCO Kalinga Prize for Science Popularisation (jointly with Romanian Radu Iftimovici) in 1991. For his popular science writings, he also received an inaugural fellowship of the Indian Science Writers’ Association in 1993.

With his erudition, foresight and trendsetting leadership, Sehgal left a strong imprint in the minds of all those for whom he made science a little more accessible and understandable.

*Vigyan Prasar, Department of Science and Technology, Government of India.



Narendra Sehgal being honoured by former Indian president Pratibha Patil.

Maharaj Kishan Bhan

(1947 – 2020)

Developer of India's first rotavirus vaccine

Shahid Jameel*

Eminent Indian paediatrician and clinician scientist Maharaj Kishan Bhan, known for developing a rotavirus vaccine and as a former chief of the country's Department of Biotechnology (DBT), died in New Delhi on 26 January 2020. He was 72.

Good leaders inspire and are remembered long after they move away from the corridors of power. This is true of Maharaj Kishan Bhan.

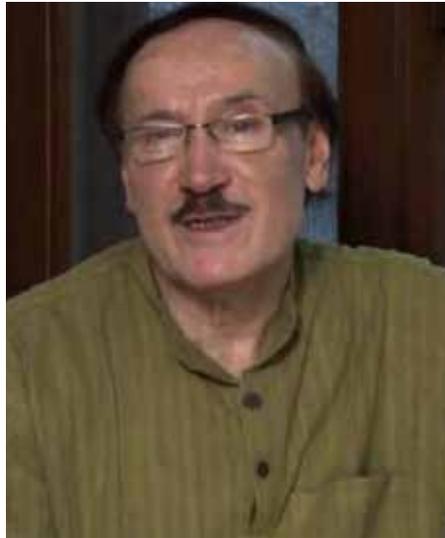
After a medical degree from the Armed Forces Medical College in Pune, Bhan pursued an MD (paediatrics) from the Postgraduate Institute for Medical Education and Research in Chandigarh. As a faculty member at the All India Institute of Medical Sciences (AIIMS), New Delhi, he researched childhood diarrhoea and nutrition, which became his lifelong passion. The work led to an understanding of the role of micronutrients, especially zinc, and the development of India's first indigenous vaccine – for rotavirus.

Vaccine researchers often joke that it's a safe field to be in. The process of vaccine development, trials and licensing is so tedious and drawn out that by the time a vaccine fails trials, the researcher has most certainly retired or is possibly dead.

But Bhan was different. He made the fortuitous discovery at AIIMS of an attenuated (weakened) strain of rotavirus from an Indian child and was smart enough to recognize it as the basis for a future vaccine. He persevered, built teams, developed structures and guided the vaccine through a nascent regulatory process. The resultant vaccine, Rotavac, was licensed for use in India in 2014.

The story of Rotavac and Bhan is also the story of developing policies and institutions. Being a firm believer in collaboration, translation of laboratory research and public-private partnerships, Bhan started many new initiatives as the DBT secretary between 2005 and 2012. Among them is the Translational Health Science and Technology Institute (THSTI), which has centres dedicated to vaccines and infectious diseases, paediatric biology, bio-design and drug development.

THSTI was conceived as the heart of a bio-cluster in the national capital region, with a policy development centre and one for teaching and international cooperation.



Bhan was committed to childhood health.

His idea was to link this to existing institutions such as AIIMS, the Indian Institute of Technology Delhi, the Jawaharlal Nehru University, the International Centre for Genetic Engineering and Biology, and the National Institute of Plant Genome Research. Turning this into reality would be a real tribute to him.

Another legacy Bhan leaves is BIRAC – the Biotechnology Industry Research Assistance Council – which brings academia and industry together. Bhan used to say that India needs enormous capacity for advance innovation and recognized how the global biotechnology enterprise has its roots in academic research.

I first met Bhan on an Indian delegation to Russia in the late 1990s. Apart from his clarity of ideas, superb articulation and the ability to engage, I remember his unfazed focus on work through an incident I'll never forget. The flight we were taking was terrible, Bhan's seat was wet, and a couple of towels had to be used so he could sit on it during take-off and landing. He and I spent the entire flight from Moscow to Delhi standing by our seats and talking, the wet seat forgotten as we exchanged ideas on research and science.

