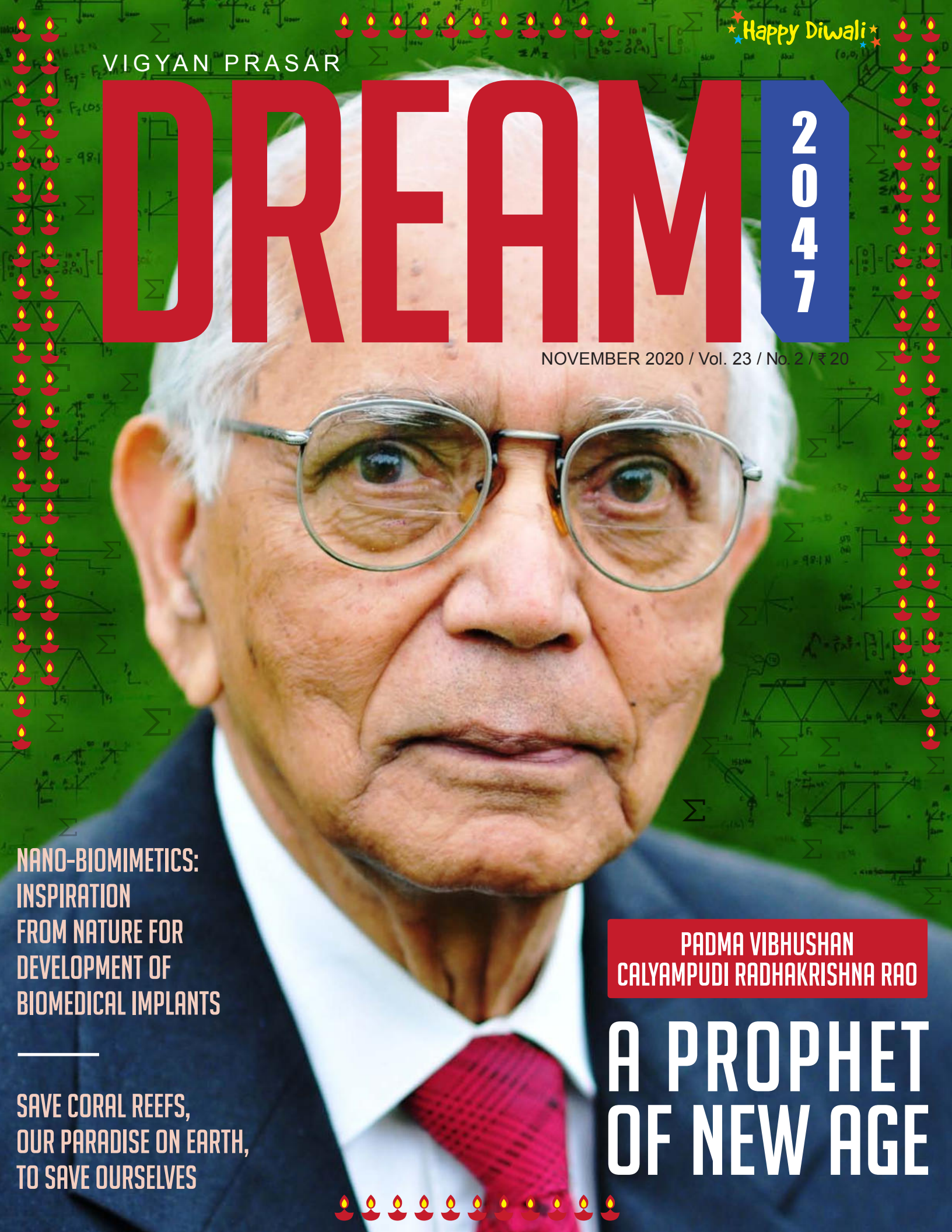
VIGYAN PRASAR

Happy Diwali

DREAM 2047

NOVEMBER 2020 / Vol. 23 / No. 2 / ₹ 20



NANO-BIOMIMETICS: INSPIRATION FROM NATURE FOR DEVELOPMENT OF BIOMEDICAL IMPLANTS

SAVE CORAL REEFS, OUR PARADISE ON EARTH, TO SAVE OURSELVES

PADMA VIBHUSHAN CALYAMPUDI RADHAKRISHNA RAO

A PROPHET OF NEW AGE

Editor-in-Chief:
Nakul Parashar

Editor:
Nimish Kapoor

Production:
Pradeep Kumar
Bipro Kumar Sen
Amitesh Banerjee

Expert member:
Biman Basu
Sumita Mukherjee

Address for correspondence:
Vigyan Prasar, A-50,
Institutional Area, Sector-62,
Noida-201 309, U.P., India

Tel: +91-120-2404430, 35

Fax: +91-120-2404437

e-mail:
dream@vigyanprasar.gov.in

website:
http://www.vigyanprasar.gov.in

Published and Printed by
Dr Nakul Parashar on behalf
of Vigyan Prasar, A-50,
Institutional Area, Sector-62,
Noida-201 309, U.P., India
and Printed at Chandu Press,
469, Patparganj Industrial
Estate, Delhi 110 092
Telefax: 22424396, 22526936.

Cover Design By: BIPRO KUMAR SEN

NAKUL PARASHAR

Festivity but no complacency

MARCH, April, May... and now, come November - like any Indian farmer who waits for the monsoon clouds, the entire humanity anxiously awaits a vaccine for COVID-19. Scientists continue to work round-the-clock as part of their race-against-time endeavour, but no respite in the near future is in sight! Well, while the number of cases tested COVID positive continues to swell, number of those who have recovered has also increased significantly. The WHO dashboard available on the web shows positive cases and deaths, whereas our national sources indicate those who have recovered as well. Amidst all this, every good news is welcome. Isn't it!

With the festivities of Deepawali and the onset of the rabi season around, the relevance of good news becomes much bigger. Recall every year around this time, we've been celebrating the India International Science Festival. We have so far seen these festivals getting organised in New Delhi, Chennai, Lucknow, and Kolkata. In the new normal, every meeting is happening through the web. A geographical location is no longer relevant. IISF 2020 too, would be held in a virtual manner. Stay tuned; exact dates and programmes would be shortly notified. With the announcement of the IISF 2020 already out, efforts are being made to organise it on a much larger scale than in the previous year in terms of attendee turnout and the number of programmes to be organised, to give it a much larger international face. Most of it would, obviously, be in virtual mode. The show must go on!

Yet, words of caution override any statement till a vaccine is effectively tried, tested, and made available. Masks, hand sanitisation, and social distancing have now become the unsaid yet mandatory parts of the new normal. That's exactly the way by which we, as citizens of the country, can contribute our bit to this joint cause. It's time that we shun every bit of complacency and strictly adhere to norms set forth by the WHO and our own Government. It is indeed time for all of us to act as responsible citizens and create scientific awareness amongst fellow citizens to maintain personal hygiene and keep the neighbourhood, city, state and country clean.

Besides Deepawali, November is the birthday month for Sir C.V. Raman (7 November) and Acharya J.C. Bose (30 November). Several books, articles, and research papers, including biographies have been published so far on these two geniuses. More than their research, these two scientists have interesting events in their lives.

Incidentally, we also celebrate the centenary of the notable biography of Acharya J.C. Bose, written by Sir Patrick Geddes (see *Dream* 2047's July 2020 issue). Indeed, it is an inspiring and worth reading book that takes you back in time to show how Bose worked and achieved so much.

Whilst talking about the centenary, we feel honoured that one of the pioneering mathematicians and statisticians Prof C.R. Rao recently celebrated his 100th birthday. While we wish him a much longer and healthy life ahead, we look forward to his continued service to the subject and humanity.

Wishing you a very happy Deepawali. Please stay safe, stay healthy.

Email: nakul.parashar@vigyanprasar.gov.in

BIMAN BASU

2020 NOBEL PRIZES IN SCIENCE

The Nobel Prizes in Science for 2020 have been shared by eight scientists–three share the prize for Physiology or Medicine, three for Physics, and two get the prize for Chemistry.

The Nobel Prize in Physiology or Medicine has been awarded jointly to Harvey Alter of the US National Institutes of Health, Michael Houghton of the University of Alberta, Canada, and Charles Rice of the Rockefeller University, USA, for the discovery of hepatitis C virus. According to the Nobel Committee, the methodical studies of transfusion-associated hepatitis by Harvey J. Alter, at the US National Institutes of Health, demonstrated that an unknown virus was a common cause of chronic hepatitis. Michael Houghton used an untested strategy to isolate the genome of the new virus that was named the hepatitis C virus. Charles M. Rice, a researcher at Washington University in St Louis, provided the final evidence showing that the hepatitis C virus alone could cause hepatitis.

The Nobel Committee noted that "the discovery of the hepatitis C virus is a landmark achievement in the ongoing battle against viral diseases. Perhaps, the findings by the three Nobel laureates allowed the design of sensitive blood tests that have eliminated the risk of transfusion-transmitted hepatitis in a large part of the world". The breakthrough work also enabled the development of several antiviral drugs that can help cure the disease.

(From left) Harvey Alter, Charles Rice and Michael Houghton (Credit: NIH History Office, John Abbott/ he Rockefeller University, Richard Siemens/University of Alberta)

The Nobel Prize for Physics has been awarded to Roger Penrose of the University of Oxford, UK, Reinhard Genzel, of the Max Planck Institute for Extra-terrestrial Physics in Garching, Germany and a professor at the University of California, Berkeley, USA, and Andrea Ghez of the University of California, Los Angeles, USA, for discoveries related to black holes.

