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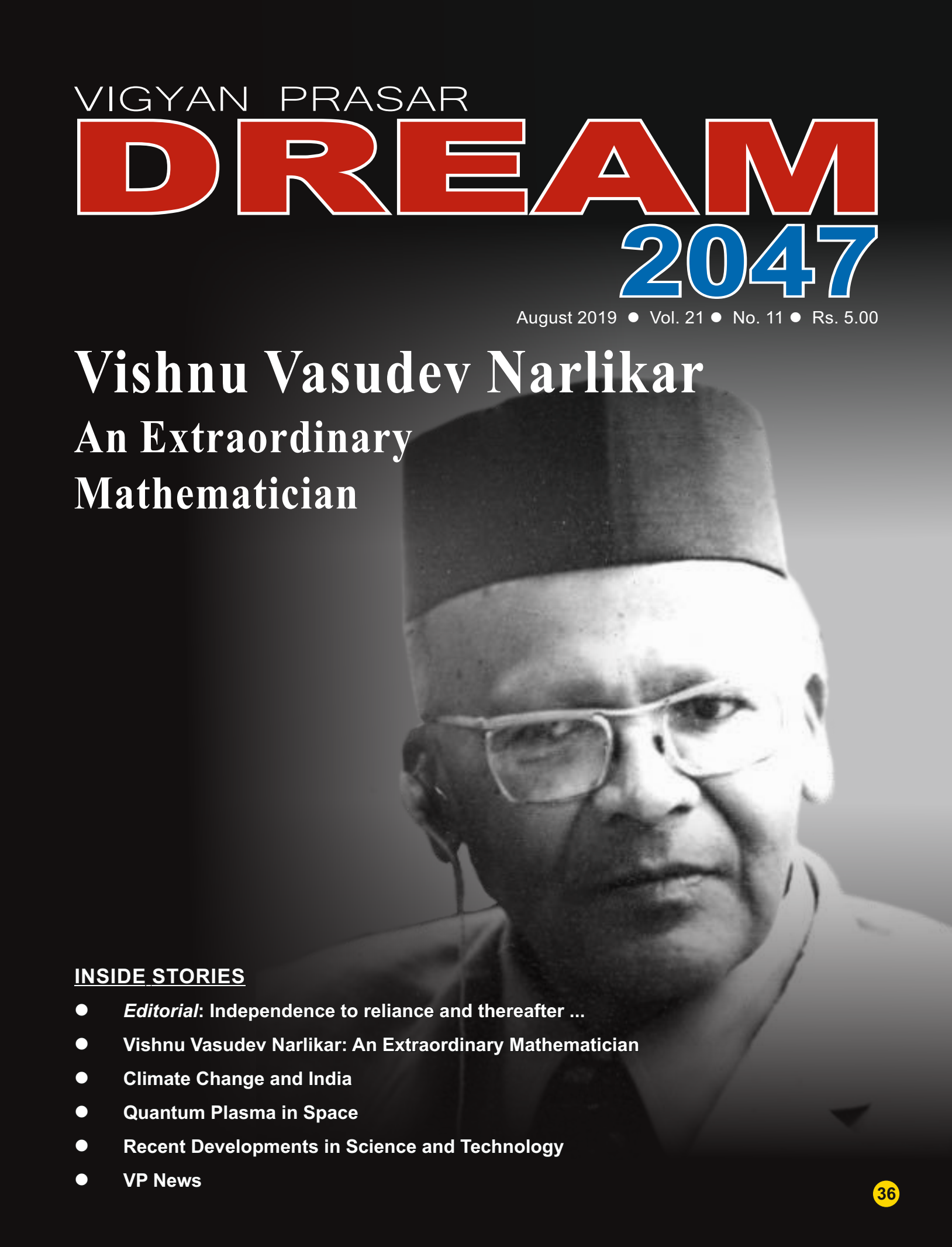
# Vishnu Vasudev Narlikar
## An Extraordinary Mathematician



**INSIDE STORIES**

EDITORIAL

# Independence to reliance and thereafter ...

*Nakul Parashar*

Thinking of August every year, one date that crops up in the mind of every Indian is the 15th of August. The day when India embarked on a journey to redeem her pledge made during the tryst with destiny many many years ago. It is this day when India woke up to freedom and thus breaking the 200-year-old shackles of dependence. In 1947, this moment was as much an occasion of rejoicing as it was a challenge. India thus needed to the required guidance to reach the goal of self-reliance through the shortest possible route.

This, obviously, could not have been possible without science and technology. New-age temples of modern India were conceived and constructed. This is where rationality worshipped the ideals of the greater public good through the instruments of modern science. Establishing the Council of Scientific and Industrial Research (CSIR) was a milestone in this direction. Consequently, 38 different laboratories came up in the country. The task of building various components of infrastructure related to science and technology at different levels was expedited. A special emphasis was laid on making science and technology as an important part of our education. The result was the emergence of some of the globally-acclaimed institutes in this field. This journey of augmenting country's prowess in science and technology still continues. Both the Indian government as well as the private sector have made theircontribution to making the realization of self-reliance easier. Yet, much still remains to be accomplished. The ever-evolving world of science and technology keeps throwing fresh challenges with time. It's notable that the process has accelerated in recent decades. In this regard, many expertsbelieve that the advent of artificial intelligence has the potential to radically transform the world of science and technology.

I distinctly remember once when I was thrown upon a challenge of getting headnotes written for around 8 lakh cases emanating from various courts of the Indian judiciary. I started looking for duly qualified advocates and law graduates to assist me in meeting this humongous task. The assignment was big, but finding people with the right skill-set was far more challenging. Since all these cases belonged to different courts at different levels, they had no resemblance to one another. Therefore, it was difficult to apply pattern recognition. This is when computer science, statistics, and related data scientists came to my rescue.

We sat together with a team of legal experts, who could write headnotes correctly as domain experts, and the necessary team of data scientists. The task at hand was to write new algorithms that could help us extract various elements of a headnote, most of which were quite subjective in nature. Even after penning down over 66,000 statistical rules, small and big, artificial intelligence could bring us only limited success. We could match some components of these headnotes without any intervention of the human mind. However, the real goal was still far away. We kept on augmenting the numbers of algorithms. On the other hand, the number of cases was still increasing. Employing the traditional hand-operated way that hindered the numbers to be produced, compromising with fluctuating quality due to manual intervention and increasing costs enhanced the risk of losing out on the project itself. Artificial intelligence, finally, saved the day in the end.

The point is to draw attention towards the immense potential of this upcoming domain, that's finding a place for itself in every part of life. The list of benefits and applications of artificial intelligence is growing rapidly... This has thus, led to the emergence of a new field of opportunity -- data science.

Computer science and statistics are one of the greatest gifts of science & technology that independent India has given to the world community. It is not only propelling the growth of artificial intelligence but also helping the country reach new heights of self-reliance. We are making continuous efforts with relentless commitment towards greater self-sustenance and reliance.

Back at Vigyan Prasar, after Bangla, Urdu, Malayalam, and Tamil, we are now headed towards the launch of our Marathi and Gujarati editions. Our aim is to take science to the masses in their own languages. From Newsletters and writing original books to VIPNET clubs in schools; the list of our activities is getting longer rapidly.

Wishing you Happy Independence Day.

Jai Hind!

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**(Translated by Shri Deepak Sharma)** ■

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# Vishnu Vasudev Narlikar : An Extraordinary Mathematician

*Utpal Mukhopadhyay*

*Vishnu VasudevNarlikar was one of the two pioneers in research on general theory of relativity in India. He made important contributions in various fields of mathematical physics like, extension of Bode's law, Milne's kinematical relativity, gravitational space-time matrix , equations of Unified Field Theory of Einstein and Schrödinger and many more. He was a very successful teacher and his students had a great respect for him. To him teaching and research work were complementary to each other.*

*Vishnu Vasudev Narlikar*

Most of us are familiar with the name of famous cosmologist Professor Jayant Vishnu Narlikar (born 1938). In scientific community he is well known as JVN. However, it is a little-known fact that his father Vishnu Vasudev Narlikar (VVN) was a prolific mathematician.

