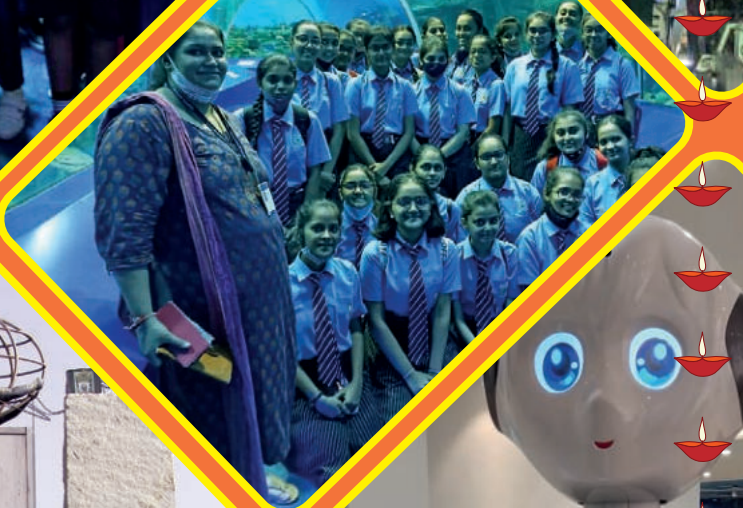
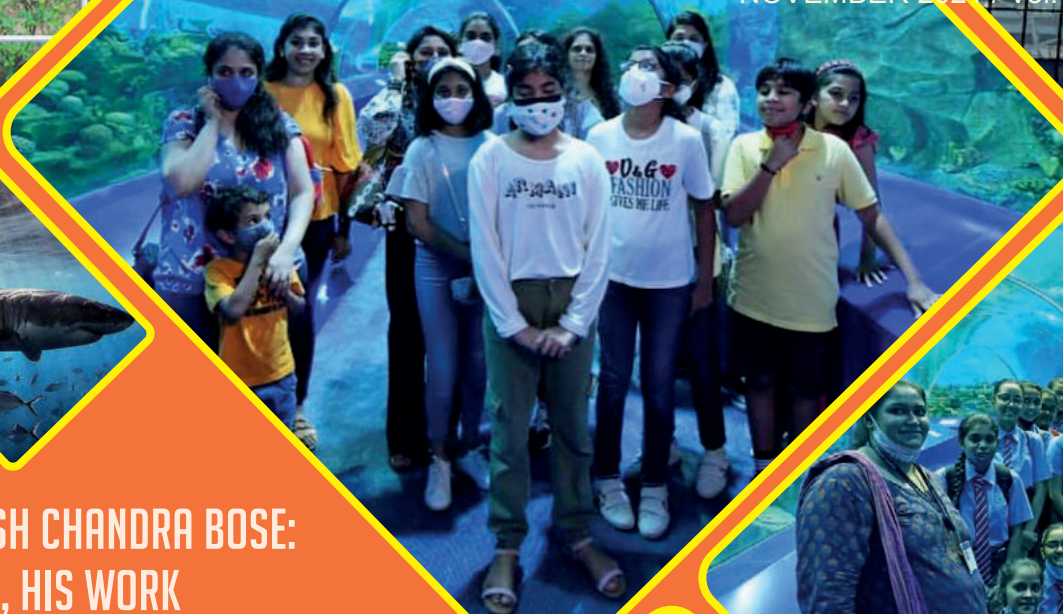


# DREAM

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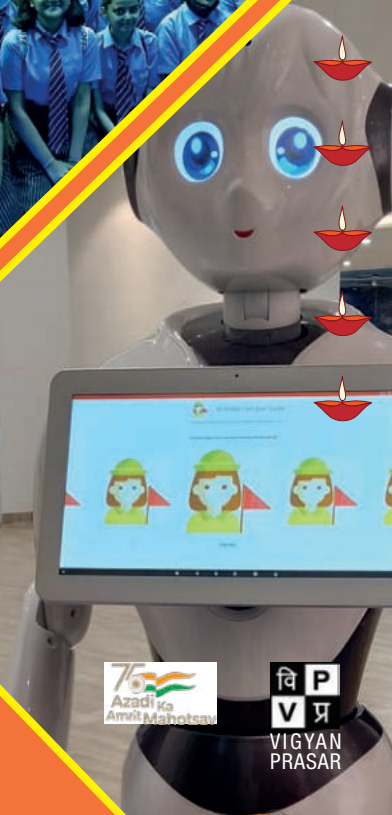


JAGADISH CHANDRA BOSE:  
HIS LIFE, HIS WORK  
AND HIS TIMES

ROLE OF SCIENTIFIC LITERATURE  
IN MULTIDIMENSIONAL  
DEVELOPMENT OF CHILDREN



GUJARAT SCIENCE CITY  
CONNECTING COMMUNITY  
WITH SCIENCE



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# MY WORD

NAKUL PARASHAR

## Complexity Simplified

### THE WEATHER

and climate of our planet Earth are very complex. This complexity is a function of randomness and disorder present in them. Over the time, several models to understand them have been developed. This year's Nobel Prize for Physics has gone to scientists who have worked around such complex systems, be it weather and climate and disordered complex materials. Syukuro Manabe of Princeton University, USA and Klaus Hasselmann of Max Planck Institute for Meteorology, Hamburg, Germany have received this year's award for their work in understanding the complexity of weather and climate, while Giorgio Parisi has found out the hidden patterns in disordered complex materials. Interestingly Parisi's work has found relevance in mathematics, biology, neuroscience, and machine learning. Congratulations.

The festival of lights is here again! Pall of gloom seems to be fading away as scientists in the lab and the science communicators on the streets of our country are working relentlessly to ensure that no other wave resurfaces. It's been two years since the pandemic began, and the return-to-normal still seems to be a distant one. Let's hope that as scientific and technological advancements make progress in our fight against COVID-19, we get closer to business-as-usual. Hope, health, and happiness shall prevail—wishing all the readers a very happy onset of the festive season—seasons' greetings.

Festivity, fun, and frolic are an integral part of our festivals. If we utilize this atmosphere in propagating science understanding, a lot can be achieved. General interest in science would automatically increase. Scientific temper build-up would further be strengthened, and

much more. Perhaps, that's the reason the annual India International Science Festival is organized around this time. This year, it's being planned for the second week of December in Goa. Stay tuned for more details.

Besides the festival, come November, and kids anxiously await the national children's day (November 14th). At Vigyan Prasar, children have an important place in its activities of Science Communication, Popularisation and its Extension (SCoPE). Toys and do-it-yourself kits have been among the most sought-after popular SciComm products that VP has developed so far.

Besides, amongst a long list of titles (books) published by Vigyan Prasar so far, most of them cater to children. In this sequence, IndiaScience, the nation's S&T OTT Channel, is currently running a series on young innovators called Vigyan Veer. It is a series of short films that inspire kids at the school level. These are those kids who have gone beyond the routine realm of studying science. They have applied science principles to automate various processes that directly affect life around them. I distinctly remember how science melas had models and replica of things that we should find in our books. As technology improved and penetrated our lives, libraries of software commands evolved to control and execute several actions that we perform in our daily lives. At a similar Science Mela in early 2020, I could see how school students at the Urdu Science Congress in MANUU, Hyderabad, showcased the intelligent use of these software libraries.