(From left) Roger Penrose, Andrea Ghez and Reinhard Genzel (Credit: Max Planck Institute)

Penrose will receive half of the prize "for the discovery that black hole formation is a robust prediction of the general theory of relativity", while Genzel and Ghez will share the other half of the prize "for the discovery of a supermassive compact object at the centre of our galaxy". It turned out to be a black hole; not just an ordinary black hole, but a supermassive black hole, 4 million times the mass of our Sun. Now scientists know that all galaxies have supermassive black holes. Ghez is only the fourth woman to win a Nobel Prize in physics.

The Nobel Prize in Chemistry has been awarded jointly to Emmanuelle Charpentier of Institut Pasteur, Paris, France and Director of the Max Planck Unit for the Science of Pathogens, Berlin, Germany, and Jennifer Doudna of Harvard Medical School, Boston, USA, for discovering one of gene technology's sharpest tools: the CRISPR/Cas9 genetic scissors, which has revolutionised genetic research. This the first time ever, two women together have won the Nobel Prize in chemistry.

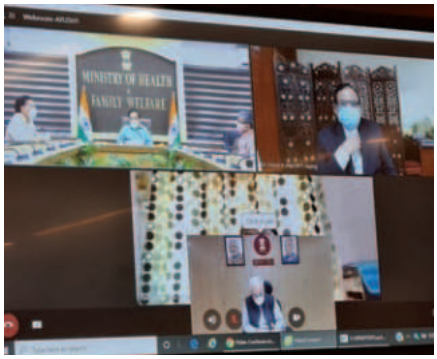
Charpentier and Doudna accidentally discovered CRISPR/Cas9 in 1990 when they were investigating the immune system of a Streptococcus bacterium with the hope of developing a new form of antibiotic against it. The significance of the discovery can be judged from the fact that just eight years after their discovery, these genetic scissors have reshaped the life sciences. It can be used to investigate the functions of different genes and their possible role in the progression of diseases. In plant breeding, using CRISPR/Cas9, researchers can endow plants with specific characteristics, such as the ability to withstand drought and salinity in a warmer climate. In medicine, this gene editor is contributing to new cancer therapies and the first studies attempting to cure inherited diseases. The new tool has also contributed to many important discoveries in basic research, and plant researchers have been able to develop crops that withstand mould, pests and drought. In medicine, clinical trials of new cancer therapies are underway, and the dream of being able to cure inherited diseases is about to come true.

Jennifer Doudna and Emmanuelle Charpentier

Biman Basu is a former editor of the Science Reporter, published by CSIR.
Email: bimanbasu@gmail.com

Dr Harsh Vardhan released National Clinical Management Protocol based on Ayurveda and Yoga for management of COVID-19

On October 6, 2020 Dr Harsh Vardhan, Union Minister for Health & Family Welfare released National Clinical Management Protocol based on Ayurveda and Yoga for management of COVID-19 in the virtual presence of Sh. Shripad Yesso Naik, Minister of State for AYUSH (Independent Charge).



Dr Rajiv Kumar, Vice Chairman and Dr V.K. Paul, Member (Health) of NITI Aayog also joined virtually. Shree Rajesh Bhushan, Secretary (AYUSH); Vaidya Rajesh Katoch and other senior officials of AYUSH Ministry were also present at the event.

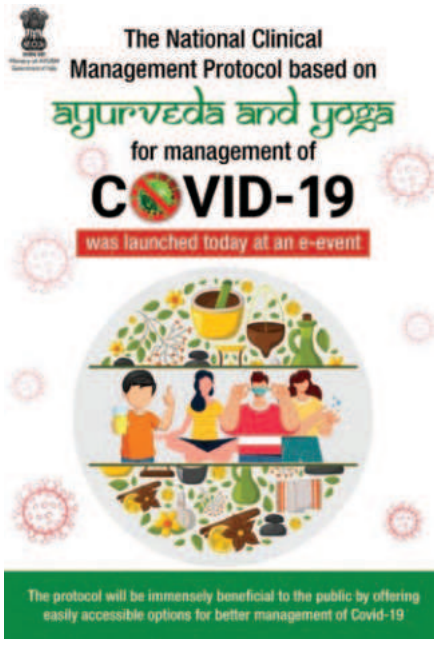
An Interdisciplinary Committee for integration of Ayurveda and Yoga Interventions in the 'National Clinical Management Protocol: COVID-19', chaired by Dr V M Katoch, former Director General, ICMR and composed of a group of experts with domain knowledge had formulated the report and submitted recommendations based on acceptable experimental and clinical data. Based on their recommendations, the Ministry of AYUSH constituted a National Task Force which prepared the National Clinical Management Protocol based on Ayurveda and Yoga for management of COVID-19.

Hailing the achievement on the part of Ministry of AYUSH that the advisories for boosting the immunity of the people have become highly popular, Dr Harsh Vardhan noted, "Prime Minister Shree Narendra Modi ji has emphasized following AYUSH advisories for management of COVID-19 crisis. This protocol dealing with preventive and prophylactic measures is a significant step in not only in management of COVID but also in making traditional knowledge relevant to solving problems of the modern time".

India's new paper-based COVID-19 test could be a 'game changer'

A team of scientists at the Delhi-based CSIR-Institute of Genomics and Integrative Biology (IGIB) has developed an inexpensive paper-based test for coronavirus that could give fast results similar to a pregnancy test. The test is based on the gene-editing technology, Crispr. Scientists estimate that the kit called FELUDA (FNCAS9 Editor-Limited Uniform Detection Assay) would return results in under an hour and cost Rs. 500.

"This is a simple, precise, reliable, scalable and frugal test," Professor K VijayRaghavan, Principal Scientific Adviser to the Indian government, told the BBC. Researchers at the IGIB as well as private labs tried out the test on samples from about 2,000 patients, including ones who had already tested positive for the coronavirus. They found that the new test had 96% sensitivity and 98% specificity. The accuracy of a test is based on these two proportions. A test that is highly sensitive will detect almost everyone who has the disease, and a test that has high-specificity will correctly rule out almost everyone who doesn't have the disease. The first ensures not too many false negative results and the second not too many false positives.



The first is the time-tested, gold standard polymerase chain reaction, or PCR swab tests, which uses chemicals to amplify the virus's genetic material in the laboratory. The second is the speedy antigen test, which works by detecting virus fragments in a sample. The PCR test is generally reliable and costs up to Rs 2,400. It has low false positive and low false negative rates. The antigen tests are cheaper and use finger-prick blood samples to find signs of previous infection. They are more precise in detecting positive infections, but generate more false negatives than the PCR test. The FELUDA test could potentially replace the antigen tests because it could be comparatively cheaper and more accurate.

DBT-IBSD takes up new research initiatives on phytopharmaceuticals to fight COVID-19

As part of efforts to fight against COVID-19 pandemic, DBT-Institute of Bioresources and Sustainable Development (DBT-IBSD) has taken up new research initiatives on Phyto-pharmaceuticals Mission and has established a Centre of Excellence for Phytopharmaceuticals.

The Institute is extensively working on exploration and documentation of a large number of medicinal plants of north east India for scientific intervention for the characterization of bioactive compounds having antiviral and other therapeutic activities. It is also planning to establish a photo-markers library useful as standard reference compounds for evaluation of phytopharmaceuticals.