Vishnu Vasudev was born in Kolhapur on 26 September 1908 in British India. At present Kolhapur is a city in Maharashtra, but at that time it was a native Indian state. Vishnu Vasudeb was the youngest son of Vasudev Shastri, a Sanskrit scholar. Academic life of VVN started in Vidyapith School of Kolhapur. Despitethe untimely death of his father, Vishnu Vasudev continued his studies and stood fourth in Matriculation examination. Securing a scholarship, he studied in Elphinstone Collegeand Royal Institute of Science in Bombay (now Mumbai) with Honours in Mathematics. In 1928, he obtained first class first with 96% marks in B.Sc. final examination. After doing B.Sc., Vishnu Vasudev went to Cambridge for higher studies by virtue of J.N. Tata Endowment Scholarship. He received some financial assistance from Kolhapur State also on the condition that after completing his studies, he would have to serve in that state. In Cambridge, he became Star Wrangler in Mathematical Tripos Examination in the year 1930.

Vishnu Vasudev started his research career by investigating the famous work of Russian mathematician and physicist Alexander Lyapunov (1857-1918) on rotating fluids. In October 1930, he was awarded the prestigious Issac Newton Fellowship and Rayleigh Prize for writing an important paper on the method of Lyapunov and its critical analysis. Then he started research work under the supervision of famous British Astrophysicist Arthur Stanley Eddington (1882-1944). In 1931, V.V. Narlikar became Fellow of Royal Society (FRS) at an age of twenty-three. In 1932, he came to India for a brief period. Shortly before that Pandit Madan

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*Madan Mohan Malaviya*

Mohan Malaviya (1861-1946) founded Benaras Hindu University (BHU). Pandit Malaviya invited Vishnu Vasudev to join in the Mathematics Department of BHU and advised him to attract young scholars of India towards mathematical science by pursuing research work himself staying in his motherland. Pandit Malaviya sent a letter in this regard to Eddington who advised Vishnu Vasudev to join BHU. At that time Vishnu Vasudev was scheduled to spend a year at California Institute of Technology and Mount Wilson Observatory for research work. But keeping aside that attraction and without completing his research under the guidance of Eddington, he joined BHU as a Professor and Head of the Department of Mathematics. Pandit Malaviya himself repaid the debt of Narlikar to Kolhapur state. In 1932, Vishnu Vasudev married Sridevi Navare. But after her demise within a few years, Narlikar married SumatiHuzurbazar who was sister of famous statistician Vijay Shankar Huzurbazar (1919-1991).

Vishnu Vasudevand Sumatihave two sons–cosmologist Jayant Vishnu (born 1938) and physicist Anath Vishnu (born 1940). During 1932-1960 Vishnu Vasudeb was Professor of mathematics in BHU. Within this period, he obtained M.A. degree in mathematics, relativity and cosmology from Cambridge University in the year 1946. From 1960 to 1966 he acted as Chairman of Public Service Commission of Rajasthan. Again in 1966, he joined Pune University as Lokmanya Tilak Professor and retired from there in 1973. In BHU, apart from general relativity and Riemannian geometry, Professor Narlikar taught a variety of topics, viz., modern algebra, wave mechanics, spinor and their applications, Hilbert space, quantum mechanics, stellar structure, etc.

Professor Vishnu Vasudeb Narlikar was a very successful teacher and his students had a great respect for him. To him teaching and research work were complementary to each other. For this reason, his reputed student Prahlad Chunilal Vaidya (1918-2010) called him teacher-mathematician. According to Narlikar- "The first lesson that I learnt was: one cannot be a good teacher, a successful teacher without being always absorbed in the research topics concerned with lectures". After retirement, Professor Narlikar spent last eighteen years of his life with his elder son Jayant Vishnu Narlikar. The legendary mathematician Vishnu Vasudev left this world due to old age problems on 1 April 1991.

## Scientific Contributions

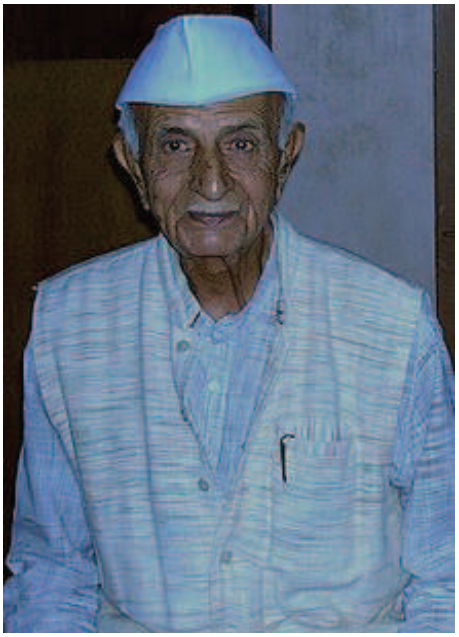
Vishnu Vasudev Narlikar was one of the two pioneers in research on general theory of relativity in India, the other person being renowned applied mathematician Nikhil Ranjan Sen (1894-1963). The main equation of general relativity of Einstein hinted at a dynamic universe. For this reason, Einstein, a believer in static universe, included a new term denoted by Greek letter Lambda ($\Lambda$) in his equation of general relativityto give the universe a static nature. At the beginning of his research under Eddington, Vishnu Vasudev solved Einstein's equation of general relativity ignoring the Lambda term and obtained a picture of a dynamic universe. When he showed his results to Eddington, he was very much pleased and advised Narlikar to prepare a research paper on it and send it to the prestigious journal Monthly Notices of the Royal Society. But right at that time Eddington received by post a paper of Georges Lemaitre (1894-1966) published in 1927 in which the same equation was solved without Lambda termand the same picture of dynamic universe was obtained. That paper of Lemaitre was published in a little-known Belgian journal and hence it remained completely unknown to Eddington. Expressing his sadness, Eddington told Narlikar that his paper could not be published. But historically, about five years before Lemaitre's paper was published, Russian mathematician Alexander Friedmann (1888-1925) did the same work in his two papers published in a mediocre journal of Russia in 1922 and 1924 and hence it remained largely unknown to scientific community. When in 1929, Edwin Hubble (1889-1953), by virtue of his observational work, announced that the universe is not static but is expanding, then only the theoretical works of Friedmann and Lemaitre received due recognition. Thus, it was unfortunate that Narlikar's effort had gone in vain. Similarly, an important work on curvature invariant, done in 1949 by Professor Narlikar and his research scholar K.R. Karmakar remained almost unknown due to its publication in Proceedings of Indian Academy of Sciences, a not-so-reputed journal, although later it came to be known as Narlikar-Karmakar invariant.

Vishnu Vasudev Narlikar has made important contributions in various fields of mathematical physics,viz., extension of Bode's law, Milne's kinematical relativity, gravitational space-time matrix and their fourteen invariants, equation of motion of Einstein-Infeld-Tolman, equations of Unified Field Theory of Einstein and Schrödinger, etc. In forty years of his research career, spanning from 1931 to 1971, Narlikar had 39 publications. More than half of them were related to theory of relativity. Of those 39 papers, 11 were published in Nature, 9 in Philosophical Magazine and one in Proceedings of Royal

*A. S. Eddington*

Society A. That means more than half of the research papers of Professor Narlikar were published in world-famous journals. This denotes the high quality of the papers written by him.