I wish our readers and all associated with Vigyan Prasar Happy Diwali and Happy Children's Day

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# Nobel Minds in Science, 2021

The scientific fraternity has got its hands together to clap and celebrate once again! Just as it does every year and like it has been doing so since 1901. But then why just the scientific community, it is celebration time for every citizen of the world as the impact is far-reaching. The Nobel Prizes 2021 for Physics, Chemistry, and Medicine among others have been announced!

Ever since the awards were constituted in 1901 as directed by the will of Alfred Nobel, the Nobel Prize has so far been awarded 608 times to 941 individuals and 25 organizations for Physics, Chemistry, Medicine or Physiology, Economic Sciences, Literature and Peace. In some cases, the award was given to an individual while in others it was shared between two and sometimes a maximum of three persons. It may be noted that an elaborate and tedious process is followed for the selection usually starting in September each year and culminating with the announcements after a majority voting, the following year in October, and then the Nobel Laureates are given the prizes after two months in December.

The Nobel Prizes for Physics, Chemistry, and Medicine are particularly awaited eagerly as these come with a lot of expectations and potential for future growth and developments in these disciplines, with implications for the humanity. The prestige attached to the Nobel Prizes and the source of inspiration that they become for the current generation is unparalleled. The announcements for the year 2021 were made between 4-11 October. The Royal

Swedish Academy of Sciences in Sweden is responsible for selecting the Nobel Laureates in Physics and Chemistry while The Nobel Assembly at Karolinska Institutet in Sweden is responsible for selecting the Nobel Laureates in Physiology or Medicine.

### ***The Nobel Prize for Chemistry:***

The 2021 Nobel prize has been jointly awarded to Benjamin List and David MacMillan who independent of each other developed an ingenious tool to build molecules.

Fifty-three-year-old Benjamin List earned his Ph.D. from Goethe University in Germany and is currently the Director of the Max-Planck Institute for Coal



Benjamin List



David W.C. MacMillan

Research in Germany. David W.C. MacMillan who is also of the same age as Benjamin List hails from the UK and was awarded his Ph.D. degree from the University of California in the USA. He is currently a Professor at Princeton University in the USA.

***The core research:*** The building of molecules is a complex task. It requires the help of catalysts, which are substances that control and accelerate chemical reactions, without itself becoming part of the final product. Catalysts are thus fundamental tools for chemists, but researchers have for long believed that

in principle, metals and enzymes were the only two types of catalysts available. List and MacMillan in the year 2000, independent of each other, developed a third type of catalysis called asymmetric organocatalysis. This tool builds upon small organic molecules. The ingenuity of this concept lies in its simplicity which makes us wonder why it was not developed earlier!

Organic catalysts are known to have a stable framework of carbon atoms. Often, more active chemical groups and common elements like oxygen, nitrogen, sulphur, or phosphorus can attach to this framework. This implies that these catalysts are both environmentally friendly and cheaper to produce. There has been a rapid expansion in the use of organic catalysts primarily due to this ability to drive asymmetric catalysis. In the process of building the molecules, situations often occur where two different molecules can form, which are each other's mirror image, just like our hands. Chemists will often only want one of these, especially while producing pharmaceuticals.

Before chemists were able to conduct asymmetric catalysis, many pharmaceuticals contained both mirror images of a molecule. One of these molecules was active, while the other could sometimes have unwanted side effects. This new catalyst can now help avoid major side effects and can be a game-changer by giving chemists a precise new tool for molecular construction during pharmaceutical research, and also in the process, in making chemistry environment friendly.

### ***The Nobel Prize for Physics:***

The 2021 Nobel Prize has been awarded one half jointly to Syukuro Manabe and Klaus Hasselmann, and the other half to Giorgio Parisi. Together these Laureates have laid the foundation of our knowledge of the Earth's climate and how humans influence it. At the same time, they have revolutionized the theory of disordered materials and random processes in physical systems ranging from atomic to planetary scales.

Ninety-one year-old, Syukuro Manabe earned his Ph.D. from the

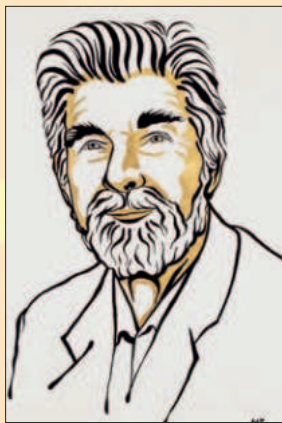


Syukuro Manabe

University of Tokyo and is currently a Senior Meteorologist at Princeton University, USA. His discovery distinctly demonstrated how increased levels of carbon dioxide in the atmosphere lead to increased temperatures at the surface of the Earth. He has been leading the development of physical models of the Earth's climate and in exploring the interaction between radiation balance and the vertical transport of air masses. His work laid a foundation for the development of current climate models.

Ninety-year-old, Klaus Hasselmann earned his Ph.D. from the University of Göttingen, Germany, and is currently a Professor at Max Planck Institute for Meteorology in Germany. He created a model linking weather and climate. This offered an answer to the question of why climate models can be reliable despite the erratic and chaotic nature of weather. He also developed methods for identifying specific signals and fingerprints, that both natural phenomena and human activities imprint on our climate. His methods have proved without a doubt that the increased temperature in the atmosphere is due to human emissions of carbon dioxide.

Seventy-three-year-old, Giorgio Parisi with a Ph.D. from Sapienza University in Italy, is currently a Professor at



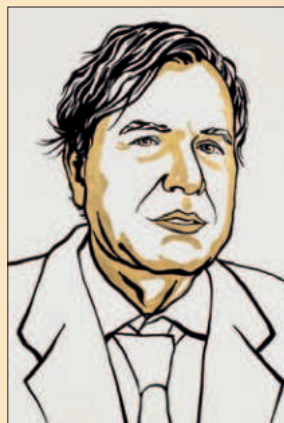
Klaus Hasselmann

the same university. He has received the other half of the Nobel Prize for the physical modelling of Earth's climate, quantifying variability, and in reliably predicting global warming. Parisi discovered hidden patterns in disordered complex materials in the 1980s. His discoveries contribute significantly to the theory of complex systems. Now it is possible to understand and describe apparently many different and entirely random materials and phenomena. This is true not only in physics but also in other very different areas such as mathematics, biology, neuroscience, and machine learning.

**Nobel prize for medicine:** This year's Nobel prize for medicine has been jointly awarded to David Julius and Ardem Patapoutian. Their discoveries have enabled unlocking of the secrets of nature by explaining the molecular basis for sensing heat, cold and mechanical



David Julius



Giorgio Parisi



Ardem Patapoutian

force. This is fundamental for our ability to feel, interpret and interact with our internal and external environment. In other words, it focuses on the sensors that allow us to interact with the outside world. We have sensors in our skin, that sense changes; like when there is a burn in the sun or when you put your hand in cold water, these sensors get activated. These sensors are formed by receptors. In addition, when we touch each other, other receptors are activated and sense and convert that touch into nerve signals and send it to the brain.