COVID-19 Newsletter Team of VP

india SCIENCE

A DST-Vigyan Prasar Initiative

INDIA'S OWN 24X7

SCIENCE & TECHNOLOGY CHANNEL

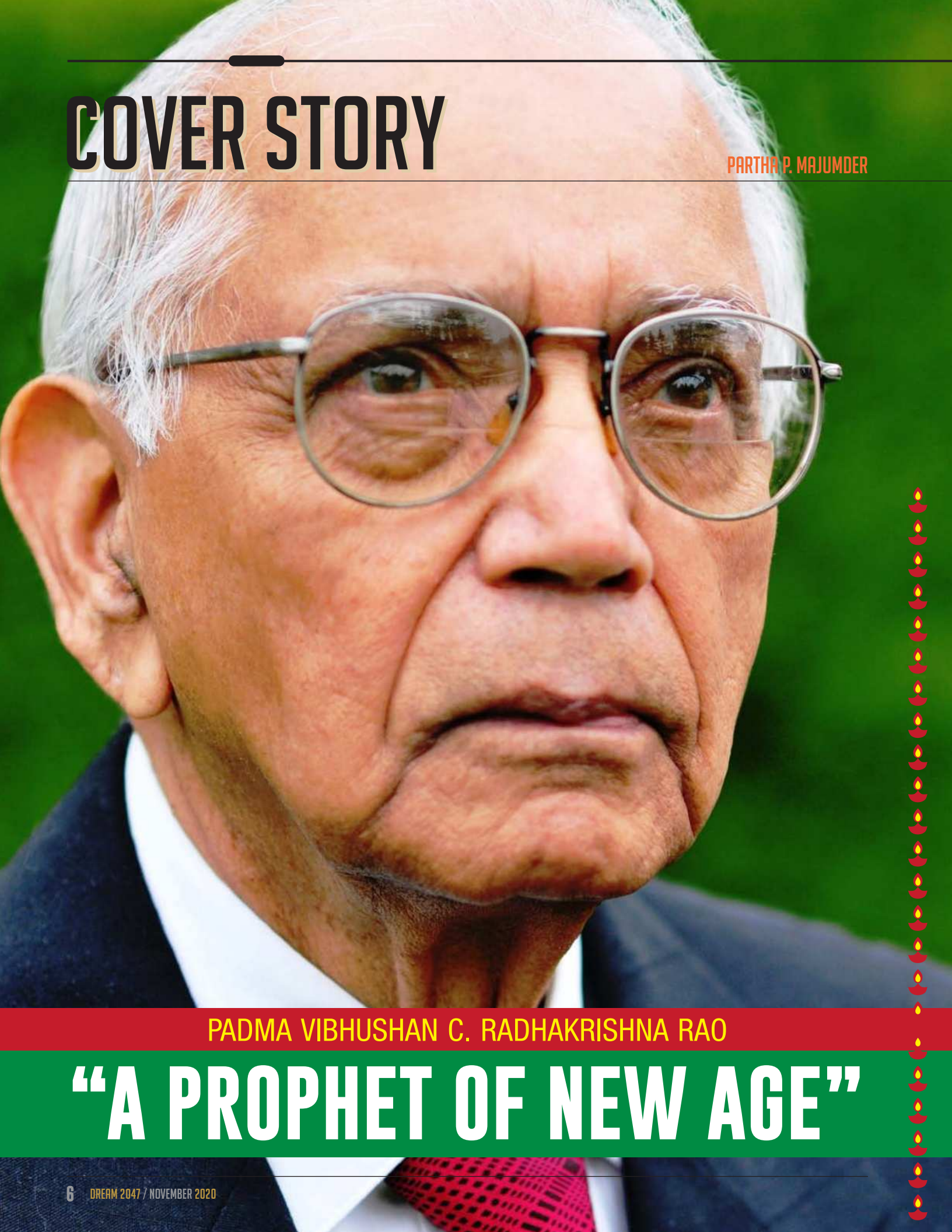
India Science is an Internet-based Over-The-Top (OTT) TV channel. This 24x7 video platform is dedicated to science and technology knowledge dissemination, with a strong commitment to spreading scientific awareness with Indian perspectives, ethos and cultural milieu.

www.indiascience.in

GET IT ON Google Play | Download on the App Store

COVER STORY

PARTHA P. MAJUMDER



PADMA VIBHUSHAN C. RADHAKRISHNA RAO

"A PROPHET OF NEW AGE"

The world celebrated the birth centenary of Professor Calyampudi Radhakrishna Rao in September. He was born on September 10, 1920. The Government of India felicitated him on the eve of his birthday; an online function was organised by the Department of Science & Technology (DST). "Prof C.R. Rao was working on the science of data 70 years ago and was much ahead of his times," said Professor Ashutosh Sharma, Secretary, DST. "It is amazing to see the breadth of [his] work," said Professor K. VijayRaghavan, Principal Scientific Advisor to the Government of India.

In an interview given some years ago, Professor C.R. Rao had quoted, tongue-in-cheek, one of his mentors, famous statistician and geneticist Ronald A. Fisher, "A ballet dancer gets her ovation on the spot, while she is still warm from her efforts. A wit gets his laugh across the table, but a scientist must expect to wait about five years for his laugh. Recognition in science, to the man who has something to give, is, I guess, more just and more certain than in most occupations but it does take time. And when it comes it will probably come from abroad."

Rao went on to say, "The first award I received came from abroad. It was the Fellowship of The Royal Society (FRS)." That was a long time ago in 1967. He has been honoured with Padma Vibhushan in 2001 and was awarded the India Science Award in 2010. On June 12 2002, he was presented the National Medal of Science by US President George W. Bush "for his pioneering contributions to the foundation of statistical theory and multivariate statistical methodology, and their applications, enriching the physical, biological, mathematical, economic and engineering sciences". President Bush called him "A prophet of new age".

We celebrated Professor Rao's birth centenary as an occasion not only to honour the most-respected statistician in the world today, but also because statistics has become an indispensable applied tool in all walks of life through his seminal contributions and efforts. Rao has defined statistics as "the science of learning from data." We are now passing through an age of data revolution. The demand for statisticians in global employment is one of the highest and the demand is predicted to increase in the coming years. "I was fortunate to have made some fundamental contributions to the field of statistics and to see the impact of my work in furthering research. In my lifetime, I have seen statistics grow into a strong independent field of study ... its importance has spread across numerous areas such as business, economics, health and medicine, banking, management, physical, natural, and social sciences," he says.

C.R. Rao was the eighth in a family of 10 children. His father, C.D. Naidu, who worked in the police department, attached great importance to scholastic achievement of his children. His mother, A. Laxmikantamma, was a stern disciplinarian. Rao dedicated his book Statistics and Truth to her "for instilling in me the quest for knowledge" and "who, in my younger days, woke me up everyday at four in the morning and lit the oil lamp for me to study in the quiet hours of the morning when the mind is fresh."

He had an interest in mathematics from an early age. As a six-year-old boy he knew by heart the multiplication tables up to 20 by 20. He won the Chandrasekara Iyer Scholarship, named after C.V. Raman's father, in physics in Intermediate. However, he decided to pursue a career in mathematics, joined Andhra University, and obtained the equivalent of a Master's degree even before he was 20. Pressure from his family forced him to prepare for the Indian Civil Service (ICS).

While he had to wait for about 18 months for the entrance test, he decided to take a job and came to Calcutta (now Kolkata) to face an interview. A chance meeting with a young man, Mr. Subramanian, in a south Indian hotel on this trip was to change his life. Mr. Subramanian was undergoing training in statistics at the Indian Statistical Institute (ISI). He took Rao to ISI, which was then located in the physics department of Presidency College. Rao joined ISI in 1941 in a training programme. His father had just passed away and there was financial stress in the family. However, his elder brother and mother encouraged him to pursue the training at the ISI.

"I did not learn much from the courses" during the training programme, Rao says. However, he came in contact with three well-known statisticians, Raj Chandra Bose, Samarendra Nath Roy, and Keshvan Raghvan Nair, who were all working in the ISI, but did not participate in teaching. Within three months of joining the ISI, Rao wrote his first scientific paper with Nair. In July 1941, while he was still a student of the one-year training programme in the ISI, the Master's programme in statistics was started in Calcutta University, with Prasanta Chandra Mahalanobis as a head of the statistics department. This was

> **"Statistics is the science of learning from data ...In my lifetime, I have seen statistics grow into a strong independent field of study ... its importance has spread across numerous areas such as business, economics, health and medicine, banking, management, physical, natural, and social sciences."** **C.R. Rao**

the first degree course in statistics in India. Rao enrolled himself as a student, and graduated in 1943 with a first rank, obtaining 87.5 per cent marks, still a record at Calcutta University. While a Master's student, he published several papers with Raj Chandra Bose. His MA dissertation contained original contributions to several areas of statistics.

After he obtained MA, Prasanta Chandra Mahalanobis offered Rao a job in the ISI as a technical apprentice in November 1943. In 1946, Mahalanobis sent Rao to Cambridge to carry out statistical analyses of some data on skeletal material collected by J.C. Trevor. "The period from January 1944 to July 1946, before going to Cambridge, was, perhaps, the most eventful of my research career," Rao says. While he was teaching a course on statistics at Calcutta University in 1944, a student had asked him a question. He did not have a ready answer, but worked out the answer that night. This turned out to be the seminal result with which his name is associated-the Cramer-Rao bound, independently discovered by Harold Cramer.

In 1945, he proved a result that is now known as the Rao-Blackwell theorem. Often, we need to obtain knowledge of an unknown feature of a population; for example, the average monthly income of an Indian. It is not possible to collect income data from every Indian living anywhere in the world. Data can be collected only from a small number of Indians, suitably selected. From these data, one can then obtain an approximate, not the exact, knowledge-an estimate. There are several ways of obtaining estimates from data, but the method proposed by Rao in 1945, and two years later by David Blackwell, results in highly reliable estimates.

In Cambridge, Rao registered for a Ph.D under Ronald A. Fisher, a founder of modern statistical science. Fisher told Rao to find his own problem to solve and write a PhD thesis and asked him to seek his advice only when he "encountered difficulties". Fisher worked in the genetics, not in the statistics, department. He asked Rao to spend some time in the genetics laboratory. Fisher was trying to find which genes are on which chromosomes in the mouse. This inquiry naturally led to formulation of some hypotheses and testing them. Rao proposed a novel method to find how physically close two genes are. The method bears his name-Rao's Score Test-and is now used in all branches of science, both natural and social.

After submitting his Ph.D thesis, Rao returned to India from England in 1948 and became a professor at ISI at the age of 28. In 1964, he assumed directorship of the ISI. After his retirement from ISI, he moved to the US. In 1982 he established the Center of Multivariate Analysis at the University of Pittsburgh. He joined the Pennsylvania State University in 1988.

Rao's contributions to mathematics and statistical theory and applications have become part of graduate and postgraduate courses in statistics, econometrics, electrical engineering, and many other disciplines at universities throughout the world. His scholarship has heavily influenced the theory and application of statistics in such diverse fields as anthropology, geology, biology, psychology, social sciences, and national planning. His work in multivariate analysis, for example, is used to improve economic planning, weather prediction, medical diagnosis, tracking the movements of spy planes, and monitoring the course of spacecraft.