During his tenure in BHU, Narlikar created an active school of research in relativity. Under his guidance nearly twenty scholars obtained their Doctorates by working on the solution of equations of general relativity, solution of equations of Unified Field Theory, scalar invariant of Riemannian metric, etc. Not only that, some of those scholars created their own groups of research scholars. The greatest achievement of research work under the leadership of Professor Narlikar is 'Vaidya Metric'. Prahlad Chunilal Vaidya (whose name has been mentioned already), after obtaining post graduate degree from Bombay University, joined BHU as a research scholar in 1942 for working under the supervision of Vishnu Vasudev Narlikar. In should be mentioned here that German mathematician and astrophysicist Karl Schwarzschild (1873-1916) was the first to solve Einstein's equation of general relativity for a spherically symmetric (for instance, a star), non-rotating, uncharged body (one may consult the article 'Karl Schwarzschild and His Last Gift' in Dream 2047, November 2017). The metric, i.e., the distance formula he used for that purpose is known as Schwarzschild metric. For his solution, Schwarzschild assumed that the neighbouringregion of the spherically symmetric body is empty. But in reality, radiations coming from a stellar body must be present in the adjoining area of it. For this reason, Professor Narlikar advised Vaidya to solve Einstein's general relativity equation considering the presence of radiation fieldaround a spherically symmetric body. This means that the task of extending Schwarzschild's work was given to Vaidya. While working on the problem, Vaidyarealised that Schwarzschild metric was not suitable for that purpose. So, selecting an appropriate metric, he solved Einstein equation for a radiating sphere by adopting a special mathematical technique. The metric devised by Vaidya subsequently became famous as Vaidya metric. Nearly twenty-five years after the inception of Vaidya metric, the physical significance of it was realised for research on quasars, active galactic nucleus, gamma ray bursts, etc. That important paper of was published with Vaidya as its sole



*P. C. Vaidya*

author. In this connection Professor Vaidya has written – "A research paper was presented on the solution. He put down my name as the soleauthor. Though he had suggested the problem and guided me throughout, he gave full credit to me because the idea which provided the breakthrough had been mine. The paper became famous. What came to be known as Vaidya metric could have been called the Narlikar metric if he so desired. But Professor Narlikar preferred purer academic norms to those prevailing". This comment of Vaidya highlights the greatness of Professor Narlikar.

Vishnu Vasudev Narlikar was associated with many scholastic institutions. He was Fellow of Royal Astronomical Society and National Academy of Sciences of India. He was the President of Mathematics Section of Indian Science Congress in 1953. During 1958-1960 he was a member of Calcutta Mathematical Society. In 1970 and 1981 he acted as President of Indian Association of General relativity and Gravitation (IAGRG) and The Indian Mathematical Society respectively.

In 1991, after demise of Professor Narlikar, IAGRG introduced a prize awarded once in every four years to the best thesis on general relativity and its related areas done during that period. Afterwards, in accordance with the suggestion of Professor Vaidya, it was named as 'V. V. Narlikar Best Thesis Award'. Ranjan Sharma of North Bengal University in West Bengal was the first recipient of this award for the period 2000-2004. The title of his thesis was A Model for a Class of Compact Stars. For paying tribute to Prof. Narlikar, Centre for Theoretical Physics of Jamia Milia University organises 'V. V. Narlikar Memorial Lecture'. In 2009, the first Memorial Lecture was delivered by Professor Naresh Dadhich of Inter University Centre for Astronomy and Astrophysics, Pune. The title of his lecture was Why Do We Live in Four Dimensions? Finally, it must be mentioned that in the history of relativistic research in India, the name of Vishnu Vasudev Narlikar will be written with golden letters forever.

# Climate Change and India

*Shephali Sachan*

*The combined efforts at the local level and by every individual are essential to combat effects of climate change. To achieve the goal, firstly, there should be the awareness to be created among every section of the society. Secondly, there is need to follow a few simple steps like cleanliness of nearby surroundings, proper management of daily garbage, reduce water wastage, reduce the use of plastics, judicious use of electricity, reuse of garbage, reduce the emission of harmful gases and discharge of chemicals from industry and last but not the least, plant more and more trees.*

"Climate change is now affecting every country on every continent. It is disrupting national economies and affecting lives, costing people, communities and countries dearly today and even more tomorrow. People are experiencing the significant impacts of climate change, which include changing weather patterns, rising sea level, and more extreme weather events. The poorest and most vulnerable people are being affected the most." – Goal 13, UN Sustainable Development Goals

The word "climate change" has become a very loud and vibrant word in present times. The reason behind this is its extremely dangerous impact on every corner of the globe, which is continuously increasing somewhere gradually and somewhere rapidly. First of all, what does climate change mean? Why is the impact of climate changeso dangerous and why is it increasing; how to protect ourselves from this situation?


*Picture showing decline of arctic sea-ice due to rise in temperature, 1984-2012*

## What is 'climate change'?

According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to the long-term changes (typically decades or longer) in the average state of the climate with statistically significant variations. The IPCC is anUN panel which deals with the science related to climate change.

## Why is climate change happening?

The Earth's climate has always been changing. This is how we and our surroundings have evolved. But in the last hundred years or so, the Earth's climate has drastically changed and become warmer than before. Also, besides the increasing temperature, there are increased levels of atmospheric carbon dioxide, changes in the precipitation (rainfall and snow) and in some extreme climatic events.

The phenomenon of climate change has been the result of natural processes as well as human-created process. However, the rapidly increasing population and the in discriminate use of land and water resources by human beings have become the main cause of worsening the situation. Deforestation, shifting cultivation (cultivating a piece of agricultural land temporarily and then abandoning it to allow it to revert to its natural vegetation), wasting and polluting water, decreasing agricultural land, increasing mining and industrial activities and spreading of urban areas are some of the examples of human/man-made activities.

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## Why is climate change a threat?

The changing climatic conditions are affecting every corner of the Earth. Itsmain impacts aregivenbelow:

1. There is a rise in the average temperature of Earth by 1°C as compare to pre-industrial times and may reach 1.5°C between 2030 and 2052 if the warming continuesat the current rate.
2. The polar ice is melting and leading to rising sea levels, risking flood-like situation in many coastal areas, small islands and nearby cities.
3. The rainfall patterns have changed as a result of which somewhere there is drought and somewhere there is a flood-like situation.
4. The quality and quantity of the major food and resource sectors like agriculture, forestry and fisheries have declined and continue to deplete at a faster rate.
5. Several plant and animal species have become extinct and many are approaching to become extinct.
6. Due to rising temperatures, growing seasons are becoming longer and there is anorthward shift in the range of insect species.
7. The less-developed countries are facing more difficulties due to climate change.

## Climate change in India

India is a large developing country with a population of 1.35 billion (2019). Climate change is affecting the major climate-sensitive sectors such as agriculture, fisheries and forests on which nearly two-thirds of the population depend directly. More than 50 million people in India would be directly affected by sea-level rise and associated coastal flooding. Two-thirds of the agricultural land of the country is affected by drought and about one-fifth is very frequently exposed to floods. The impacts also include intensified heatwaves, salinisation of soil, increasing barren and degraded lands, habitat degradation and reduction of crop yields and forest productivity.

Decreasing food and resource availability also creates health problems in animals and human beings. Some of the major effects and events are given below:

1. Kolkata and Mumbai are the 'potential major hotspots' for the direct and greater impact of sea-level rise and flooding.
2. Rapid deforestation in the Himalayas has changed its ecology, posing a potential threat to the greenery of the Indo-Gangetic belt, causing sporadic floods in some and droughts in other areas.
3. About 32.55% of the land of the country is affected by drought-stress spread over Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.
4. The districts located in Gangetic Plains, the Brahmaputra Valley, Eastern Coastal plain and in western Rajasthan (Indira Gandhi canal command area) are under the strong pressure of water logging.
5. 142 districts distributed in Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu are affected by soil salinity (accumulation of salt in soil).
6. There are visible vegetation-shift patterns in the Northeast, Himachal Pradesh and the Western Ghats along with declining biodiversity.
7. Several animals including the yak, house sparrow, Indian bustard, Red panda, Nilgiritahr, etc., and plants including the Red sandalwood, Musli, Malabar mahogany, Ebony, etc., are endangered (approaching to become extinct)
8. Rice, wheat, maize and sorghum are the most climate-change-sensitive crops.
9. The 2013 Uttarakhand floods and landslides, the 2015 Chennai flood and the 2016 drought conditions are examples of direct and dangerous impact of climate change in India.


*Picture showing Alaska's Muir Glacier's contined retreat and thining in the second half of the 20th century, from 1941 to 2004 (**Source:** https:climate.nasa.gov/climate_resources/4/graphic-dramatic-glaciers-melt/)*

## How to protect ourselves and the environment?

***International / National Level*** – There is need for stricter laws, acts, rules and regulations enacted at the global level, and at the Central as well as State government-levels to reduce the process of climate change by man-made activities. For example, in the Paris Agreement of 2015, all nations were bought together to take necessary steps to understand the climate change problems and fight against it. The Indian government has also enacted stricter legal boundaries to maintain the air and water quality the violation of which is punishable with fine and criminal prosecution.