Sixty-five-year old David Julius hails from New York. He received his Ph.D. from the University of California and is now a Professor at the same university. Julius was particularly interested in our reaction to eating hot foods, through these sensors, and, he found the receptor that was activating this chilli or capsaicin that is the active compound. Then soon enough he also found that the receptor was also sensing heat and that it is a thermosensitive receptor.

Fifty-four-year-old, Ardem Patapoutian hails from Beirut in Lebanon. After leaving the war-torn Beirut early in life, he received a Ph.D. from the California Institute of Technology in USA. Since 2000, he is a Professor at Scripps Research in California. He is also a Howard Hughes Medical Institute Investigator since 2014. He wanted to know about the sensors that are allowing us to sense touch and mechanical change in the force on our body or our skin. This led him to the important discovery of finding the piezo channels that endow us with the sense of touch and the ability to feel the position and movement of our body parts. These channels also contribute to numerous additional physiological functions that depend on sensing temperature or mechanical stimuli. This knowledge is being used to develop treatments for a wide range of disease conditions, including chronic pain

Source of information and images:  
[www.nobelprize.org](http://www.nobelprize.org)

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# COVER STORY I

NAROTTAM SAHOO



## Gujarat Science City

# CONNECTING COMMUNITY WITH SCIENCE



***Every great advance in science has issued from a new audacity of the imagination.***

*John Dewey: The Quest For Certainty 1929*

**G**ujarat Science City (GSC) is a unique concept—an all-time dream project—as it connects community with science and technology, younger generation with career and future, students with imagination and innovation, and the state and country as a new science tourism destination to inspire one and all.

GSC, working under the aegis of Department of Science & Technology, Government of Gujarat, is emerging as an effective and large-scale science education and popularization platform in the state and country by promoting innovative and experimental hands-on activities and minds-on exposures.

The concept and design of GSC has emerged as a landmark, leading-edge science and technology exploration centre targeting, stimulating, and inspiring the inquisitive minds. It is more than just an exciting place to explore; it is home to a sustainable, collaborative, socially-engaged organization managing a dynamic network of science and technology-related programmes that reaches out across the length and breadth of the country.

Its approach and methodology is focused on informal community-based learning which is different from the formal mode of education. All of the programmes are intended to enliven the imagination, foster creativity, and develop a spirit of inquiry, especially in young minds. School children, during their visit, are discovering the wonders of science and technology and getting an access to the most exciting and contemporary form of entertainment, regardless of the social stratum, education, or age group and creating a culture of learning.

The GSC is being developed in a phased manner and conceptualized on hexagonal grid patterns that house various theme pavilions. The first phase of the Science City consists of the India's First IMAX 3D Theatre, Hall of Space, Hall of Science, Energy Education Park, Children Activity Centre, Musical Fountain, Amphitheatre, LED Screen, Life Science Park, Planet Earth, Simulator, Auditorium etc. amid the beautiful lush green landscape of the campus. It is now a popular destination of interest to one and all. The second phase has already been initiated with more applied and cutting-edge science and technology themes.

To give the students a firm foundation in science, it is necessary to encourage them to think about and interact with

the world around them. Concrete experiences that require the use of children's senses, such as planting and watching a seed germinate, provide a strong framework for abstract thinking later in life.

Science city is on the ideal platform and perfect venue to engage the world's citizens to learn about and address solutions to global challenges we face. Educational programmes, exhibitions, demonstrations and interpretive tools have the potential to help millions of students and visitors understand the social, environmental and economic impact of human behaviour on the planet's future. After the COVID-19 pandemic situation, the Gujarat Science City 2.0 version was inaugurated by Hon'ble Prime Minister on 16 July 2021 virtually with three new attractions, Aquatic Gallery, Robotic Gallery, and Nature Park. After the inauguration, Gujarat Science City has been opened for public with new attraction and engagements.

With new breed of exhibits and frontier areas of Science & Technology and the high-tech-based presentations, the development of Gujarat Science City 2.0 serves as a catalyst and an epicentre of science, technology, engineering, and math (STEM) learning for people of all ages and all walks of life.



## **Aquatic Gallery**

Marine life holds a special importance as Gujarat has the longest coastline in India with a variety of marine biodiversity.

The sea and ocean water nurture a variety of aquatic flora and fauna with creatures of fantastic colours and patterns. The Aquatic Gallery thus holds a special place where one can explore the excitement of the underwater world. It is just like the ocean has come to meet you in the city.

The Aquatic Gallery has the state-of-the-art gallery over an area of 15,000 sq. m. One can discover marine ecosystem and aquatic fauna through tunnel and large oceanarium with creative and immersive experiences. The 360° walkway tunnel takes you into exploration of ancient relics, the hidden treasures of the deepest waters, with sharks merrily swimming into and out of these treasures. It is one of the top aquariums not only in the country but also in Asia.

The gallery has been designed as a unique learning and exploration centre that combines interdisciplinary science, culture and education in order to promote sustainable development and community involvement in the conservation of natural heritage and environment.

The gallery has 72 exhibit tanks, ranging from small to very large in size with wide range of aquatic creatures across the globe. Students and visitors can explore 181 aquatic species that includes Indian, Asian, African, American and other aquatic systems of the world. The gallery will also have touch pools for an engaging learning experience for the kids and elders.

## Robotic Gallery

The Robotic Gallery aka Roboseum has been designed as a base for spreading the science culture by providing opportunities to experience the latest robotics technology such as Artificial Intelligence, Machine Learning, Internet of Things, Virtual and Augmented Reality, Hologram, etc. It is also running an in-depth training course to explore new robots.

The Robotic Gallery is a perfect platform for exploring the future of man-machine interaction with all types of robots. A huge sculpture of a transformer has been placed at the entrance and a pretty humanoid robot Pepper at the reception to receive the visitors.

Visitors can see the Robo history gallery and other galleries displaying Robots built for specific uses. The Sport-o-mania section has robots playing games, while the Natya Mandap has a set of robotic orchestra and dances. The Botulity section demonstrates robotic applications for difficult terrains; in



space, in surgeries, wall climbing operations, defence uses, and so on. And of course, nobody will be able to resist the experience of a robotic chef at Robo Cafe and the pleasure of eating the food served by the robot waiters at the Robotic Gallery.

It has been observed that robots are the perfect co-workers in a pandemic like COVID-19. Let our students get an inspiration to develop medical robots, which never get sick, and can do the dull, dirty and dangerous work that puts our health workers at risk.

Indibots is a dedicated gallery section that has been



designed to showcase robots built by our students through GUJCOST-ROBOFEST competition every year. A workshop space has been provided for hands-on training in building and programming robots for school and college students, to be organised round the year.

At the same time, interacting with robots in Robotics Gallery is not only the centre of attraction, but it will also inspire our youth to work in the field of robotics and will instil curiosity in their mind.

## Nature Park

A large nature park, spreading over an area of 25 acres of land is a new attraction in the Science City 2.0. The Park has been designed with an excellent nature trail consisting of water bodies, fountains, children play area, outdoor exhibitions, and many more.