Rao has authored or co-authored 14 books and more than 300 research papers. His book Linear Statistical Inference and its Applications, published in 1965, has been translated into six languages and has remained as one of the most cited books in science.

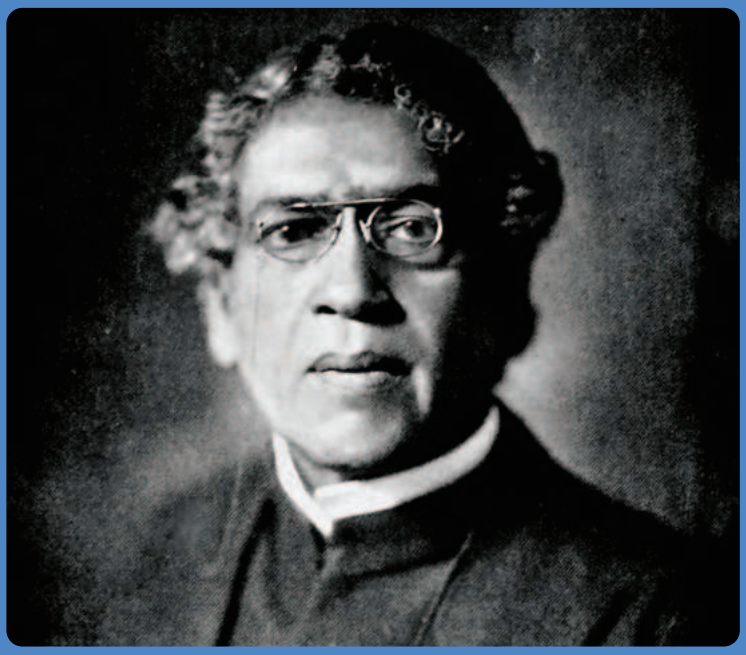
Rao has an uncanny and a subtle sense of humour. In his lectures, even on theoretical statistics, he always began with a practical example. He has always emphasised that statistical research, even on statistical theory, should largely arise from real-life problems. He has spent his entire career promoting statistics and their usefulness in society. "If there is a problem to be solved, seek statistical advice instead of appointing a committee of experts. Statistics can throw more light than the collective wisdom of the articulate few," he says. He was the chairman of the UN Committee, which examined the demand for statistical personnel in Asian countries. The Committee recommended the establishment of an Institute to provide training for statisticians working in government and industrial organisations for statistical development in South East Asia. On the basis of this recommendation the Asian Statistical Institute, now known as the Statistical Institute for Asia and the Pacific was established in Tokyo in 1970.

Rao has categorised creativity into two different kinds. "At its highest level, it is the birth of a new idea or a theory which is qualitatively different from and not conforming to or deducible from any existing paradigm, and which explains a wider set of natural phenomena than any existing theory. There is creativity of another kind at a different level, of a discovery made within the framework of an existing paradigm but of immense significance in a particular discipline." C.R. Rao has excelled in creativity of both kinds, which is why he is the most respected statistician in the world today.

"If there is a problem to be solved, seek statistical advice instead of appointing a committee of experts. Statistics can throw more light than the collective wisdom of the articulate few." C.R. Rao

Dr Partha P. Majumder is National Science Chair, Distinguished Professor and Founder, National Institute of Biomedical Genomics, Kalyani; Emeritus Professor, Indian Statistical Institute, Kolkata; President, Indian Academy of Sciences; and President, West Bengal Academy of Science & Technology.
Email: ppm1@nibmg.ac.in

NAKUL PARASHAR

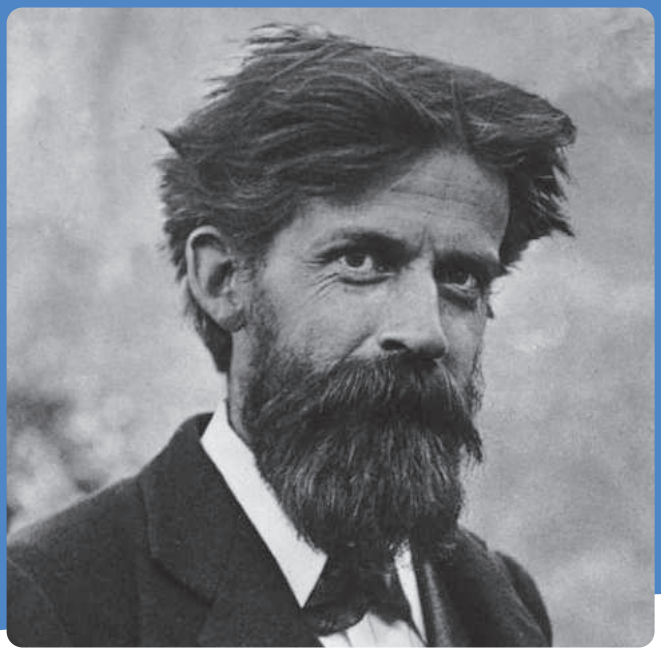


100 years of 'The Life and Work of Sir Jagadis C Bose'

Why has a 260-page book written 100 years ago become all of a sudden so relevant now? Is it because it was written on one of the greatest scientists that India has produced so far? Is it because of its unique author, who was a biologist, an urban planner, and someone who travelled a large part of the world? Of course, much more than the reasons, this unique book is none other than the famous and one of the widely read biographies of a scientist - An Indian Pioneer of Science - The Life and Work of Sir Jagadis C Bose.

Written by Sir Patrick Geddes FRSE, this biography of Acharya J.C. Bose was published in October 1920 by Longmans Green & Co., UK. This book has nineteen chapters meticulously planned from childhood and early education to the establishment of the Bose Research Institute that later became the world-renowned Bose Institute, now an autonomous organisation of the Department of Science & Technology, Government of India.

Bose passed away in 1937 while Geddes died in 1932. This means that this biography was written seventeen years before Bose's demise. Interestingly, the very few initial lines of the book say it all - "I am asked whether the title of this book means especially



Sir Patrick Geddes

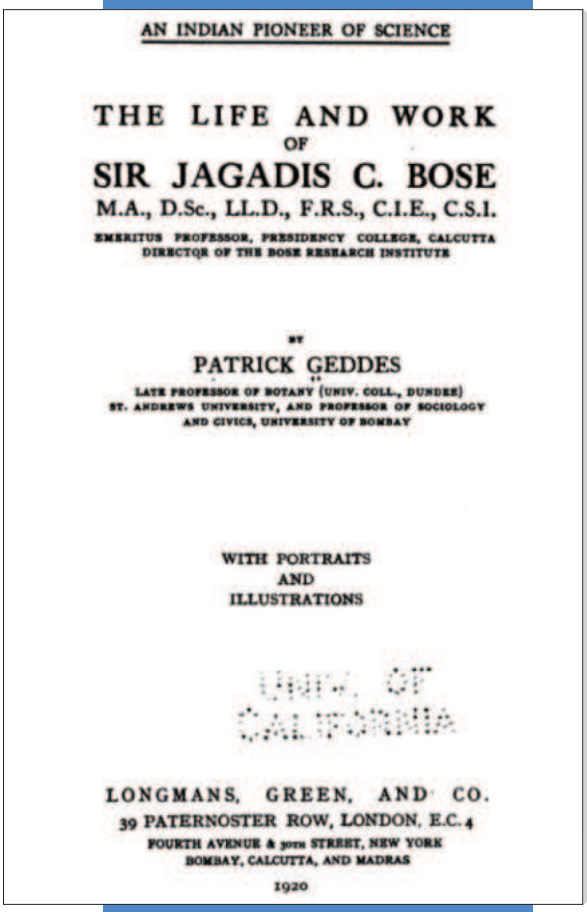
a pioneer in science in and for India. The answer is - both. For on one hand, Bose is the first India of modern times who has done distinguished work in science, and his life story is thus at once of interest to his scientific contemporaries in other countries and of encouragement and impulse to his countrymen".

The book brings out different aspects of the life of the great scientific genius, Bose, as portrayed by yet another great scientist and town planner of modern times, Sir Patrick Geddes.

Geddes has weaved this book perfectly well. Describing Bose's early days vividly, Geddes mentions - "The boy is the father of the man. Hence the writers of biographies have always sought to learn and tell they could of the early environment of their subjects; for these formative influences, and the response of childhood and youth to them, are often seen to throw light on characters as brought out in later years, and so on their achievements".

Bose's interests to pursue science from his early childhood guided his parents to get him admitted to St Xavier's College in Kolkata, and later London for a degree in science rather than pursue the civil services route. Descriptions of Bose's school and college days in India and later in the UK have been described in a duly concatenated manner. This makes reading faster and more engrossing. Stories of hardships faced by young Bose in the UK, and later, post his return to India are described in detail in the chapter titled 'Early Struggles'.

Bose was an avid traveller as well. His passion for hills, especially the Himalayas, can be seen from the vivid description of his holidays and pilgrimages. Geddes says that Bose was highly fascinated by the Kumaon hills (now a part of the state of Uttarakhand) and visited Nainital, Almora and Pindari Glacier as well. Besides the Himalayas, Bose in fact travelled all across the Indian subcontinent too. In an interesting incident when travelling in south India, he was allowed to go inside the sanctum sanctorum of a South Indian temple. The priest of the temple compared him to someone who has dedicated his life to the extension of science in the country.