***Local / Individual Level*** –The combined efforts at the local level and by every individual can improve the chances of reduction of climate change in India. To achieve the goal, firstly, there should be the awareness about the meaning, causes and effects of climate change at the level of local communities /groups, individuals and students invarious schools, colleges, institutions and other private and government sectors. Secondly, there is need to follow a few simple steps like cleanliness of nearby surroundings, proper management of daily garbage, reduce water wastage, reduce the use of plastics, judicious use of electricity, reuse of garbage, reduce the emission of harmful gases and discharge of chemicals from industry and last but not the least, plant more and more trees.

# Quantum Plasma in Space


*Kaushik Roy & Prasanta Chatterjee*

*About 90% of all matter in the visible universe exists in the form of plasma. Plasmas are observed on the Sun's surface, and in Earth's magnetosphere and interplanetary and interstellar media. In modern physics there are numerous applications of quantum plasma. There has been a growing interest in quantum plasmas, motivated by applications in ultra-small electronic devices and dense astrophysical plasmas.*

Quantum mechanics was born to describe physics in a completely new way in the first quarter of the 20th century. The interpretation of quantum theory looks confusing, but has a wide range of applications in astrophysics, microelectronics and nanotechnology. In physics, many-body systems are described by a so-called density matrix, which has no classical counterpart. Many scientists like Max Plank, Albert Einstein, Niels Bohr, Werner Heisenberg, Erwin Schrodinger, and Paul Dirac significantly contributed to develop the subject. The development came about in two stages. The first stage started with Max Plank's hypothesis, which is a combination of classical and non-classical theory. On 14 December 1900, Plank delivered a presentation at a meeting of the German Physical Society in which he stated that radiation is emitted or absorbed by matter in discrete packets or quanta each of energy h $\nu$, where $\nu$ is the frequency of radiation, and h the Planck's constant.

The second stage of quantum mechanics started in 1925, where Heisenberg introduced a particular form of quantum mechanics, which is also called 'matrix mechanics'. The following year, Schrodinger introduced another mathematical form of quantum mechanicscalled 'wave mechanics'. This mechanics combined the theory of the classical waves and Louis de Broglie's wave-particle relationship. Mathematically, theories of wave mechanics and matrix mechanics are different, but they are same according to the concept of physics.

In 1929, American physicists Lewi Tonks and Irving Langmuir first coined the term 'plasma' (the word 'plasma' in Greek means 'something formed') to describe the inner region of a glowing ionised gas produced by means of an electric discharge in a tube. Plasma is considered as the fourth state of matter, next to solids, liquids and gases. Plasma physics deals with the N-body dynamics of a system of charged particles interacting through electromagnetic forces. The study of plasma arose in the twentieth century when scientists got interested in the physics of gas discharges. After World War II, researches in plasma physics got a tremendous boost because of its applications in nuclear fusion, as in hydrogen bomb or in energy production through controlled thermonuclear fusion. Plasma physics was also developed by astrophysicists and geophysicists. About 90% of all matter in the visible universe exists in the form of plasma. Plasmas are observed on the Sun's surface, and in Earth's magnetosphere and interplanetary and interstellar media.

A classical system of charged particles qualifies as plasma if it is quasi-neutral (a region where electric field is zero) and if collective effects play a significant role in the dynamics. Actually, traditional plasma physics has mainly focussed on regimes characterised by high temperatures and low densities for which quantum mechanical

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effects have virtually no impact. However, recent advances in semiconductor technology have made it possible to envisage practical applications of plasma physics where the quantum nature of particles plays a crucial role. At room temperature and standard metallic densities, quantum effect can no longer be ignored, so that electron gas constitutes an ideal arena to study the dynamical properties of quantum plasma. However while studying some astrophysical objects under extreme conditions of temperature and density, such as white dwarf stars and neutron stars, where the density is some tens of magnitudes larger than that of ordinary solids, quantum aspect should be considered along with plasma.

In 1960s, American physicist David Pines first studied the quantum plasmas, which consist of electrons, ions, positrons, and holes. The concept of quantum plasma was developed with the help of famous mathematical models, namely (i) Schrodinger-Poisson model, (ii) Winger-Poisson model, and (iii) Quantum hydrodynamics model. Quantum plasma differs significantly from classical plasma in that in quantum plasma the density is extremely high and temperature is comparatively low. In contrast, traditional plasmas have high temperature and low density. Plasma can be regarded as quantum plasma when the quantum nature of its particles significantly affects its macroscopic properties.

Both fusion and space plasmas are characterised by regimes of high temperature and low density, for which quantum effects are totally negligible. However, physical systems where both plasmas and quantum effects co-exist do occur in nature; the most obvious example being the electron gas in ordinary metal. Quantum plasma also occurs in some astrophysical objects like white dwarf stars and neutron stars where the magnitude of density is larger than that of ordinary solids. Because of such larger densities, a white dwarf can be as hot as fusion plasma (108K), but still behave quantum mechanically. A white dwarf is a small star and its volume is comparable to that of the Earth but the mass is comparable to that of the Sun. Over 99% of all stars will eventually end their lives as white dwarfs. Over a very long time, a white dwarf will cool to temperatures at which it will no longer be visible, and become a cold black dwarf.

In 1926, American astrophysicist A. Fowler had assumed that electrons move non-relativistically (not according to relativity) inside the core of stars. Since the discovery of the first white dwarf, over 3,000 of these objects have been discovered in our Galaxy. Several interesting possibilities exist for degenerate matter. If the mass of a white dwarf is increased, then the electrons are forced to "squeeze" together even more and consequently the radius of the star decreases. So, massive white dwarfs are smaller compared to white dwarfs with lesser mass. In 1937, Indian-born American astrophysicist Subrahmanyan Chandrasekhar had shown that if enough mass is piled onto a white dwarf (up to 1.4 times the mass of the Sun), the velocity of the electrons continues to increase until they approach the speed of light and the white dwarf explodes as a supernova.

A surface temperature of 8,000K to 4,0000K and a Fermi temperature of 105K to 108K make white dwarfs an interesting object for the study of plasma dynamics around them. A neutron star is one of the possible end stages of a massive star which has mass greater than 4 to 8 times that of our Sun. After exhaustion of the nuclear fuel, it undergoes a supernova explosion, which blows off the outer layers of the star. The central region of the star collapses under gravity such a way that protons and electrons combine to form neutrons. Hence they are called neutron star. Pulsar is a neutron star in which 99% electrons have been captured by protons; 1% are left as electrons and protons.

Astrophysicists and geophysicists have discovered that the Sun emits some kind of invisible "corpuscular rays" towards Earth all time. In 1896, the Norwegian physicist Kristian Birkeland first discovered that besides light there were ions of many chemical elements coming to Earth from the Sun. According to him the aurora borealisis the result of the electrically charged corpuscular rays comingfrom the Sun and sucked in by the Earth's magnetic field near the poles. Today it is known that a primary link of the Sun with the Earth is through the solar wind plasma. Solar wind is a supersonic wind carrying ions (mainly protons), electrons and magnetic fields from the Sun that blows through our solar system from the Sun. During solar flares, bursts of cosmic rays along with plasma and storm-time energetic particles come from the Sun. Cosmic rays are positively-charged particles which interact with the nuclei of atmospheric oxygen and nitrogen to yield a highly complex mixture of corpuscular and electromagnetic radiations.

The meaning of the word 'aurora' is Goddess of Dawn. The aurora occurs simultaneously in both the Polar Regions due to complicated interactions between the solar wind magnetic field and the Earth's magnetosphere. The potential difference between the aurora and the magnetic field-aligned currents accelerate the electrons along the magnetic field lines and the electron shower reaches the ionosphere. The aurora lights are emitted when atoms and molecules in the ionosphere are hit by electrons blowing in from the Sun.