The Nature Park includes specific corners like the Oxygen Park, Mist Bamboo Tunnel and Cactus Arena, Colour Garden, Butterfly Garden, Maze, Chess-cum-Yoga Garden, Open Gym, and different sculptures and selfie points. In addition to providing nature education, an exposure to the Nature Park has the beneficial effects on health, reducing stress, and promoting healing.

In addition to three new galleries and attractions, the GSC leads to greater appreciation of the science themes and its popularizations by providing an environment where learning about science could be fun. The IMAX 3D Theatre has been serving as the World's largest classroom to teach science in an interesting and exciting manner. It serves as a model classroom for the exploration of new scientific concepts for students and teachers as well as common visitors through exposure to the latest facilities.

The GSC is a project that combines education, recreation



and creativity. It has such recreational activities that promote creativity in children. It has sports, fun games and at the same time it is also a platform to teach children and common citizens something new.

The Hon'ble Prime Minister, during the inauguration programme informed that, 'When I posted pictures of new galleries of Science City on social media, I came across comments that such pictures were seen only in foreign countries. People cannot believe that these pictures are from India, from Gujarat'.

The Hon'ble Prime Minister urged that more and more children and students should come to the Science City, and there should be regular tours by schools. The significance and grandeur of the Science City will increase further if it continues to sparkle with children.

The GSC has an important role to play in facilitating STEM education and lifelong learning, in terms of creative, cultural and intellectual activity beyond any merely vocational aspects. Lifelong learning, creative concept and context, and digital technologies share many of the attributes that emphasise on learning from objects (rather than about objects) and on strategies for discovering information.

Gujarat Science City opens every day from 10.00 am to 8.30 pm, except Monday, as weekly off for the visitors. You can plan your visits thorough online booking on its website: <https://sciencecity.gujarat.gov.in/> or mobile app and have all updates about the programmes and activities there. Science City: A place where science enthusiasts are always welcome!

Dr Narottam Sahoo is the Executive Director of Gujarat Council of Science City, Ahmedabad.

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# COVER STORY II

MADHU PANT

## ROLE OF SCIENTIFIC LITERATURE IN MULTIDIMENSIONAL DEVELOPMENT OF CHILDREN



A child is the unit of the family that provides foundation to it, carries the heritage of the rituals and traditions, communicates the knowledge, provides a window to the society and acts as the conscience of the time. Always curious like a scientist, the child questions and seeks answers to expand their horizon. That tender, innocent mind is always eager to learn something new, they are full of originality, inquisitiveness, emotions, creativity, playfulness, attention, fun-loving, appetent, and active. But quite often their quest remains neglected and unattended. Their emotional needs and expectations remain unquenched. Their mental development is forgotten under the stress of the present time and priorities of the adults!

The children of present time seem helpless and entangled, as if stuck in a web of what, why, how, when, where, that continuously rise in their mind and quite often remain unanswered. They need someone who would answer their queries and meaningful literature is their best option in such situations.

What do we mean by 'meaningful literature'? It is the literature that suits a child's psychology, contains unique content and offers novelty. Unless it presents something innovative, a child would never be attracted to it. Besides being humorous, funny and interesting, the literature must be thought provoking and encourage learning by doing. If it contains imaginary fairy land with mysteries and adventures then it must have the realism associated with the environment. It must include the possibility of analysis-synthesis and argument. Children do not need books that only teach or provide knowledge. It should provide them opportunities to draw conclusions from the facts presented, and then only it would be reckoned meaningful. It should be based on scientific rationale with possibilities of problem solving.

Let us explore some examples to establish my observations.

A story talks about a fictitious germ city. One day there comes a little germ that looked amazingly healthy and all pink and pleasant! All germs in the city want to know the secret of its health. The little germ explained how it lodged itself in the dirty tooth of a child, Nirmal Kumar, and lived happily ever after. Nirmal Kumar never brushes his teeth or eats the right kind of food. He avoids salad, fruits, milk and green vegetables. Instead, he gorges on fried, spicy food and sweets. The little germ told all the germs in the city that if they wanted a nice life, they should live in Nirmal Kumar's teeth! But, they must stay away from Shubhra, who sits beside Nirmal Kumar in the same class. Shubhra brushes her teeth daily, rinses her mouth and eats green vegetables and drinks milk and controls her diet. She always rinses her mouth immediately after eating sweets. If they enter her teeth, they would perish soon, as they would be immediately flushed off. The story ends here, leaving the decision to the readers: what they would like to do? Be like Nirmal or Shubhra?

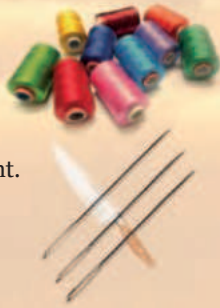
Many a time, in pursuance of presenting scientific composition, we forget using logic and power of analyses and observation, which are effective tools that compel the readers in thinking scientifically. Often, an apparently illogical and meaningless piece leads to original, interesting, humorous and significant scientific content. Let us go through this poem titled "Wedding of a Needle" to explore my points.

The Needle once said to the knife,  
"Please help me find a spouse.  
See how thin and lean I've become,  
I'm so lonely in this big house."  
Scissors and knife set off



## COVER STORY II

For needle to find a husband dear,  
They searched and hoped that  
She'll remain free, no work and no fear.  
The Knife got a fork,  
While the scissors brought a cloth,  
But who would be the spouse?  
Fork or the cloth, they fought and fought.  
"Don't you fight, I got the thread!!"  
The thread also came forward and said,  
"Yes, for you the needle, I am made."



Here is one more reference; the title is "Owl and the Black Goggles." The most humorous context is why would an owl need black goggles? An owl sleeps through the whole day and is awake only at nights. So, why on earth he needs a sunglasses? Forest dwellers were all at a loss. The owl asks the crow to bring the goggles for him. Now there is a commotion in the forest; why the one who sleeps during the day needs goggles? They all went to ask the owl. The owl burst into laughter after listening to them. Then he explained that as the colour black absorbs heat, he wanted to use the goggles to warm up his eyes as some whit got into it. He thought while he sleeps during the day the goggles would get some heat from the sun and would also save it from direct sunlight. And this might also help him in having a sound sleep! Dwellers of the forest were also amazed with his wisdom and they understood how science can be used for their benefit. The narrative is not only funny and entertaining but at the same time conveys a scientific message.

Here I would like to present one more example that compels children to imagine. It is a poem, "The Rainbow-colored Umbrella of the little Fish." A little fish wanted a colourful umbrella. Isn't it odd for someone living in water needing an umbrella to protect itself from water? Children would not only wonder but would be eager to know further out of curiosity. The little fish, who thinks like a child, explains to her mother why she needs an umbrella. To emphasize her point, she lists various advantages of an umbrella; for example, one can hide under it, it can save her from big fish, she can tease her grandmother hiding under it, she can show magic to her friends while twirling it to make it look white and so on. Human beings have polluted the environment with poisonous carbon; so when it rains, she would also use it to stay away from the poisonous water. The reasons she presents are interesting, logical and scientific and also spread awareness against pollution. This is an effective way to spread awareness among children without being preachy.