In 2009 Bhan constituted an expert committee to suggest changes in DBT's extramural funding and asked me to chair it. Later he sent me a heartfelt thank you note, the only such I have ever received for serving on a committee.

The DBT/Wellcome Trust India Alliance, which I now head, also owes its existence to Bhan. Bhan and Mark Wolport, then director of The Wellcome Trust, agreed to co-fund India Alliance sitting in a pub.

Audacity, aided by chemicals, sometimes catapults ideas that might otherwise be too crazy to consider. Bhan continued to be interested in the work of the India Alliance till the end and was always generous with his time. Based on his advice, we started a partnership with the European Molecular Biology Organization (EMBO) to co-fund meetings in nascent research areas, and he happily chaired the selection committee.

His friends called him "Raj" Bhan but for me he was always Dr. Bhan, a revered figure full of advice, appreciation and positive energy. At our last meeting in November 2019, reeling from the effects of chemotherapy, he was still generously giving us positive advice.

It was this spirit that endeared him to many in the scientific research and administration community.

Once a retired senior bureaucrat, and a friend, ran into Bhan at AIIMS. "Whenever I hear of the rotavirus, I think of you," the bureaucrat said. In his characteristic self-deprecation, Bhan guffawed: "Rightly so. I owe much my professional growth to it".

In Bhan's death, India's scientific community has lost not just a visionary leader but also an unassuming, good person.

**Director, Trivedi School of Biosciences, Ashoka University.*

M. K. BHAN'S FAMILY

Govind Swarup

(1929 – 2020)

Pioneer radio astronomer, father of frugal science

Somak Raychaudhury*

Govind Swarup, who passed away on 7 September 2020 at 91, was a pioneer in radio astronomy. He also heralded an era of frugal science, and helped build robust institutions that post Independence India yearned for.

With a larger-than-life personality and extraordinary ideas, he created world-class scientific facilities of the kind that India had not seen before. He built unique astronomy instruments from scratch and inspired people around him to dream of the impossible, and to achieve them.

Educated at Allahabad University in the early 1950s, Swarup worked at the National Physical Laboratory in Delhi with electronic parts from leftover radar equipment used in the Second World War. With his teacher K S Krishnan, he began measuring the “spin resonance of the electron” at three centimetres – considered a hot topic in physics at the time. This was the first sign of the innovation that became the hallmark of the Swarup brand.

If India is known for *jugaad* or frugal innovation, Govind Swarup was its embodiment.

After a couple of years of learning to build a radio array to study the Sun with Australian radio physicist Joseph Pawsey at Potts Hill in New South Wales, Swarup ended up at Stanford University, in California, US.

He worked on a doctoral thesis with pioneering radio astronomer Ron Bracewell. In between, he worked at the Harvard Radio Astronomy Station at Fort Davis, Texas, setting up a radio array for the Sun. Stanford University wanted him for its faculty, but Swarup had other ideas.

Even half-a-century later, over a cup of tea, Swarup loved talking dreamily about how he, along with three other Indian radio astronomers in the US, wrote to Indian institutions to set up radio astronomy facilities in India. A positive response from Homi Bhabha, Indian nuclear physicist and founding director of the Tata Institute of Fundamental Research (TIFR), led to the establishment of a unique radio astronomy group at TIFR.

Following an initial experiment at Kalyan, near Mumbai, with antennae shipped from Potts Hill, Swarup and his group found a suitable hill near Ooty in Tamil Nadu. Here he built his first unique giant telescope – a parabolic



Swarup made his fantastic ideas a reality.

cylinder 500 metres long and 30 metres wide – on the natural Equatorial mount, so that the rotation of Earth could help track celestial sources.