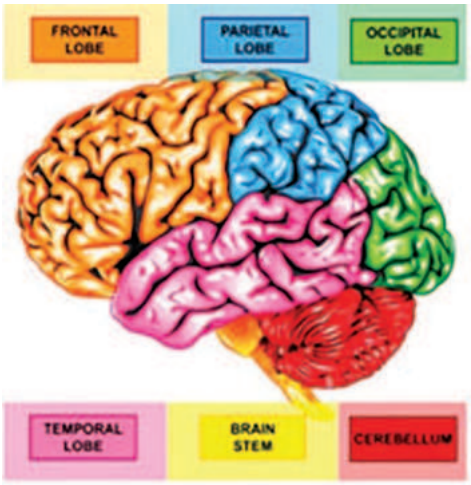
In modern physics there are numerous applications of quantum plasma. There has been a growing interest in quantum plasmas, motivated by applications in ultra-small electronic devices and dense astrophysical plasmas. The interaction and the quantum effects are also significant in dense plasmas which are relevant for intense laser solid-density plasma experiments, microplasmas, micro and nano scale objects like quantum diodes, quantum free-electron lasers, quantum dots and nano-wires, nano-photonics, and ultra-small electronic devices, and semiconductors, etc.

# The Animal Tool Users

*R. Vathsala*

*Tool use by animals is a phenomenon in which an animal uses any kind of tool in order to achieve a goal such as acquiring food and water, grooming, defence, recreation or construction. Originally thought to be a skill only possessed by humans, some tool use requires a sophisticated level of cognition. There are many tool users among animals including mammals, birds, fish, cephalopods and insects. Humans are not the only species endowed with this ability.*

The human brain is considered to be the ultimate product of evolution. It is highly evolved and most sophisticated and can perform very complicated and complex tasks. The biggest and the most important part of the brain, the cerebral cortex, controls all the voluntary muscles of the body. The frontal lobe of the cerebral cortex is the area responsible for all voluntary movements.




*The cerebral cortex*

The region of the cerebrum that controls the muscles of the hand is large, in the sense that each and every muscle of the hand controlled by a particular part of the brain performs a particular skilful movement. The human hand can draw, paint, sculpt, operate intricate machines, can perform micro surgeries, use complicated tools and much more.

*Human hands at work*

Now the question arises: Can animals also use tools? The sight of an animal making and using a tool is an interesting sight, perhaps because it makes us to question some of our ideas about human uniqueness. Does the tool-making animal know how the tool works? Does the animal anticipate the need for the tool and make it in advance? Animals engage in many other complex activities, like nest building and we know that complex behaviour need not be cognitively demanding. But tool-using behaviour can also provide a powerful opening into the minds of animals and help us learn what capacities we share with animals.

Tool use by animals is a subject of vast controversy, for it is difficult to draw a line between instinct and culturally transmitted learning. Learning process in young animals is based on instinct rather than on intelligence and is transferred from the parents to the offspring through observation and training. Tool use by animals is a phenomenon in which an animal uses any kind of tool in order to achieve a goal such as acquiring food and water, grooming, defence, recreation or construction of a shelter.

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Originally thought to be a skill only possessed by humans, some tool use requires a higher level of cognition. A wide range of animals including mammals, birds, fish and many invertebrates such as cephalopods and insects are known to use tools.

Let us take as an example the sea otters smashing mollusc shells with rocks. Is it because they are intelligent and adaptive, or are these mammals born with this innate ability?

The coconut octopus, a tiny cephalopod, has been observed retrieving discarded coconut half-shells, swimming with them up to 15 metres away and then carefully arranging the shells on the sea floor for later use. Other octopus species also engage in tool use, surrounding their dens with shells, stones, and even bits of discarded plastic garbage, but it is not clear whether this behaviour is any more "intelligent" than the nests built by terrestrial birds.

## Elephants

Elephants are equipped with a very efficient natural "tool", namely their long, flexible trunk. These mammals use other tools also. Asian elephants have been known to rip-off smaller side branches from fallen tree branches with their trunks and then use these tools as primitive back-scratchers. Some elephants cover up small watering holes with "plugs" made of stripped tree bark, which prevents the water from evaporating

*Elephant using tools*

and keeps it from being drunk by other animals. Both wild and captive elephants are known to create tools using their trunk and feet, mainly for swatting flies, scratching and reaching tree branches which are out of reach.

## Primates

Primates are well-known for using tools for hunting or gathering food and water, cover for rain, and self-defence.

Orangutans use a variety of tools for extracting insects or honey and for opening up fruits. They use tools made from branches and leaves to scratch, scrape, wipe, clean, swat, scoop, hit and cover. They will break-off a tree branch, remove the twigs and then use the stick to dig in holes for termites. Some orangutans use handfuls of leaves as napkins to wipe their faces while in parts of Sumatra they are known to use leaves as gloves, helping them handle spiny fruits and branches, or as seat cushions on spiny trees.

*Orangutan using a tool*

In some primates, tool making reveals higher cognitive functioning. Chimpanzees pick up leafy twigs, remove the leaves and

*Rain cover- chimpanzee*

use the stems to fish for insects. Chimpanzees are highly evolved tool users doing tasks like cracking nuts with stone tools. These animals not only use sticks to fish out their meal, but they in fact build their own 'tool kits' .They first use a smaller stick to break open the termite or ant mound, then use a larger stick to make holes in the prey's colony, and then insert a 'fishing probe' into the hole and pull out the termites or ants that have gathered on the stick.

Both bonobos and chimpanzees have been observed making "sponges" out of leaves and moss that suck up water and using these for grooming. Wild chimpanzees predominantly use tools in the context of food gathering, while wild bonobos use tools mainly for personal care.

Gorillas use tools in several ways, including using wood wool as "slippers" when walking on hard ground. A gorilla was seen pushing a stick into the ground and using it as a stabilising stick while gathering aquatic plants.

Tool use has been observed in capuchin monkeys. These animals use a stick to push food from the centre of a tube and retrieving it when it reaches the far end. They have been observed cracking nuts by placing them on a stone anvil and hitting them with another large stone (hammer).

*Tool-using chimpanzees*

Capuchin monkeys also use pieces of stone as digging tools for probing the substrate and sometimes for excavating tubers from

*Capuchin monkey breaking a nut*

ground and use sticks to flush prey from inside rock crevices.

In the wild, mandrills have been observed to clean their ears with twigs.

Asian, crab-eating macaques use stone tools to open nuts, oysters and other bivalves, and various types of sea snails

## Dolphins

A community of dolphins was observed to use conical sponges as tools while hunting for food. This behaviour, termed "sponging", occurs when a dolphin breaks off a sponge and wears it over its rostrum while foraging on the seafloor. During sponging, dolphins mainly target fish that burrow in the substrate. Therefore, the sponge may be used to protect their rostrums as they forage in a niche where echolocation and vision are less effective hunting techniques.

Bottle-nose dolphins have also been observed carrying conch shells. In this behaviour, dolphins insert their rostrum into the shell's aperture. They appear to use the

*Bottle-nose dolphin using sponge*

conch shells to scoop fish from the substrate then carry the shell to retrieve the fish near the surface.

Sea otters use stones to break open their prey like shells. This appears to be a learned behaviour passed down by parents to offspring in only a few bloodlines—but the ones that do are extremely nimble with their "tools". Sea otters have been seen wielding their stones (which they store in specialised sacs underneath their arms) as hammers to smash snails, or as "anvils" resting on their chests on which they dash their hard-shelled prey. Some sea otters even use stones to pry barnacles off undersea rocks

## Alligators

Alligators were observed gathering sticks on their heads during bird nesting season, when there is fierce competition for nest-building materials. Desperate, unwary birds see the sticks "floating" on the water, dive down to retrieve them, and are caught and eaten up by the alligators

## Fishes

The tusk fish are known to fan sand to unearth a bivalve, takes it into its mouth, swim several metres to a rock and use it as an anvil for smashing the mollusc apart with thrashing of the head. It has been reported that freshwater sting-rays use water as a tool by manipulating their bodies to direct a flow of water and extract food trapped amongst plants.

Before laying their eggs on a vertical rock face, male and female whitetail major damselfish clean the site by sand-blasting it. The fish pick up sand in their mouths and spit it against the rock face. Then they fan the area with their fins. Finally, they remove the sand grains that remain stuck to the rock face by picking them off with their mouths.