Children must never be stopped to asking questions. Instead, they should be motivated to enquire more without hesitation or fear. The only way to know is to ask questions!!

I would end my conversation with this poem, "Ask It!"

If nothing gets into the head, ask it, ask it!  
Why in the morning rises the Sun?  
How wheels on the road run?  
Why things fall down?

Without air, why the ball cannot roll?  
Why a few things float or drown?  
Under water, why is the fish happy and full of bliss?  
Ask it, just ask it!  
Why water changes shape?  
Why clouds roar in the sky?  
The rainbow doesn't show up daily, why?  
Why we don't have money on trees?  
How the mangoes ripe soon  
When covered with dry grass and straw?  
Ask it, ask it!

Why water turns into steam?  
Why winters and summers  
Come without a call?  
How to know how far  
Live the sun, moon and the star?  
How happens the eclipse  
When grandma keeps me inside?  
Ask it, just ask it!  
How trees make seeds?  
How do we grow so many things?  
Leaves make their food every day,  
Why nothing they ever say?  
Trees clean the air!  
How they do this with flair?  
Ask it, ask it!  
Why we daily cook?  
But why salad only raw is good?  
Why eating gives us energy?  
and jumping around makes us tired?  
Why the milk boils when we heat it?  
Ask it, ask it!

From where comes all the colours?  
And why white contains them all?  
Why cannot we see colours in dark?  
And why black is always bad in the lurk?  
Why red warns us risk?  
Ask it, ask it!  
Where do we stop counting?  
What are these divisions and multiplying?  
How to measure the infinite?  
Where does the zero sleep at night?  
Who made these tables that give us fright?  
Ask it, just ask it!  
How do the children come on Earth?  
Why tears flow when we weep?  
Why we dream in our sleep?  
Why the spent time never comes back?  
How in the world of questions we shine bright?  
Ask it, you just ask it!



Translated by Kshama Gautam

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# JAGADISH CHANDRA BOSE: HIS LIFE, HIS WORK AND HIS TIMES

**A**charya Jagadish Chandra Bose was the first non-violent freedom fighter. If the Sepoy Mutiny of 1857 was the First War of Independence against the British rule, then the protest of Jagadish Chandra, who was born a year after the mutiny, in Calcutta (now Kolkata), was the first non-violent protest against British misrule, which he won.

Bose's early life and education helped him keep his feet on the ground all through his life. He received his bachelor's degree

from St. Xavier's College, Calcutta. Father Lafont, a Belgian priest and professor at the college, initiated Bose in the study of natural sciences. Physics was earlier called natural philosophy, and Father Lafont instilled in Jagadish a love for natural philosophy which sustained him throughout his life.

Bose married Lady Abala in 1887, who remained his main inspiration throughout his life.

After getting his BSc degree from

Calcutta University, he went to England to study medicine, but his ill health flared up in the cold weather of England and rendered him unable to study medicine. He shifted to Cambridge to study Tripos in the natural sciences, namely, physics, chemistry and botany. He graduated in 1884 and simultaneously also graduated in Bachelor of Arts, from the University College of London.

After getting his degrees in England, he returned to Calcutta and became a

professor at Presidency College. Though Bose was much more qualified than most of his European colleagues, he was appointed in the Provincial Service, and that too on a temporary basis. His salary was one-third that of a professor. Bose refused to accept the salary but continued to teach at Presidency College. After three years, finally the government of Bengal relented and he was appointed as a full professor with both rank and salary. This was one of his first non-violent peaceful protests that he won! He would stand for the rights and ethics through his entire life.

Any student of physics knows about James Clark Maxwell's equations that say electricity and magnetism are forms of the same kind of interaction. As a result of which we now have the unified picture of fundamental interactions in physics. This set of equations is the backbone of the field theories; Maxwell's equations introduced the scalar and vector potentials and the coulomb gauge. Unfortunately, when this was proposed in 1864, the contemporaries and practitioners found the formulation extremely difficult to follow.

Before the theory could be experimentally verified Maxwell died. Many tried to construct mathematical models hoping to get rid of the troublesome abstractness of the formulae. Maxwell, Thompson, Kirchoff, Fitzgerald, Helmholtz and many others worked on it. This was essentially the holy grail of theoretical physics at that time. There was also a few who tried to understand the basis and implications of Maxwell's equations through observation and experiments.

Soon, a German scientist called Hertz showed that by discharging output of a spark gap generator into a dipole antenna one could generate sparks. Since there was no coil connecting these gaps, the spark from the Ruhmkorff coil must have been propagated through the means of waves. This 66-cm-wavelength was called the Hertzian wave. It travelled at the speed of light and could be shown to diffract using a slit and also shown

to be linearly polarised. If all these could be established experimentally then Maxwell's predictions or equations would be vindicated, because his equations showed that electromagnetic waves or Hertzian wave, that would be the outcome of his equations, would have the properties of light waves. Many detectors were fashioned to detect these waves. For example, a mass of iron filings held together in a case could serve as a detector of electrical waves because, according to Maxwell's equation, when electric waves pass, there would be a magnetic field associated with it.

During the initial eight or nine years of Bose's professorship in Presidency College, though he was not engaged in serious research, he must have kept himself involved and informed about the kind of work going on in the field of



Earliest available photograph of Bose Institute (1920)

electromagnetic research through his contacts in Cambridge. In a diary entry on his 36th birthday (30 November 1894) he wrote that his service to the motherland would be through the pursuit of scientific research and knowledge. With his preparation of eight years he felt confident to embark on serious research. And lo and behold, in six months he reported a monumental discovery. In 1894 he had set up a small laboratory in Presidency College. He started working on generating the Hertzian waves of a manageable size; because to reflect and disperse a 66-cm-long wavelength through prisms, one would need lenses and prisms the size of a room. That would make these waves open to all kinds of distortions and none of the conclusions would be tenable. So, the challenge was

to produce a small manageable wave. This is what Bose succeeded in doing. He produced what he called a micro wave then, a wave of five-mm wavelength.

Bose's primary achievement was the discovery of a new detector, other than the iron filings mentioned earlier, that he called Spiral Spring Coherer. Earlier, the iron filings had to be brought back to their random configuration after every experiment because it retained the magnetic field of the experiment. The advantage of Bose's discovery was that this did not die after each detection. It is now called a Multi contact Semiconductor. Using a train timetable (the Bradshaw), that had metals interleaved in between, he prepared a polariser. Through it light was allowed to pass in one direction but not in the other. This was entirely homemade, a hallmark of Bose. He made several extremely sophisticated and sensitive equipments using his own designs, out of materials locally available, and got them made with the help of local artisans. This essentially started the tradition of developing sophisticated yet affordable machines in India which has been the hallmark of Indian science since then.

In 1894-95 at Presidency College, and later at the Town Hall of Calcutta, Bose demonstrated that his waves could travel through air, wood, walls and human body up to a distance of 75 ft. Note that this was done without the aid of any wires. So, essentially this was the first demonstration of transmission of waves without wires. It was two years before Marconi's first demonstration of wireless transmission. Marconi got the Nobel Prize for it and when Bose was asked whether he felt deprived of the honour he said, "it is not important who gets the honour as long as the discovery is made and is used for human society."