Swarup also chose 327 MHz as the operating frequency – a range of radio waves that had not been well studied before. He built his monolith with material sourced from India and with help from a small team of dedicated students and engineers. Some of the measurements of the counts of radio sources he made with colleague V. K. Kapahi at the Ooty Radio Telescope (ORT) went on to provide strong support to the Big Bang theory of cosmology. Built in 1969, this telescope is still operational with numerous discoveries of pulsars, quasars and gravitational lenses to its credit.

The Ooty telescope did not just put India on the world map of astronomy, it also produced a confident and ingenious bunch of young engineers and scientists. Inspired by this visionary who came up with an idea a minute, this young group was ready to take up any challenge. Moving base to Pune, they started building the largest radio telescope array in the world – 45-metre lightweight wire-mesh dishes, spread over 30 km of vineyard territory along the Pune-Nashik highway. Operating at frequencies as low as 150 MHz, the array was looking to find the spin-flip transition of hydrogen at distances near the edge of the Universe.

This mammoth contraption – the Giant Metrewave Radio Telescope (GMRT) – has been one of the top astronomical facilities of the world for two decades now, studying all sorts of sources from planets, stars to radio galaxies and supermassive black holes. Observers from all over the world compete for time on this over-subscribed facility. It has also been a pathfinder for the Square Kilometer Array, an international effort to build the world’s largest radio telescope – the next big thing in radio astronomy.

Swarup envisioned other kinds of institutions too. He was a firm believer of research as a way of learning, and was uncomfortable that Indian students could not get to do original research until they had done four to five years of strictly bound training. With V. G. Bhide, the then Vice-Chancellor of Pune University, his ideas led to the establishment of today’s Indian Institutes of Science Education and Research (IISERs).

Govind Swarup won many accolades in his life: the Shanti Swarup Bhatnagar award, the Padma Shri, the Grote Reber award and the Fellowship of the Royal Society, to name a few. But his greatest reward seemed to be in mentoring generations of peers and young students. He was very generous with his time and ideas. I cannot recall a single conversation with him when he was not excited about at least three new things, and in no time everyone around him would be talking about those things.

Along with his telescopes and institutions, Govind Swarup’s lasting legacy would be that breathless and infectious inspiration.

A hundred years from now, he will be remembered as the “Man Who Had All The Ideas”, and knew how to make them real.

**Director, Inter-University Centre for Astronomy and Astrophysics in Pune, India.*

TIFR ARCHIVES

Pandemic in pictures

The 2020 theme for Nature India's annual photo contest was 'pandemic'. Entries captured the many hardships of the contagion, and the hope for an infection-free future. The images went beyond science into the socio-economic, cultural and psychological outcomes of the pandemic.

For many, the pandemic brought immense suffering, bereavement,

loss of livelihoods or vocation, uncertainty, and unimaginable mental turmoil.

The entries portrayed many unprecedented situations, as well as the prompt response of science, and astonishing healthcare efforts. We present a selection of the top pictures from the competition.



Partha Paul

Immunity snapshot

“A health worker collects blood sample from a child in Kolkata, West Bengal, as part of a sero survey to determine prevalence of SARS-CoV-2 in populations. In the middle of the COVID-19 pandemic, these surveys were conducted to determine what proportion of a population had developed antibodies. This was the first day of antibody tests in Kolkata's Belgachia slum, one of the worst affected by COVID-19. This child, seen here with her mother, came from a 'red zone' where the government had enforced maximum containment measures.”

1

Amitava Chandra

Immersive innovation

2

“The annual Durga Puja festivities end with the immersion of the gods’ idols in the river Hooghly, a tributary of the Ganges. Every year thousands of people take part in the idol immersion processions. Following COVID-19 restrictions, festival organizers created temporary water bodies to immerse idols made of clay by dissolving them with high-power water jets. This picture was taken in October at the Tridhara Sanmilani Puja Pandal, Kolkata.”



Kaushik Dutta

On the move

3

“Sending millions of migrant workers from across Indian cities back to their home towns was an enormous task for the government during the COVID-19 lockdown. This little girl was en route to board a train of migrant workers, hoping to return home with her family. She looks on with trepidation as a healthcare worker takes her temperature at the Howrah train station in West Bengal.”



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