The triggerfish blows water to turn sea urchins over and expose their more vulnerable ventral side.

The archerfish is found in tropical mangrove swamps of Asia and Australia. They approach the surface, take aim at insects that sit on plants above the water surface, squirt a jet of water at them, and grab them after the insects have been knocked-off into the water. The jet of water is formed by the action of the tongue, which presses against a groove in the roof of the mouth. Some archerfish can hit insects up to 1.5 m above the water surface. They use more water, which gives more force to the impact, when aiming at larger prey.

*Archer fish shooting at prey*

Several species of wrasses have been observed using rocks as anvils to crack bivalve (scallops, urchins and clams) shells. These are examples of highly specialised natural adaptations.

## Birds

There is a genetic predisposition for tool use in birds, which is then refined by individual trial-and-error learning during early development. While young birds in the wild normally learn to make stick tools from elders, crows are among the only animals that create their own tools. Tool use in other birds is best exemplified in individual nest building ability.

Crows use stick tools to make first contact with objects that are new to them and hence potentially dangerous. It has been claimed that the tool-making skills of the crow exceed those of chimpanzees and are more like human tool-making than those of any other animal.

*Tool-using crows*

Other related species, such as rooks can also make and use tools in the laboratory, showing a degree of sophistication like that of New Caledonian crows. While not confirmed to using tools in the wild, captive blue jays have been observed using strips of newspaper as tools to obtain food

Blue jays are highly curious and are considered intelligent birds. Young blue jays playfully snatch brightly coloured or reflective objects, such as bottle caps or pieces of aluminium foil, and carry them around until they lose interest.

Crows, ravens and rooks are well-known for their large brains and subsequent tool use. They mainly manufacture probes out of twigs and wood (and sometimes metal wire) to catch larvae.

*Woodpecker finch fishing out worms with a stick*

Finches and woodpeckers also insert twigs into trees in order to catch or impale larvae.

Warblers build 'pouches' to make their nests. Some birds, such as weaver birds build complex nests.

The tailorbird makes a pouch out of leaves by stitching them together with thread made of spider web. The bird then builds its nest in the pouch. The leaves are sewn together in such a way that the upper surfaces are outwards making the structure difficult to see. The punctures made on the edge of the leaves are minute and do not cause browning of the leaves, further aiding camouflage. The processes used by the tailorbird have been classified as sewing, riveting, lacing and matting. There are many variations in the nest.

*Tailor bird building nest*

Brown-headed nuthatches have been observed to methodically use bark pieces to remove other flakes of bark from a tree. The birds insert the bark piece underneath an attached bark scale, using it like a wedge and lever, to expose hiding insects.

Macaws have been repeatedly observed to use tools when breaking open

*Macaw using a stick*

nuts, for example, by using pieces of wood as a wedge. Several birds have been observed to wrap a piece of leaf around a nut to hold it in place. This behaviour is also shown by cockatoos. The blue-coloured hyacinth macaw uses tools to manipulate nuts.

When an Egyptian vulture encounters a large egg of a prey, it takes a stone in its beak and forcefully throws it at the egg until the shell breaks, usually taking a few minutes.

*Egyptian vulture using stone to break egg*

These birds also use twigs to collect sheep wool for padding their nests. Although both twigs and wool can serve as nesting material, this appears to be deliberate tool use.

In Australia, the black kite, whistling kite and brown falcon use their beaks or talons to carry burning sticks from a forest fire to spread the fire, complicating human efforts to contain forest fires using firebreaks.

Seagulls have been seen dropping oyster shells on hard surfaces or roads so that vehicles can drive over them and break the shell. Some species of seagull exhibit tool use behaviour using pieces of bread as bait to catch fish.

Shrikes impale their prey like lizards and insects on thorns for future use. Several

*Shrike with impaled dead lizard*

other birds use spines or forked sticks to anchor a carcass while they flay it with their beak. However, the use of fixed skewers may not be true tool-use because the thorn or forked stick is not manipulated by the bird.

The green heron and the striated heron have been seen using food (bread crusts), insects, leaves, and other small objects as bait to attract fish, which they then capture and eat.

## Carnivores

Mongooses regularly use a hard shell to open food items such as beetles, bird eggs, snail shells, etc.

Honey badgers have been filmed manipulating various objects to assist them in climbing.

North American badgers hunt ground squirrels. The most common hunting technique is excavation of burrow systems and plugging of openings into ground-squirrel tunnels. Badgers usually use soil from around the tunnel opening.

## Invertebrates

The octopus uses a nut-shell and clam-shell as shelter. The coconut octopus retrieve coconut shells, manipulating them, stacking them, transporting them some distance and then reassembling them for use as a shelter. The octopuses eventually use the shells as a protective shelter in areas where no other shelter exists. If they just have one half, they simply turn it over and hide underneath. But if they are able to retrieve two halves, they assemble them back into the original closed coconut form and sneak inside.

Octopuses deliberately place stones, shells and even bits of broken bottle to form a wall that constricts the entry to the den, a type of tool use.

## Insects

Some ants in the wild pick up stones and other small objects with their mandibles and drop them down the vertical entrances of rival colonies, allowing workers to forage for food without competition. Several species of ants are known to use substrate debris such as mud and leaves to transport water to their nest.

Hunting wasps use weights (such as small pebbles) to settle sand surrounding a recently made burrow containing eggs and live prey in order to camouflage and seal the entrance.

## What governs the tool using process in animals?

**1. For getting food**

Tool use by animals may indicate different levels of learning and cognition. For some animals, tool use is largely instinctive and inflexible. For example, the woodpecker finch of the Galápagos Islands uses twigs or spines as an essential and regular part of its foraging behaviour. This type of tool using is often quite inflexible and is not applied effectively in different situations.

**2. For collecting water**

When chimpanzees cannot reach water that has formed in hollows high up inside trees, they have been observed taking a handful of leaves, chewing them, and dipping this "sponge" into the pool to suck out the water.

It has been reported that orangutans use tools for a wide range of purposes including using leaves as protective gloves or napkins, using leafy branches to swat insects or gather water and as covers to protect them from the rain or hot sun. Orangutans have also been observed using sticks to measure the depth of water. Sumatran orangutans use large leaves as umbrellas in a tropical rainstorm.

**3. For reproduction**

Prior to laying their eggs on a vertical rock face, male and female whitetail major damselfish clean the site by sand-blasting it.

**4. For grooming**

**5. For protection**

Orangutans use large leaves like banana leaves for protection from rain or hot sun.

Taking inanimate objects and using them to solve a problem was, until relatively recently, thought of as being an exclusively human skill. But the more we observe the natural world, the more we discover about the extraordinary ways other animals have managed to survive.

Sometimes the tools are simple – for example, Galapagos finches use cactus spines to fish for insects in hollows. But some animals are very sophisticated in their tool use, putting effort to produce new objects to improve their effectiveness.

Tool use by animals is a phenomenon in which an animal uses any kind of tool in order to achieve a goal such as acquiring food and water, grooming, defence, recreation or construction. Originally thought to be a skill only possessed by humans, some tool use requires a sophisticated level of cognition. There is considerable discussion about the definition of what constitutes a tool and therefore which behaviours can be considered as true examples of tool use. As we have seen, there are many tool users among animals including mammals, birds, fish, cephalopods and insects. Humans are not the only species endowed with this ability.

# Water on Earth came from formation of Moon

***Biman Basu***

*A recent finding about the behaviour of thermal plasma on the Sun shows how matter behaves in the extreme conditions of the Sun's atmosphere. Understanding how plasma behaves in the Sun's atmosphere may help researchers learn how to control this exotic matter on Earth. Plasma is exotic matter not commonly found on Earth. It is also known as the fourth state of matter (besides solid, liquid and gaseous phases) and can be created only at extremely high temperatures.*

The Earth is unique in our solar system: It is the only planet of our solar system with a large amount of water. Two-thirds of the Earth's surface is covered with water and most life on Earth cannot survive without water. It has long been debated how our planet got its water. There have been many theories; they include collision with comets, trans-Neptunian objects, or water-rich meteoroids from the outer reaches of the asteroid belt. But new research by scientists of the University of Münster in Germany show for the first time that water came to Earth during the formation of the Moon some 4.4 billion years ago. Besides being the source of Earth's water, the Moon is also important for us because its relatively large size is crucial for stabilising the Earth's axis of rotation.