AN INDIAN PIONEER OF SCIENCE

THE LIFE AND WORK OF SIR JAGADIS C. BOSE

M.A., D.Sc., LL.D., F.R.S., C.I.E., C.S.I.

EMERITUS PROFESSOR, PRESIDENCY COLLEGE, CALCUTTA
DIRECTOR OF THE BOSE RESEARCH INSTITUTE

BY

PATRICK GEDDES

LATE PROFESSOR OF BOTANY (UNIV. COLL., DUNDEE)
ST. ANDREWS UNIVERSITY, AND PROFESSOR OF SOCIOLOGY AND CIVICS, UNIVERSITY OF BOMBAY

WITH PORTRAITS AND ILLUSTRATIONS

LONGMANS, GREEN, AND CO.
39 PATERNOSTER ROW, LONDON, E.C. 4
FOURTH AVENUE & 30TH STREET, NEW YORK
BOMBAY, CALCUTTA, AND MADRAS

1920

The book brings out different aspects of the life of the great scientific genius, Bose, as portrayed by yet another great scientist and town planner of modern times, Sir Patrick Geddes.

Geddes also describes the influence of a number of people in Bose's life. Besides Bose's father, his sister and her husband inspired Bose to quite an extent. Geddes very briefly mentions about Bose's acquaintance with Mahatma Gandhi and Gopal Krishna Gokhale. Sister Nivedita (Margaret Noble), Swami Vivekanand's disciple, played a very important role in Bose's life. Establishment of the Bose Institute and many other areas where Bose's contribution to the scientific world was highlighted is credited to Sister Nivedita.

Despite financial constraints, Bose went ahead and established the famous Bose Institute. In his inaugural address on 30 November 1917, he said, "I dedicate today this institute-not merely a laboratory but a temple."

The last two chapters of the book details various aspects of how the Bose Institute came up and eventually became one of the few Indian research institutes of international repute.

Twelve of nineteen chapters of the book are set aside for the works of Bose and each of them turns out to be a major reference work in itself. From electric waves, his first researches in physics to plant responses, irritability of plants, movement in plant, tropism, sleep of plants, the book provides seamless flow of thoughts and interconnectivity - describing how a perfect biography should be written.

The book is easily available through a number of online stores and is a must-read for every science enthusiast. In short, even after 100 years after its publication, it still remains relevant and inspiring.

Dr Nakul Parashar is Director, Vigyan Prasar and also a science writer and communicator.
Email: nakul.parashar@vigyanprasar.gov.in

T.V. VENKATESWARAN

Ramanujan Yatra: Journey So Far

Ramanujan Yatra commenced on 26 April 2020, with a small group, at Kumbakonam, Tamil Nadu and it will formally conclude on 22 December 2020, Ramanujan's birth anniversary and the National Mathematics Day.

Srinivasa Ramanujan died on 26 April 1920. This year is his hundredth death anniversary. He was just 32 years old, usually a life too short to make big waves, yet he was considered one among the top ten mathematicians of his day. His eminence was so radiating, even in the high noon of colonialism, a miserable brown 'native' could not be ignored. He was the youngest to be elected as a fellow of the Royal Society, the second Indian to secure the place on the high table. In his short but productive life of just 32 years, he had worked out 3,900 odd theorems and results, scribbled on scraps of paper, which still continue to be relevant, enchanting brightest minds in the mathematics even today. In a rare honour, two years ago, the Royal Society observed the 100th anniversary of his election, hinting that the Royal Society is worthy by his presence amongst its fellows, more than the honour it conferred on to Ramanujan.

Says Sujatha Ramdorai, a professor of mathematics and Canada Research Chair at University of British Columbia, Canada, "Generations of mathematicians will marvel at Ramanujan's mathematical discoveries. His results will never cease to astound, appreciate and his life will always be an inspiration. His life and

work is the mathematical equivalent of the poet William Blake's lines:

To see a world in a Grain of Sand,
And a Heaven in a Wild Flower
Hold Infinity in the palm of your hand
And Eternity in an hour."

Ramanujan did not directly take part in the national struggle, yet his accomplishment was seen as a part of the freedom movement. P.V. Seshu Iyer, a contemporary mathematician and a freedom fighter, wrote way back in 1917, "The age we are living in has been one of many great national upheavals. We are today claiming for the wider recognition of our powers, active and dormant. Politically we are issuing into a united nationhood and materially we hope soon to be abreast of the more civilised countries of the world. Intellectually too, our literary and scientific achievement has not been behind hand but has been receiving world-wide recognition. The poet went out, sang and was honoured with a prize and a knighthood. The scientist struck famous academies of Europe and America in tremulous wonder and Mr S. Ramanujan is in a fair way to do a similar thing for mathematics."

Hundred years after his death, Ramanujan still evokes hope and inspiration. "The music of his mathematics emanates both from his life and work. Rising from the dust of India and teaching himself higher mathematics, he rose to great heights. His story is a beacon of inspiration for young minds everywhere," points out M. Ram Murty, A.V. Douglas Distinguished University Professor & Queen's Research Chair, Queen's University, Ontario. "Ramanujan did not have the advantage of contact with the mathematical world outside India. His gigantic leaps arose from himself only... Interest in Ramanujan's mathematics will continue unabated for many decades," says Bruce Carl Berndt, professor at the University of Illinois at Urbana-Champaign and the editor of The Ramanujan Journal.

The world is moving towards what expert observers call 'Industrial revolution 4.0', driven by cyber physical systems, which includes artificial intelligence, robotics, sensors, big data analytics, geographical information systems and advanced materials. As India braces itself, not only to not miss the bus but take proactive initiatives to be one among the leaders in the area which is considered as next paradigm

shift succeeding Internet, recalling and remembering Ramanujan is relevant. R Ramanujam, Professor of mathematics at Institute of Mathematical Sciences says, "Both Ramanujan's life and his mathematics attest to the tremendous freedom of human intellectual endeavour to reach beyond the confines of extant thought and technique, unfettered by grinding poverty, debilitating disease and stifling social hierarchy. Ramanujan will continue to inspire every child, every mathematician, and hopefully every teacher as well."

Vigyan Prasar, even under the trying circumstances during the pandemic, undertook a massive effort to commemorate the memory, struggle and the relevance of Ramanujan during this year. A national committee was formed with Dr R Ramanujam from Institute of Mathematical Sciences as its chair. With the involvement of various organisations and individuals a unique programme 'Ramanujan Yatra' was planned.

The Yatra commenced on 26 April 2020, with a small group, adhering strictly the pandemic protocols, placing a garland and paying homage to the statue of Ramanujan at Kumbakonam, Tamil Nadu. As face-to-face activities were not viable, due to the COVID pandemic, online mode was resorted to. Popular lectures were organised in various Indian languages. In addition, international experts on Ramanujan gave online webinars. These were live-streamed through IndiaScience.in, a web-based television channel of Vigyan Prasar. Further, these lectures were also live-streamed on social media platform such as the YouTube, Facebook live.

https://zoom.us/j/95746467914?pwd=V2R6eUIkS0V2amNxdVB5eEpzbVREZz09

RAMANUJAN YATRA

I. LECTURES IN INDIAN LANGUAGE ON RAMANUJAN YATRA:

Language/Name of the Speaker/Date:

1. Tamil/Dr R. Ramanujam/19.05.2020
2. Kannada/Shri V.S.S. Sastry/31.05.2020
3. Telugu/Prof P.V. Arunachalam/16.06.2020
4. Malayalam/Dr P.T. Ramachandran/24.06.2020
5. Gujarati/Dr Devbhadra Vadilal Shah/14.07.2020
6. Bangla/Dr Parthasarathi Mukhopadhyay/04.08.2020
7. Marathi/Dr Vinayak Sholapurkar/25.08.2020
8. Assamese/Dr Nayandeep Deka Baruah/18.09.2020

II. LECTURES BY INTERNATIONAL EXPERTS ON RAMANUJAN YATRA:

Name of the Speaker/Title/Date:

1. Dr Ken Ono/Why Does Ramanujan, The Man Who Knew Infinity, Matter?/28.05.2020
2. Dr Sujatha Ramdorai/Ramanujan's Mathematical Legacy/25.06.2020
3. Dr Bruce C. Berndt/Ramanujan-The Ultimate Super Hero/23.07.2020
4. Dr R. Balasubramanian/Impact of Ramanujan on Number Theory in India/27.08.2020
5. Dr M. Ram Murty/The Ramanujan Tau Function/24.09.2020
6. Prof. Don Zagier/Ramanujan and Geometry/29.10.2020

The Yatra will formally conclude on 22 December 2020, Ramanujan's birth anniversary and the National Mathematics Day. However, Vigyan Prasar is engaged in shaping innovative mathematics popularisation programmes and developing hands-on kits to create interest and alleviate maths phobia. Professor Ken Ono Thomas Jefferson Professor of Mathematics at the University of Virginia, the Vice President of the American Mathematical Society, says, "Ramanujan matters because he represents endless curiosity and untapped potential, which we all have to believe in to proceed in the sciences. Science usually advances on the work of thousands, over generations, fine-tuning and extending the scope of understanding. But from time to time, creative fireballs like Ramanujan burst onto the scene propelling human thought forward."

Dr T.V Venkateswaran is Scientist 'F' in Vigyan Prasar.
Email: tvv@vigyanprasar.gov.in

R. CHANDRAN

Save Coral Reefs, Our Paradise on Earth, to Save Ourselves

Coral reefs, one of the most diverse and most productive ecosystems of the world, are highly vulnerable and perhaps the first victims of climate change. Saving them is more beneficial for our existence than their survival.