In 2007, when Bose Institute was celebrating its foundation day on 30 November, there was an unannounced visitor. He visited the museum of the institute, looked at the archival

museum and in the visitor's book wrote, "having been here and seen the records I am now convinced that Sir J. C. Bose had done the experiment on wireless transmission substantially before that by my grandfather Guglielmo Marconi." He signed his name Francesco Parese Marconi. He is an astronomer of substantial standing, associated with the European Space Agency.

When Bose was demonstrating wireless transmission during his lecture at the Royal Institution, his handwritten notes disappeared from the table. The story goes that the notes had the design for a Horn Antenna that he had designed. These designs are valid even today and are widely used in millimetre wave astronomy. Much later, when the Horn Antenna design surfaced in Marconi's experiments, and he was asked how he got the idea for it, he said that Augusto Righi, his mentor, had suggested it. However, Righi denied it. So, there was a suspicion that somehow Bose's notes were the source of that information.

J.C. Bose was awarded the D.Sc. degree of the University of London in 1896 for his wireless transmission of signals. He was also invited by Cambridge and other laboratories to take his work ahead there. With the strong recommendation of the scientists like Lord Kelvin the British government of India had to permit him leave. But, he had to come back because his leave was denied when he wanted some more time to complete his work. Consequently, he then had to take leave without pay.

Swami Vivekananda, who attended the International Congress of Science and Religion, in Paris, 1900, writes, "From among that white galaxy of geniuses there stepped forth one distinguished youthful hero to proclaim the name of our motherland, Bengal – it was the world famous scientist Dr J C Bose. Alone, the youthful Bengali physicist with galvanic quickness charmed the western audience today with his splendid genius that electric charge infused pulsations of new life into the half dead body

of the motherland. At the top of all physicists today is J.C. Bose an Indian, a Bengali, well done hero!"

Two disciples of Swami Vivekananda had enormous influence on Bose, Sister Nivedita and Sara Chapman Bull. Sister Nivedita had met Bose in Presidency College. She struck an immediate rapport with Bose and his wife, Abala. Sister Nivedita's contribution to India's freedom struggle and education in India are quite



Sir J. C. Bose at Bose Institute with his pupils (a who's who of Indian science) in 1928 Back row from left: N.C. Nag, J.C. Ghosh, J.C. Bose, M.N. Saha, S. Dutta; Front row: N.R. Sen, J.N. Mukherjee, S.N. Bose, D.M. Bose

well known, but her influence on Bose's scientific work as well as his writings and his later life are also enormous and incomparable. Sara Chapman Bull was the wife of the celebrated violinist Ole Bull. She became a huge benefactor of Bose and made enormous contributions to the founding of Bose Institute subsequently. They urged Bose to patent part of his findings and scientific discoveries. So, for the first time, he filed an application for an US patent for a detector for electrical disturbances in 1899 and was finally granted the patent in 1904. Interestingly, despite getting the patent he never bothered to renew it. He later said that patents should not be the goal of a scientist's inventions or discoveries. The fruits of science should be available to the entire mankind. Mrs. Bull had paid a sum of £80 at the time of the application for the patent. When Bose later wrote a cheque for the amount in her favour to return the debt, she gave it back to Lady Abala Bose. This cheque was relegated into the archives of Bose's papers and was never encashed!

From 1894 to 1899, Bose's research was highlighted by the creation of this smallest possible electromagnetic waves and verification of their quasi-optical properties. From 1899 to 1902, the study of the coherers led to the discovery of similarity in response between the living and the non-living. The material used for the detector for electrical disturbances, for which he had applied for the patent, was a substance called Galena, lead sulphate, which is a semiconductor. This was the first instance of use of a semiconductor for scientific purposes. The legendary Nobel Laureate Sir Neville Mott mentioned in the 1970s that Bose's discoveries in electromagnetism were 50 to 60 years ahead of the times, and he had probably anticipated the existence of P types and N types of semiconductors. From 1902 to 1933, during the major part of his scientific life, Bose moved to the study of response phenomena in plants, the complexity of whose response lie intermediate between those of inorganic matter and of organic lives.

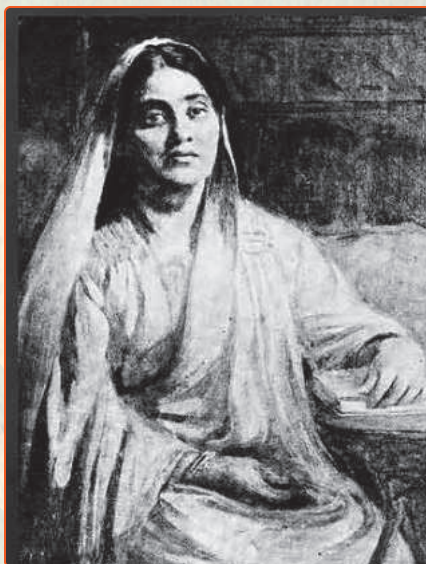
During this period, Bose devoted most of his time and energy in studying the biophysical aspects of the living, namely, the plant systems. His views ran contrary to the beliefs of that time, even those which were prevalent who were prevalent until very recently. He was called a charlatan by the western scientists and was denounced as an eastern yogi who was not given to proper scientific rigour. Papers that he had written were withdrawn even after scrutiny and the journal of the Royal Society refused to publish him. Bose did not fret or despair. He resolved to meet the objections and arguments through scientific proof.

He designed and developed a large number of extremely sensitive equipments through which many of the biological processes could be quantitatively measured to a degree beyond imagination at that time. So, Bose is the father of modern quantitative biological study using physical means.

They were all designed and developed by him. His friendship with Rabindranath Tagore, the first Asian Nobel Laureate and India's greatest poet and humanist, is legendary. When the government of India denied him leave with pay to stay on in England to finish his work, Tagore used his contacts to garner support for Bose to continue his stay in England and finish his work.

Sister Nivedita's contribution in Bose's work is evident also in the architecture of Bose Institute. Bose wrote to Mrs Wilson, "the Bose institute will also be beautiful architecturally. As you enter there is a large stone lotus on the left that is the basin in which water lilies will grow. Just overlooking that will be a bas-relief of a woman with prayer beads and a lamp in her hands. This institute is the embodiment of her prayer. Sister Nivedita." Her sketch of the Ajanta caves was used to design the main door of the Bose institute. Most relevant was her sketch of Vajra, which was also used in the emblem of Bose Institute. In a letter to Mr Herbert, a month before he died, Bose had eulogised Sister Nivedita saying, "she was also greatly interested in the revival of all intellectual advances made by India and it was her strong belief in the advance of modern science accomplished by Indian men of science that led me to found my research institute."

Legacy literally means inheritance, heritage, tradition or something that is received from a predecessor. It also includes achievements, contributions, personality, character, spirit, disposition and message. The legacy and lessons that J. C. Bose left for us are enormous. He was a scientist of rare talent. In fact, Einstein had once said, "if monuments have to be erected for scientific discoveries, then J.C. Bose should have at least six monuments erected in his memory." Bose's personality, his philosophy, his belief in the universality of science, in the role of science for the good of mankind, and his literary imaginations, are to be cherished



Lady Abala Bose

by all. His inaugural address on the foundation day of Bose Institute on 30 November 1917 is available as a document called 'The Voice of Life'. This is a 'must-read' for every literate Indian. He was a nationalist seer and a humane person. His legacy is domination over adversity.