*Diagram showing the sequence of events leading to formation of Moon as a result of collision between proto-Earth and Theia, which brought water to Earth. (Credit: Sean Raymond)*

The giant impact hypothesis for the Moon's formation states that shortly after formation of an initial crust, the proto-Earth was hit by a body about the size of Mars, called Theia, some 4.4 billion years ago. Until now, scientists had assumed that Theia originated in the inner solar system near the Earth, which is considered a hot and dry region. Researchers from Münster have now shown that Theia did not come from the inner solar system; rather it came from the outer solar system and delivered large quantities of water to Earth (Nature Astronomy, 21 May 2019; DOI: 10.1038/s41550-019-0779-y).

The Münster researchers base their finding on the amounts of the element molybdenum isotopes present in Earth's mantle. According to them, "from earlier studies, we know that the solar system became structured such that the 'dry' materials were separated from the 'wet' materials: the so-called 'carbonaceous' (carbon-containing) meteorites, which are relatively rich in water, come from the outer solar system, whereas the drier 'non-carbonaceous' meteorites come from the inner solar system. The measurements made by the researchers from Münster show that the molybdenum isotopic composition of the Earth lies between those of the carbonaceous and non-carbonaceous meteorites,

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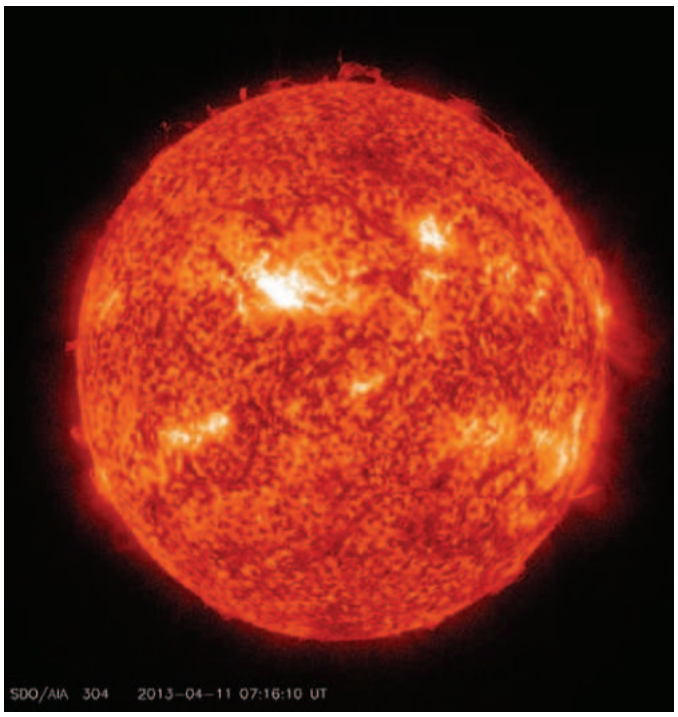
demonstrating that some of Earth's molybdenum originated in the outer solar system.

While previous studies have shown that carbonaceous materials were likely responsible for delivering the water to Earth, it was not known when and how this carbonaceous material–and thus the water–came to Earth."The molybdenum isotopes allowed us to clearly distinguish carbonaceous and non-carbonaceous material, and as such represent a 'genetic fingerprint' of material from the outer and inner solar system", explains Dr. Gerrit Budde of the Institute of Planetology in Münster and lead author of the study. The chemical properties of molybdenum play a key role because, as it is an iron-loving element, most of the Earth's molybdenum that arrived early is found in the core.




*Ultraviolet image of the Sun taken by the SOHO (SOlar Heliospheric Observatory) satellite. It shows helium plasma at a temperature of 60,000 degrees Celsius. (Credit: SOHO's Extreme Ultraviolet Imaging Telescope)*

The scientists show that most of the molybdenum in Earth's mantle came from the protoplanet Theia, whose collision with Earth 4.4 billion years ago led to the formation of the Moon. The molybdenum that is accessible today in the Earth's mantle, therefore, originates from the late stages of Earth's formation, while the molybdenum from earlier phases is present entirely in the core. The scientists' results therefore show, for the first time, that carbonaceous material from the outer solar system arrived on Earth late. The scientists say the collision provided enough carbonaceous material to account for the entire amount of water on Earth.

According to the researchers, "Our approach is unique because, for the first time, it allows us to associate the origin of water on Earth with the formation of the Moon. To put it simply, without the Moon there probably would be no life on Earth".

## Study of plasma on Sun may help in fusion power generation

Nuclear fusion offers a clean and plentiful source of energy if harnessed properly. But nuclear fusion is not possible without creation of adequate high-temperature plasma and maintaining it for sufficient time to cause fusion. Plasma is exotic matter not commonly found on Earth. It is also known as the fourth state of matter (besides solid, liquid and gaseous phases) and can be created only at extremely high temperatures of the order of 100,000 K or more, at which atoms exist in completely ionised form. Such high-temperature plasma, known as thermal plasma, occurs on the Sun and in fusion reactors that are being developed and tested for power generation on Earth.

One of the major obstacles in the way of generation of fusion power is the instability of thermal plasma. In fusion reactors, as soon as the plasma starts generating energy, some natural process switches off the reaction. While this switch-off behaviour is like an inherent safety switch–fusion reactors cannot form runaway reactions–it also means the plasma is difficult to maintain in a stable state for energy generation. Scientists have long been trying to find out the cause for this instability, but without much headway.

A recent finding about the behaviour of thermal plasma on the Sun by Irish and French scientists may lead the way. The researchers carried out the study using large ground-based radio telescopes and ultraviolet cameras onboard NASA's Solar Dynamics Observatory to discover how matter behaves in the extreme conditions of the Sun's atmosphere. Understanding how plasma behaves in the Sun's atmosphere may help researchers learn how to control this exotic matter on Earth(Nature Communications, 24 May 2019 | DOI: 10.1038/s41467-019-10204-1).

The international collaboration is led by Dr. Eoin Carley of Trinity College Dublin and the Dublin Institute of Advanced Studies (DIAS). He says, "The solar atmosphere is a hotbed of extreme activity, with plasma temperatures in excess of 1 million degrees Celsius and particles that travel close to light-speed. The light-speed particles shine bright at radio wavelengths, so we're able to monitor exactly how plasmas behave with large radio telescopes".

The DIAS team worked closely with scientists at the Paris Observatory, which has a long history of making radio observations of the Sun, dating back to the 1950s. The researchers performed observations of the Sun with a large radio telescope located in Nançay in central France. Then they combined the radio observations with images from ultraviolet cameras on NASA's space-based Solar Dynamics Observatory spacecraft to show that plasma on the Sun can often emit radio beams that pulse like a lighthouse. Scientists have known about this activity for decades, but the use of space and ground-based equipment by the international team allowed it to image the radio pulses for the first time and see exactly how plasmas become unstable in the solar atmosphere.