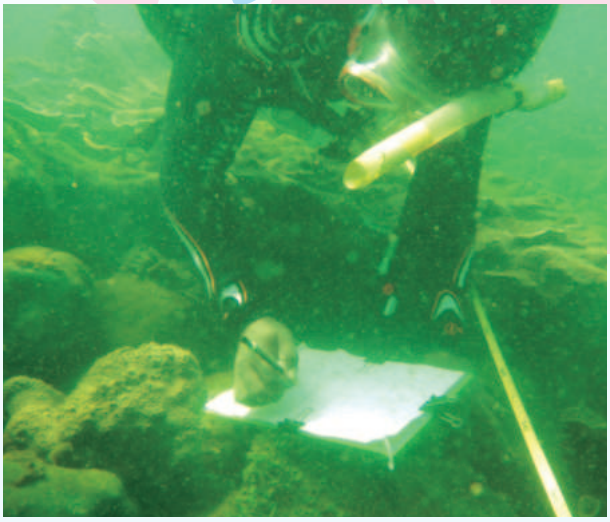
Nature created this living planet for us with a nice balance of organic and inorganic components and provided it with a self-repairing mechanism. Species that are incapable and threatening are always replaced with advanced and useful species through massive global events also known as mass extinctions. In the past, the Earth has gone through five such mass extinctions, which wiped out many species. The well-known last mass extinction happened 65 million years ago, which wiped off the mighty dinosaurs, making way for humans to appear on Earth. Mammals would not have flourished well in presence of dinosaurs on this planet and our appearance in this world would not have happened. Now, the sixth mass extinction has already started. Global warming, which was responsible for a few mass extinctions in the past, is the main cause. The warming of the globe takes place at a slow pace. Unfortunately, our greed has accelerated its speed now, which is removing all our natural shields, leading us to extinction, perhaps, within this century itself.

The changing global climate is already distressing nearly all the Earth's ecosystems and biodiversity and pushing them to a high risk of even more serious crisis over the coming decades. Global climate predictions foretell more frequent and intense catastrophic environmental events. Coral reefs, one of the most diverse and most productive ecosystems of the world, are highly vulnerable and perhaps the first victims of climate change. These coral reefs are nature's underwater paradises, created with marvellous architecture and decorated with multi-coloured curios. Although they occupy less than 1% of the ocean floor, they render home for a quarter of all living species. Sometimes thousands of species can live in just a single metre square area on a coral reef. The coral reef ecosystems are teeming with organisms that survive in a mutualistic society in which coral species play the role of 'ecosystem engineers' taking care of the construction and maintenance of the society. Every available centimetre of space on the coral reef is occupied by some species, making the reefs like 'congested underwater metro-cities', and each centimetre of coral reefs is useful to humans too.

The existence of coral reefs may be translated directly into food, security, revenue and a multitude of other benefits to us. Over a billion people worldwide are wholly or partially dependent on coral reef resources for their livelihood via harvestable marine resources that they generate through tourism and biodiversity. In fact, more than 850 million people living within 100 km of a coral reef and are likely to obtain some benefits from nearby coral reefs. It is also estimated that healthy and well-maintained reefs can give up to 35 tonnes of fish per square kilometre every year. By minimising wave impacts from storms such as cyclones, hurricanes or typhoons, coral reefs play an important role in shoreline protection of mainland coasts and island nations. Coral reefs are globally significant, as about half of the carbondioxide that enters the world oceans each year is taken up and bound into reefs as calcium carbonate. Marine organisms inhabiting coral reefs have been proven to be promising sources of novel pharmaceutical compounds for treating an array of human ailments. Coral reefs are a part of human civilisation too.

In spite of evolving and surviving on the Earth for 500 million years, coral reefs are now disappearing and dying at an alarming rate. The list of problems can seem endless and range from poor land-use practices, industrialisation and pollution along the coastal belts, destructive fishing operations, introduction of invasive species, oil spills, etc. Global warming and ocean acidification have overtaken all other impacts now. The prevalence of unprecedented coral bleaching events and coral diseases has increased unimaginably. As a result, coral reefs are predicted to disappear in less than half a century from now. Even though all these alarming events are happening in front of our own eyes, we are becoming mere spectators. Yet the loss is colossal. The loss of coral reefs potentially costs an

astounding US$1 trillion globally. Coral reefs are critically important for developing countries for livelihood, food security and economy. It is almost impossible to imagine the world without coral reefs. Studies estimated that 20% of the world's coral reefs have already been destroyed and show no immediate prospects of recovery, and about 24% of the world's reefs are under imminent risk of destruction. If we do not respond to mitigate global warming at least now, then we will surely destroy the world's great coral reefs within a half-century.



For a couple of decades, scientists and policymakers have been racing to save the world's coral reefs from peril. All our regional-scale efforts for protecting coral reefs, namely marine reserves, marine protected areas, etc., over the past three decades have almost failed. It is worth pondering whether we have a solution to tide over this mighty threat of global warming. The good news is there is one science-based systematic approach that could help in the sustenance of these underwater paradises. Resilience-based management is the most recent concept and represents a glimmer of hope for coral reef conservation for now.

'Reef resilience' is the ability to resist threats and recover to its former state after a disturbance has occurred. Several key ecological factors influence the resilience of a coral reef. They are predominantly causes that facilitate coral survivorship, good water quality, factors supporting unwanted phase-shift of the reefs, and healing from bleaching and diseases. A resilient coral reef will tend to exhibit recovery towards a coral dominant state even if subsequent disturbances prevent corals from eventually dominating. Building resilience capacity and resilience-based management of coral reefs have been demonstrated to immunise coral species to help them cope with climatic and non-climatic stresses.

Resilience-based coral reef management would also assist the evolution of thermal-tolerant coral communities. The resilience potential of each individual reef in a region may differ from one another. The recovery of severely damaged reefs is dependent on nearby highly resilient 'mother reefs' or 'stock reefs'. Hence, scaling the resilience ability of coral reefs would help us to know the present resilience status, existing threats and spatial variation in the resilience potential of coral reefs. This would also help to locate 'local stock reefs' of each region and their connectivity paradigm with its surrounding reefs.

There is no detailed study on the resilience potential of any Indian reef regions so far. A study to evaluate the resilience potential of the coral reefs along the mainland coast of India and locate 'local stock reefs' is the one I have chosen to carry out through the Zoological Survey of India (MoEFCC) with funding assistance from DST-SERB. I am glad to state that in my study so far, I have identified 10 highly potential resilient reefs, three from Gujarat (Lakku reef, Mithapur township reef and Pirotan reef); three from Maharashtra coasts (Chivla reef, Sindhudurg reef and Devbaug reef) and four from Vembar-Keelakarai in the Gulf of Mannar. All these reefs have the potentiality to serve as 'mother reefs' to sow coral seeds and maintain a healthy coral population in the surrounding reefs. Destructive fishing practices and uncontrolled tourism are identified as the potential threats existing in these areas.

There are more than three dozen factors directly or indirectly responsible for the resilience capacity of reefs. Scaling the resilience indicators, identifying local 'mother reefs' of each region and right interventions to unravel the existing threats would certainly accelerate the resilience potential of our coral reefs. This will also make the corals immunised for adapting to the forthcoming climate change impacts. Rather than spending more efforts to conserve a wide reef area, simply enforcing protection and conservation interventions at the identified local resilience reefs of each area could protect all our nation's coral reef assets from the challenging climate change crisis. Now, I am very confident that my study will certainly contribute to the sustenance of all our reefs and surely provide baseline information for replicating the results in other reef regions elsewhere. There is true magic in resilience studies. Kachchh and Maharashtra reefs, which are under threat and considered as the least attractive, are going to become the most sought-after reefs because of their potential to act as coral refugia (local environment that has escaped regional ecological change and therefore provides a habitat for endangered species).

One thing we should always remember is that our race is the most vulnerable than any other lower group of animals such as corals, which have already sustained earlier mass extinctions through their resilience capacity. Saving them is more beneficial for our existence than their survival. Let us be wise and prove that we are the best of all creations in this universe.

Dr R. Chandran, a Post-Doctoral Fellow from Marine Biology Regional Station, Zoological Survey of India, Chennai, is pursuing his research on "Resilience assessment and identifying local 'Stock Reefs' a novel proactive management approach on India's coral reefs conservation, in response to the ever-increasing global warming". This article has been selected for AWSAR Award.
Email: softcoralchandran@gmail.com

JYOTI SHARMA AND SACHIN GAUTAM

NANO-BIOMIMETICS: Inspiration from nature for development of biomedical implants

Biomimicry is leading the path to a new age of technological development by taking lessons from nature as the foundation for products.

Biomimetics, also known as bionics or biomimicry, is the use and implementation of concepts and principles from nature to creating new materials, devices and systems. Modelling their planes on the structure of bird wings by the Wright brothers, the design of a lily pad to structure the Crystal Palace in London by Joseph Paxton, and Leonardo da Vinci's work on flying machines and ships are examples of application of biomimetics from the past. However, it became popular when American inventor Otto Schmitt coined the term biomimetics in 1957 and Jack Steele, a doctor in the U.S. Air Force, coined the word bionics in the 1960s.