Sister Nivedita and Sir J.C. Bose

As he said in his speech to the students of Presidency College, "but it came to me as a flash that it was not for the man to quarrel with circumstances but bravely to accept, to confront, dominate over them. And we belong to a race which had accomplished great things with simple means." In his convocation address at the Patna University he said, "nothing is impossible if we put our whole mind

to it and pursue it with unwavering determination. Distrust acts as a blight, it is by optimism that we radiate hope and strength. Pessimism and cynicism are not only vulgar but they are signs of decadence."

In 1911, Bose gave a speech in Mymensingh (now in Bangladesh) on the difficulties of research in India and how it served as his motivation and was at the core of his determination to found Bose Institute. He said, "it is true that here we suffer from many difficulties. But how does it help us to envy the good fortune of others? Rise from your depression. Cast off your weaknesses. Let us think. We often forget that the real laboratory is one's own mind. The room and the instruments only externalise that. Every experiment has first to be carried out in the inner region. To keep the mental vision clear great struggles have to be undergone.

In his inaugural address at Benaras Hindu University (BHU), he said, "my first work in the region of invisible lights made me fully realise how in the midst of a luminous ocean we stood almost blind. But out of his senses, man has dared in science to build for himself a raft of thought by which to make daring adventures into the great seas of the unknown. But there are other truths which will remain beyond even the super sensitive methods known to science. For these we require faith tested not in a few years but by an entire life."

On Bose's 150th birth anniversary in 2008 there was an international symposium held at Christ College, Cambridge, his alma mater, and a consensus emerged that Bose's work in the area of plant intelligence, plant consciousness and electro physiology and in general, experimental bio physics was a century ahead of its time.

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# Science Heroes of India's Independence Movement (part-2)

In the earlier article (October '21 issue of Dream 2047) we have read about several Indian scientists who faced discriminations by British authorities during the pre-independence era. The rules for selection, appointment and promotion and pay were not same for the Indian and British scientists. But, in spite of such discrimination and discouragement, our scientists continued their work with an indomitable spirit. Azadi ka Amrit Mahotsav gives us an opportunity to share the saga of struggles of those scientists.

## Kishori Mohan Bandhopadhyay (1877-1929)

Kishori Mohan Bandhopadhyay, another unsung hero of Indian science,



Kishori Mohan Bandhopadhyay

was associated with the British doctor Ronald Ross who received the Nobel Prize in 1902 for the discovery of malaria parasite. Kishori Mohan had contributed a lot throughout the Nobel winning research of Ross. But Ross didn't acknowledge the contribution of his colleague Kishori Mohan. Neither in his Nobel lecture nor in his paper he mentioned Kishori Mohan.

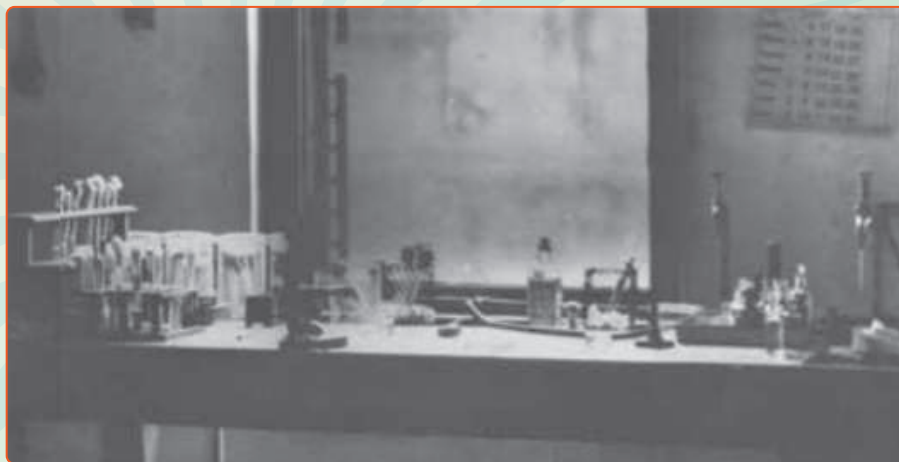
Kishori Mohan graduated in science from the Presidency College, Calcutta and became a science teacher in an

the Indians. When Kishori Mohan faced discrimination by Ronald Ross, Indian scientists like Upendranath Brahmachari, Jagadish Chandra Bose, Brajendra Nath Seal, Sivanath Sastri, Surendranath Banerjee and Prafulla Chandra Ray requested Lord Curzon to recognise the contribution of Kishori Mohan. Curzon, convinced with this appeal, awarded the King Edward VII's Gold Medal in 1903 to Kishori Mohan during Delhi Durbar by the Duke of Connaught.

Later, Kishori Mohan became an active social worker and started social campaigns in the villages of Bengal for eradication of malaria. He used to organize slide shows to make village folk aware about malaria.

## Bidhan Chandra Roy (1882-1962)

Bidhan Chandra Roy was a physician, educationist and freedom fighter. He did B.A. from Patna College with Honours



The research establishment of Kishori Mohan in the laboratory of Ronald Ross

English medium school. In 1898, he came to know that Ronald Ross was looking for a capable scientific assistant. He met him and Ross was impressed with his scientific knowledge. Kishori Mohan joined the research team of Ross at the Calcutta Presidency General Hospital as a laboratory assistant. His grandfather was a renowned practitioner of Ayurveda who had inculcated a curiosity and love for naturopathy in his grandson.

During the colonial time, Europeans rarely acknowledged contributions of

in Mathematics and then studied medicine at Calcutta Medical College. The partition of Bengal was announced when Bidhan Chandra was studying in Medical College. Nationalist leaders like Lala Lajpat Rai, Bal Gangadhar Tilak and Bipin Chandra Pal were opposing this partition. Though he was keen on joining the movement, he decided to finish his studies so that he can serve his nation better.

For his postgraduate study in medicine, Bidhan Chandra went to



Bidhan Chandra Roy

London in 1909. The Dean of St. Bartholomew's Hospital was reluctant to accept an Indian student and rejected his application. But Bidhan Chandra did not accept this rejection and kept on submitting his application. After 30 requests for admission, the Dean of the Hospital admitted him to the college. He completed his post-graduation course in just two years and three months. In May 1911, he accomplished the rare feat of becoming a member of the Royal College of Physicians and a fellow of the Royal College of Surgeons simultaneously.

He returned to India in 1911 with the motto to serve his countrymen. He believed that 'Swaraj' (self-governance or self-rule) could be achieved only when the people were healthy and strong in mind and body. He made contributions to establish medical education institutions like the Chittaranjan Seva Sadan, Jadavpur T.B. Hospital, Kamala Nehru Hospital, R.G. Kar Medical College, Chittaranjan Cancer Hospital and Victoria Institution. The Chittaranjan Seva Sadan for women and children

was opened in 1926. He believed that the youth of India must not take part in strikes and fasts but should study and commit themselves to build the nation.