Biomedical implants

Orthopaedic surgery, especially for the hip and knee region, is becoming popular nowadays due to the genetic disposition of the Indian population and present-day lifestyle. More than 15 crore Indians suffer from knee problems, out of which about 4 crore patients need a total knee replacement. The incidence of arthritis of the knee in India is 15 times more than in Western countries.

Several materials have been tested and developed for a successful implant and functioning within the human system, despite being a foreign material. It must be biologically compatible and have appropriate mechanical, wear and corrosion properties. Stainless steel is used in medical applications for its mechanical properties, corrosion resistance, ease of manufacturing and cost-effectiveness. However, low biocompatibility and high elastic modulus limit its use in implants. Hence, titanium alloys are preferred in orthopaedic implants for their lightweight, biocompatibility, improved passivity and corrosion resistance.

Apart from biocompatibility, mechanical wear, corrosion, and integration with bones, surgical site infection in orthopaedic implants is a major problem, often leading to prolonged hospitalisation, long-term antibiotic therapy, bacterial resistance and revision surgery or death. The implants act as foreign material and carry the inherent risk of bacterial infection. Common pathogens that adhere to the implant surface include *Pseudomonas aeruginosa, Staphylococcus aureus and Staphylococcus epidermidis*. They often form a biofilm layer around an implant that is highly immune to antibacterial treatment. Attachment of bacteria followed by the formation of biofilm is greatly influenced by the surface topography and roughness of the material. Hydrophobicity, electrostatic interactions, van der Waals forces, and steric hindrance are other influential factors that dictate adherence to the surface.

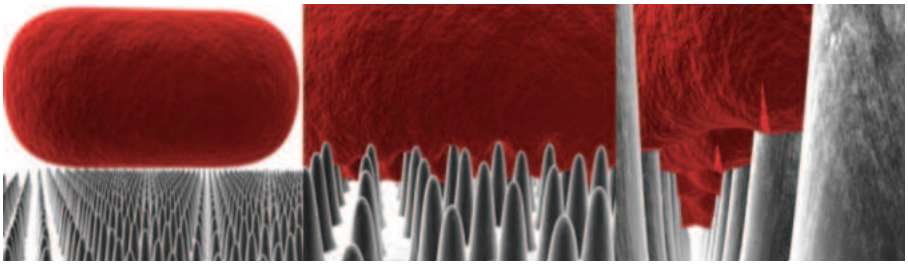
Nowadays, manufacturers are using various coating methods, surface modification and implanting ions such as silver, calcium phosphate and hydroxyapatite, which improve bone regeneration, tissue response and antibacterial properties of the implant surface. However, these coatings tend to lose their effectiveness over time and may cause toxic effects in the body. Apart from these coatings and surface modifications, naturally occurring nanostructures also provide motivation for researchers to mimic their antibacterial behaviour. To reduce the need for prolonged hospital stay, use of heavy antibiotics and revision surgery, researchers are trying to reproduce naturally occurring nano-structured surfaces, having self-cleaning and bactericidal properties. These nano and microstructures stretch, disfigure and rupture the bacterial cell wall by considerably increasing the contact adhesion area.

Naturally occurring nanostructured bactericidal surfaces

There are many plants and insect surfaces that exhibit antibacterial or anti-biofouling properties with their individual surface textures and structure dimensions. The surfaces of many plant leaves show anti-fouling behaviour, which repel bacteria and impurities based on high contact angles (142°-159°).

Lotus and taro leaves

The presence of well-ordered microscale elliptical bumps 10-30 µm in diameter, which are covered by hierarchical, waxy nanoscale crystals make leaves of taro *(Colocasia esculenta)*



Rupture mechanism of bacteria cells by nanopillar structures; as bacterium cell is absorbed onto thesurface, regions between pillars stretch the cell membrane, causing rupture. Source: Pogodin, S., et al., Biophysical journal, 2013. 104(4).

and lotus *(Nelumbo nucifera)* anti-biofouling, hydrophobic and anti-bacterial. The presence of these bumps increases the contact angle (90°-150°) of the surface, making it superhydrophobic. It helps roll off the dirt and contaminants with the water droplets, leaving the leaves clean.

The resistance of taro and lotus leaves towards biological and non-biological particles is due to the physiochemical interaction between the cell and the surface roughness of the leaf. This behaviour has increased research interest in applications such as self-cleaning paint, clothes, windows, bio-repellent coatings, and low-friction surfaces.

Cicada and dragonfly wings

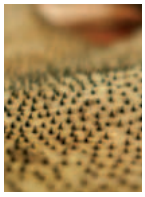
Wings of cicadas help them to adapt to a variety of environments-from underground to tall trees, high temperatures, and humidity. The wings are mainly made up of chitin, protein and wax, covered with closely packed, highly ordered nano-pillars. Studies have shown that cicada wing surfaces have less of a bactericidal effect on Gram-positive bacteria due to their increased cell rigidity, compared to Gram-negative cells.

The S-shaped pattern of nanopillars present on dragonfly wings is responsible to make it more efficient in killing both Gram-negative *(Pseudomonas aeruginosa)* and Gram-positive bacteria *(Staphylococcus aureus and Bacillus subtilis)*, as well as endospores produced by *Bacillussubtilis*. The nanostructures found on the surface of dragonfly wings are primarily composed of aliphatic hydrocarbons, with fatty acids covering the outermost layer. While cicada wings are only efficient at killing Gram-negative bacteria, dragonfly wings can kill both Gram-negative and Gram-positive cells.

Gecko skin

Gecko skin and feet have strong adhesion and bactericidal properties due to the periodic array of hierarchical microscale keratinous hairs, known as setae. Nano-scale spatulas present in these hairs are responsible for producing a small van der Waals force, which collectively creates large adhesion and anti-wetting properties. Researchers are trying to replicate the same artificially in nanostructures.

Shark skin



The surface of shark skin has self-cleaning, anti-biofouling, hydro phobic, drag reducing and aerodynamic characteristics. Tiny flat V-shaped scales, called dermal denticles, that are more like teeth than fish scales, are responsible for the anti-biofouling and self-cleaning properties of shark skin. The microstructure of the skin also facilitates high-speed swimming (up to 90 km/h). Silicone-patterned surfaces designed to mimic the microstructure of shark skin has reduced drag resistance in submarines and ships by 15% and algae cell attachment by 67%.

Butterfly wing

Butterfly wings combine the anisotropic flow effects found on shark skin and the superhydrophobic properties of lotus and taro leaves to produce an effective anti-biofouling surface. The surface of butterfly wings comprises of an array of aligned scales that cause anisotropic behaviour. Anisotropic flow combined with superhydrophobic properties produces a high contact angle and results in a surface that has low drag, anti-biofouling, and low bacterial adhesion properties.

Artificial antibacterial surface fabrication

Surfaces with antibacterial surfaces are becoming an inspirational source for scientists to reproduce, using a variety of chemical and mechanical methods. Many research groups have designed antimicrobial surfaces based on this cellular repulsion phenomenon exhibited by natural surfaces such as taro and lotus leaves. To date, researchers have developed two models that explain the mechanism of prokaryotic microbial death on nano-patterned surfaces: (1) a biophysical model, and (2) an alytical thermodynamic model. According to the biophysical model, nanostructures present on antibacterial surfaces are capable of penetrating bacterial cell walls although bacterial cell death is dependent on the composition of the cell membrane.

Safety and toxicity of nanomaterials

The use of nano-patterned biomaterial implants in the body comes with concerns over the mechanical stability of the structures and unintentional health impacts of metal oxides, leading to long-term toxicity concerns and potential cellular damage.

The toxicity of nanostructures is an unexplored research area, but the toxicity of metal oxide nanoparticles can be considered as an initial judgement of toxicity. “Needle-like” titanium oxide, aluminium trioxide, molybdenum trioxide and chromium trioxide nanoparticles have shown no effect on cellular shrinkage, and liver cells *(in vitro)* at low concentrations. However, there is a significant effect at higher concentrations.

Future perspectives

Placing medical implants in the body comes with an associated risk of bacterial infection. Patients are commonly required to take long-term antibiotics to reduce re-infection; however, the increasing resistance of bacterial strains to antibiotics is a matter of concern. Methods that are particularly effective in mimicking antibacterial surface behaviour are Focused Ion Beammilling and hydrothermal synthesis, which is currently used to find the optimal surface for bactericidal behaviour by varying hydrothermal process parameters.

Jyoti Sharma is a Senior Scientist, International Cooperation Division (ICD), Department of Science and Technology, Govt. of India.
Email: jyotisharma.dst@gmail.com

Sachin Gautam is pursuing his graduation in Life Sciences from the University of California, Davis.

MANISH MOHAN GORE

DR NARENDER KUMAR SEHGAL

Shining star of science communication

Dr Narender Kumar Sehgal, who laid the foundation of science communication in India, passed away on 7 September 2020. He worked to connect the ongoing science communication and popularisation efforts in the country into one formula and gave it a clear direction. Today the programmes of science communication, whether it is publication of popular science literature, VIPNET Clubs, Children's Science Congress, or astronomy awareness campaign, most of them were initiated by Dr Sehgal.

Some scientists like Prof. Yash Pal and Prof. Jayant Vishnu Narlikar contributed to scientific research as well as science popularisation. But Dr Sehgal was one scientist who, instead of going into scientific research, devoted his entire life to the development and promotion of science communication. After completing his PhD in particle physics (1969) from the University of Wisconsin, Madison (USA), he returned to India and started writing science-related articles. For nearly three years (1978-1981), he was a visiting scientist at the Space Applications Centre, Ahmedabad, but the passion for science popularisation brought him to NCSTC, DST. He took charge of the NCSTC Secretariat in 1982, and from here, his journey in leading science communication began.

The Architect of Science communication

Born on 7 November 1940 in Lahore (now in Pakistan), Sehgal was a promising student from the beginning. He engrossed himself in the study of sciences, completed his research work in about six years, abroad. He could pursue a bright career in the research or teaching science in India or abroad. But he returned to India and decided to dedicate his life in the service of the country. He realised that creating scientific awareness and spreading science and technology information among people is an important field. His dedication and determination were extraordinary, so whatever he did in the field of science communication became an example and proved to be a milestone.

There was a printing press in his ancestral house; so from childhood, he was fond of newspapers and magazines. In 1972, at the age of 32, he started publishing a quarterly magazine called Scientific Opinion and continued its publication for 4 years. He was the publisher, printer, writer and distributor of this magazine. At the same time, he also contributed to the prestigious international weekly science journal Nature and remained associated with it for two years (1974-1976). After the National Council for Science and Technology Communication (NCSTC) was set up, he started much-needed initiatives and launched nationwide campaigns. He felt the need for autonomy at the institutional level and created an autonomous organisation, Vigyan Prasar, under DST. Later, he also set up the NCSTC-Network, a network of 50 government and non-governmental organisations.

Dr Sehgal knew that the objectives of science communication could not be achieved without involving people in it. He gave priority to the development of scientific awareness in children. For this, he embodied the concept of creating significant literature and published books like Sach to hkuch aur hai, Aakash Darshan ka Ananda, Dekha Parkha Sach, and Kyon aur Kaise from NCSTC. Later, publication of popular science books was started by Vigyan Prasar in 1994.

Vigyan Prasar has since published more than 300 excellent books in Hindi, English and other Indian languages. His objective was to publish in areas of science which the commercial publishers do not pay attention to.

In September 1990, science filmmaker Nandan Kudhyadi gave Dr Sehgal a 32-page manuscript which was an autobiography of Ruchi Ram Sahni, the father of India's renowned palaeobotanist Birbal Sahni. Ruchi Ram Sahni was a professor of chemistry and science communicator in Punjab and used to demonstrate interesting experiments of chemistry. People bought tickets by paying one or two 'annas' to watch these demonstrations with great interest. From all possible sources, Dr Sehgal gathered information about Ruchi Ram Sahni and published a book in English in 1994 on the life and contribution of this anonymous soldier of science communication. Later, its Hindi and Punjabi versions also were published. Dr Sehgal was also interested in exploring the history of popular science literature in various Indian languages. Under his guidance, the historical document 'Hundred years of popular science writing' was published by Vigyan Prasar in Hindi, Bangla and Marathi.

'Ready to Print Science Page' was a unique initiative of Dr Sehgal, in which interesting scientific information was designed and sent to the leading newspapers and magazines for direct publication.

Dr Sehgal regularly wrote editorial articles in the magazines NCSTC Communications and Dream 2047, which were later published as a book by Vigyan Prasar (Communicating Science: Questions and Issues of Concern). Realising the need for science clubs Dr Sehgal built a nationwide network which is still run by Vigyan Prasar, called 'VIPNET' (Vigyan Prasar Network of Science Clubs).

Dr Sehgal believed that connecting with common man is very important to achieve the objectives of science. He started a 'Vigyan Jatha' (Science march) to spread awareness about the importance of pursuing the study of science. Bharat Jan Vigyan Jatha (1987) and the Bharat Jan Gyan Vigyan Jatha (1992) visited more than 50,000 places (districts, blocks, villages, and talukas) of India.

Dr Sehgal effectively used electronic media like radio and television and produced TV programmes in many Indian languages and radio science serials like 'Vigyan Vidhi' and 'Manav Ka Vikas'. He was awarded the UNESCO Kalinga Prize for the popularisation.

When a meeting was held to designate the date of birth of Sir C.V. Raman 7 November as National Science Day, Dr. Sehgal rejected the idea as it was also his date of birth. It was then decided to designate 28 February as the National Science Day. This is a small example of how particular he was in following his principles.

Translation by Suman Bajpai.

Dr Manish Mohan Gore is a scientist with CSIR-NISCAIR.
Email: mmg@niscair.res.in

DR NARENDER SEHGAL: WHAT SCIENCE COMMUNICATORS THINK ABOUT HIM

In collaboration with Vigyan Parishad Prayag, Dr Narender Sehgal carried out important work for a science writing seminar and preparation of Hindi Mei Vigyan Lekhan Ke Sau Varsh document in Hindi. His death has caused irreparable loss in the field of science communication.

Dr Shiv Gopal Mishra,
Pradhan Mantri, Vigyan Parishad Prayag

An accomplished particle physics scholar, Dr. Narender Sehgal, was a pioneer and originator of national activities of science communication in India. He insisted on networking, training of science communicators, creating source materials, setting ambitious goals and dreaming the 'impossible'. His message was "Think scientifically... Act scientifically…" It was very exciting and challenging to work with him.

Dr Subodh Mahanti,
Former Scientist 'G' and Honorary Director, Vigyan Prasar

Dr Sehgal clearly understood that in a developing country like India, all efforts of science communication should relate to the common man. Therefore, he had started significant initiatives like the Vigyan Jatha, aspects of science, which could be easily understood by the common man, on the Sangam bank in Kumbh Mela and 'Vigyan Mela' in the famous Nauchandi Mela in Meerut so that a large number of people could benefit from it. He used to implement scientific approach in his life too. In every sphere of his life, he upheld high ideals and morals.

Dr Manoj Kumar Patairiya, Head, NCSTC

With a great vision, confidence, indomitable enthusiasm and unmatched honesty, the true Indian, Dr Sehgal was my "friend, philosopher and guide" for the last three decades. I am lucky that three decades ago I became a part of this movement and worked closely with him. He laid the foundation of all popular science and technology communication projects and defined the principles of their implementation. Whenever science for the common man will be discussed, his contribution will be remembered.

Dr Arup Mishra, Director, ASTEC and Fellow, Vigyan Prasar (1998-2001), First Coordinator-VIPNET

When I became a part of Dr Sehgal's team, he was at the peak of his career. With the establishment of NCSTC and Vigyan Prasar, he had established a national network of science and technology communication. By joining him, my ability and skills in the areas of organisation, implementation, communication, planning, research and logic improved. We will miss his wit and wisdom always.

Anuj Sinha, former Head, NCSTC and former Honorary Director, Vigyan Prasar

In Dr Narender Sehgal one could find a firm commitment to the belief that scientific temper, while essential for every human being, had to be an essential part of every scientist and every scientific endeavour too. He always felt that scientific ideas and concepts should be disseminated to the public more through means that involved personal interaction.

Hasan Jawaid Khan,
Chief Scientist, CSIR-NISCAIR and Editor, Science Reporter

He was unlike anyone else I've known - rational, principled, frank to the fault though caring. Conceived and executed so much. I interacted for decades as NCSC Academic Coordinator; expert and National Coordinator of NCSC-2003 and workshops, and NW convener. Talked recently to invite to INSA meeting. Indeed fortunate to have known him.

Dr C.M. Nautiyal,
Consultant (Science Communication), INSA and former Scientist, BSIP, Lucknow

Dr Sehgal, who has been awarded the UNESCO Kalinga Prize for his outstanding contribution in the field of science communication, will always be an inspiration for future generations of science communicators. His contribution to science communication will always be remembered.

Dr K.N. Pandey, Former Scientist 'F', ICMR

Dr Sehgal, the architect of science communication and popularisation programmes of India, will be known for many innovative efforts in future. He institutionalised science communication in India, established institutions and national networks, so that science can reach out to the masses. Holding his hand, I stepped into this genre and he was my guide.

Kinkini Dasgupta Misra, Scientist 'F', Vigyan Prasar

On the basis of the programmes of science communication implemented by Dr Sehgal, the concept of present science communication in India has emerged. We have lost a genius science communication warrior.

Dr B.K. Tyagi, Scientist 'F', Vigyan Prasar

Dr Narender Sehgal is no longer with us, but the foundations of science popularisation in India which he has laid, has paved the way for many other science communicators.

Kapil Tripathi, Scientist 'F', Vigyan Prasar

The pioneer of science communication in the country, the founder of major institutions of science communication and the father of innovative programmes for science communication, Dr Narender Sehgal was also a proficient writer who wrote in Hindi as well as in English with equal fluency. He has also contributed in Avishkar. One important thing is that he knew how to connect with people and how to connect people.

Radhakant Anthwal, Senior Editor, Avishkar and Invention Intelligence

To create awareness in youth towards electronics, in collaboration with Dr V.B. Kamble, Dr Sehgal had established an Amateur Radio Club in Vigyan Prasar. In 1986, I was preparing for the Amateur Radio License exam and I used to join him on an ordinary shortwave band radio receiver during the Bharat Jan Vigyan Jatha.

Sandeep Barua, Scientist 'F', Vigyan Prasar

Dr Sehgal's incomparable contribution in the field of science communication cannot be forgotten. He played an important role in establishing the importance of science communication in society. He will always be an inspiration for science communicators.

Nimish Kapoor, Scientist 'E', Vigyan Prasar