Bidhan Chandra was Gandhiji's friend and physician. When Gandhiji was on a fast in Parnakutivin (Poona) in 1933, Dr Roy was beside him for his treatment. In pre-independence India, medicines were imported from western countries. On this ground Gandhiji refused to take medicine and asked Bidhan Chandra,

**Later, Kishori Mohan became an active social worker and started social campaigns in the villages of Bengal for eradication of malaria. He used to organize slide shows to make village folk aware about malaria.**

“Why should I take your treatment? Do you treat 400 million of my countrymen free?” Dr Roy replied, “No Gandhiji, I could not treat all patients free. But I came here not to treat Mohandas Karamchand Gandhi, but to treat “a person” who represents the 400 million people of my country.” These words convinced Gandhiji to take the medicine.

In addition to his medical profession, Dr Roy was active in the freedom struggle. He was elected to the All India Congress Committee (AICC) in 1928. He conducted the Civil Disobedience in Bengal in 1929. After this, Motilal Nehru nominated him as the Member of the Working Committee (CWC) in 1930. The CWC was declared an unlawful assembly by the British authority and Dr Roy along with other members of CWC were arrested on 26 August 1930 and detained at Alipore Central Jail.

During the Dandi March (1930), many members of the Calcutta Corporation were imprisoned. National leaders requested Dr Roy to remain out of the prison and discharge the duties of the Corporation. He served as the Alderman of the Corporation during 1930-31 and as the Mayor of Calcutta during 1931-33. In his leadership, the Corporation made records in the expansion of free education, free medical aid, better roads, improved lighting, and water supply. He played crucial role for setting up a framework for dispensing grant-in-aid to hospitals and charitable dispensaries. He served as the Chief Minister of West Bengal from 1948 until his demise in 1962. In our country, the National Doctors' Day is celebrated in his memory every year on 1 July, which is his birthday and also the day of his demise. He was awarded the highest civilian award of India Bharat Ratna on 4 February 1961.

*(To be continued...)*

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**P**rof. Thanu Padmanabhan, the renowned theoretical physicist and cosmologist and prolific writer and science communicator breathed his last on 17 September 2021 after a sudden heart attack.

Padmanabhan, fondly called Paddy, was born on 10 March 1957 in Trivandrum (now Thiruvananthapuram). His father, an employee of the forest department of the Government of Kerala, had great passion for mathematics. Since his childhood, Padmanabhan was inspired by his father and was keen on studying mathematics, especially geometry.

After earning his B.Sc. (1977) and M.Sc. (1979) degrees in Physics from the University College with gold medals, he joined the Tata Institute of Fundamental Research (TIFR), Mumbai in 1979 to pursue Ph.D. His first research paper on General Relativity was published while he was still a B.Sc. student.

His thesis work was on Quantum Cosmology, which was supervised by the renowned scientist, Dr Jayant Vishnu Narlikar. He got the degree in 1983. He served there until 1992 in different capacities before moving to the Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune, as a Professor. Later he became the Dean of Academic Programmes (1997-2015). During 1986-87, he was at the University of Cambridge for post-doctoral work. Padmanabhan had also served as adjunct faculty of TIFR, the Harish Chandra Research Institute, Allahabad, the Raman Research Institute (RRI), Bangalore and the Indian Institute of Science Education and Research (IISER), Pune.

He was the Chairman of the Time Allocation Committee of the Giant Metrewave Radio Telescope of the National Council of Radio Astronomy (NCRA) from 2006 to 2009 and the Chairman of the Indian National Science Academy (INSA)'s National Committee



Padmanabhan with his wife Vasanti

## Prof. Thanu Padmanabhan: A Scientist with a Painter's Urge

from 2008 to 2011. He was also elected as the President of the Cosmology Commission (2009-2012) of the International Astronomical Union (IAU) and the Chairman of the Astrophysics Commission (2011-2014) of the International Union of Pure and Applied Physics. As a visiting faculty he taught in many institutions of repute including the California Institute of Technology, the Princeton University and the Institute of Astronomy, Cambridge. He was an elected fellow of the Third World Academy of Sciences (TWAS) and of all the three National Academies of Science in India (The Indian National Science Academy, the Indian Academy of Sciences and the National Academy of Sciences, India).

Padmanabhan took keen interest in popularising science. He had authored more than 300 popular science articles and about 15 books in English, many of which have been translated into other languages. His comic strip "The Story of Physics" aiming at school children was published by Vigyan Prasar. He had co-authored with his wife, also a scientist, Vasanti Padmanabhan, the book, "The Dawn of Science". To commemorate the International Year of Astronomy (IYA)-2009 he, along with Dr J.V. Narlikar and Samir Dhurde, published the IYA Astronomical Dairy-2009. Popular science magazines like Science Today, Science Age and Resonance published his articles regularly.

Vasanti and Padmanabhan have a daughter, who has also worked as their research co-worker.

Padmanabhan made original and significant contributions to the field of research in gravitation and cosmology, which included quantum gravity and dark energy. His work during 2002-15 provided a clear interpretation of gravity as an emergent phenomenon (like elasticity or fluid dynamics) and showed that this paradigm could be extended to a wide class of theories of gravitation including general relativity. He also showed that certain aspects of classical gravitational theories could

be given natural interpretations in this approach, which also provided a new solution to the cosmological constant problem.

During the 1980s Padmanabhan interpreted the Plank's length as the "Zero point length" of space-time based on very general considerations as

well as several candidate models for quantum gravity. He developed the complex path method (1998) to study black hole thermodynamics, a precursor to the "Tunnelling Paradigm", now associated with a method for calculating the temperature of black holes.

Besides, he was also an authority in statistical mechanics of gravitating system and a pioneer in the subject of those concepts to study the gravitational clustering in the expanding universe. The popular descriptions of Padmanabhan's research in these fields were published in the Scientific American (India) and the technical ones were available in an article in the Journal of the Gravity Research Foundation (2008).

In 2016, he published studies advocating a new paradigm shift in understanding gravity. A key question in quantum gravity lies in understanding the primordial, pre-geometric phase of the universe, from which classical and geometric phases described by the Einstein's equations emerge along with the notion of space and time themselves. He introduced the concepts of cosmic information (or CosmIn) which allows to connect these phase. CosmIn is a conserved quantity that measures the total information transferred from quantum gravitational phase to the classical phase of the universe.

For his outstanding contributions to astrophysics Padmanabhan earned a number of awards and was honoured by many reputed institutions of national and international importance. Among these the notable ones were the Shanti Swarup Bhatnagar Award in 1996 and the Padmashree in 2007.

Padmanabhan had a great passion for knowledge. According to him the study of theoretical physics is fun. In his book "Sleeping Beauties in Theoretical Physics" he compared a theoretical physicist with a painter, who goes on painting purely for pleasure. Both of them pursue their activities for no other consideration but under the dictates of their inner urges, which are similar.

Dr Ramesh Chandra Parida is retired professor, Odisha University of Agriculture & Technology and Himansu Sekhar Fatesingh is freelance science writer and teacher.

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