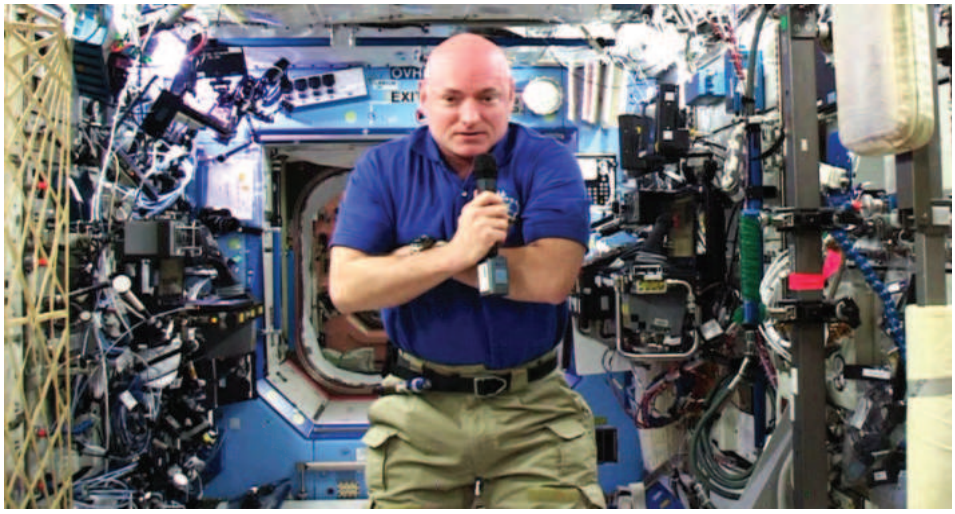
According to Carley of DIAS, "The collaboration with French scientists is ongoing and we're already making progress with newly built radio telescopes in Ireland, such as the Irish Low Frequency Array (I-LOFAR). I-LOFAR can be used to uncover new plasma physics on the Sun in far greater detail than before, teaching us about how matter behaves in both plasmas on the Sun, here on Earth and throughout

the universe in general." Moreover, knowing how plasmas become unstable on the Sun can help researchers learn how to control them on Earth.

## NASA's Twin Study reveals implications of long space flights

Space environment is entirely different from what we experience here on Earth. Lack of gravity, low temperature and high radiation levels are a few of the factors an astronaut has to contend with while living in space. While spacecraft do offer protection from cold and radiation to some extent, they cannot provide gravity, which leads to several problems such as lack of orientation and weakening of bones and muscles. But till recently, several other effects of long-duration stay in space were not known, which have come to light during a year-long study by NASA with a pair of identical twin astronauts, one of whom, Scott Kelly, spent 340 days on board the International Space Station (ISS) while the other, Mark Kelly stayed back on Earth. Scott spent nearly a year on the ISS, in a mission launched in 2015. The study revealed some interesting, surprising and reassuring data about how one human body adapted to – and recovered from – the extreme environment of space during long space travel (Science, 11 April 2019 | DOI: 10.1126/science.aau8650).

Key results from the NASA Twins Study include findings related to gene expression changes, immune system response, and telomere dynamics. There was thickening of the walls of Scott's carotid artery and thickening of his retina. He also experienced weight-loss, changes in his gut microbes, and reduced cognitive abilities. Many of the findings are consistent with data collected in previous studies, and other research in progress.



*Scott Kelly-on-ISS*

According to the published study, when Scott returned to Earth after spending 340 days in the zero gravity confines of the International Space Station, he had grown 5-cm taller, but soon returned to his original height. In addition, during his stay on the ISS, Scott experienced decreased body mass, instability in his genome, swelling in major blood vessels, changes in eye shape, metabolism shifts, inflammation and alterations in his microbiome as well as a strange lengthening of his telomeres, the protective structures at the ends of chromosomes, which, however, shortened again after he landed.

*Identical twin astronauts Scott and Mark Kelly were subjects of NASA's Twins Study. Scott (right) spent a year in space while Mark (left) stayed on Earth as a control subject. Researchers looked at the effects of long-duration space travel on the human body. (Credit: NASA)*

A second key finding is that Scott's immune system responded appropriately in space. For example, the flu vaccine administered in space worked exactly as it does on Earth, which is significant because a fully functioning immune system during long-duration space missions is critical to protecting astronaut health from opportunistic microbes in the spacecraft environment.

A third significant finding is the variability in gene expression, which reflects how a body reacts to its environment and will help inform how gene expression is related to health risks associated with spaceflight. While in space, researchers observed changes in the expression of Scott's genes, with the majority returning to normal after six months on Earth.

Jennifer Fogarty, chief scientist of the Human Research Program at NASA's Johnson Space Centre in Houston said, "We have only scratched the surface of knowledge about the body in space. The Twins Study gave us the first integrated molecular view into genetic changes and demonstrated how a human body adapts and remains robust and resilient even after spending nearly a year aboard the International Space Station. The data captured from integrated investigations like the NASA Twins Study will be explored for years to come".

According to NASA, the Twins Study helped establish a framework of collaborative research that could serve as a model for future biomedical research. "Supported by 84 researchers at 12 locations across eight states, the data from this complex study was channelled into one inclusive study, providing the most comprehensive and integrated molecular view to date of how a human responds to the spaceflight environment". However, we must keep in mind that while the present study is significant, it is difficult to draw conclusions for all humans or future astronauts from a single test subject in the spaceflight environment.

# Science Fusion-2019
# Science Activities for Children

Vigyan Prasarorganised aseven-days-long science activity-based programme Science Fusion- 2019 exclusively for children from 6-9th std from Delhi-NCR region during 20-27 June 2019, at Vigyan Prasar, A-50, Sector 62, Noida (UP). Several hands-on activities on science and technology were organisedfor enabling children to learn and understand science by doing things themselves. The objectives of the programme were; i) to sensitise children about the activity-based science learning; ii) to induce an interdisciplinary integrated approach to science learning through experimentation; and iii) to inculcate scientific temper among children through hands-on activities.

The programme was inaugurated with anaddress by Dr. Nakul Parashar,

Director, Vigyan Prasar, Noida on 20 June 2019, followed by keynoteaddresses by Shri Shri Gyanendra Kumar, Director, National Navodaya Leadership Institute, Navodaya Vidyalaya Samiti, Noida (UP). On this occasion two activity kits for science fusion were released. Shri Kapil Tripathi, Scientist E, VP made a presentation on overview of the programme. The session ended with avote of thanks by Dr. Irfana Begum, Project officer, EduSat,VP.

The main programme included aninteractive lecture session on Joy in learning Mathematics, by Shri Rintu Nath, Scientist F, VP; Robotics in Ecological

Science by Prof Monika Koul Hans Raj college Delhi University, Delhi; How we know that Earth is going around the Sun? by Dr. T.V Venkateswaran, Scientist F, VP; on Biodiversity by Shri B.K. Tyagi, Scientist F, VP; followed by science movie shows daily.

The main attraction of this event was the various Hands-onsessions on Construction of solar light by Shri Kuldeep, Toy-Joy by Dr Surjeet Singh, by Ex-Scientist, NISCAIR, New Delhi, Fun with Chemistry by Shri Narendra Singh, PGT, Delhi, Activity based science learning by Shri Kapil Tripathi, Scientist 'F', VP; Science & Math Puzzles by Ms Mohini Kumar, Delhi Math Club; Construction of Electronic circuit Science by Prof. Rashmi Chawla, YMCA University Faridabad; Day time Astronomy by Shri Vipin, Hands-on "Radio Communication" by Shri Sandeep Baruah, Scientist F,VP; Sound Energy by Ms. Anshumala Gupta, Joy of learning Foundation, Delhi; Wonder of Life Science, by Dr Irfana Begum, VP; Fun with optics by Shri Vikas, Science

Communicator; Important of Oral care –Practical Demonstration by Dr. Tanya Kumar, Practitioner, Delhi; Science Quiz by Shri Sachin Narwadiya, Scientist- C,VP; Nature Walk by Mr. Ishtiyak, Bombay Natural History, (CEC), New Delhi; Astronomy & Sky Watching by Mr. Vipin Singh Rawat, VP & Mukesh, Bhopal (MP); Joy of Aerodynamics by Shri Bhargav, MYSTEM Lab, Delhi; Hands on Robotics by Shri Vivek & Team, MYSTEM Lab,

Delhi and Science Theatre by Shri Ashok, Theatre Artist, IPTA,Nainital.

The event Science Fusion-2019 concluded with the valedictory session on 27 June 2019. Dr Hukum Singh, Ex professor and Head Mathematics, NCERT, New Delhi delivered the keynote address on this occasion. Shri Kapil Tripathi, Scientist F, VP share his view to the young children and appreciated the hard work done by them during the programme. Children also perform a Science Drama during this session. Dr Irfana Brgum, VP, coordinated this session. A total 70 children from NCR region participated in the programme. Resource materials developed by VP were provided to the children and certificates were also given to the participants.

**(Report by Shri Kapil Kumar Tripathi, Scientist-F, Vigyan Prasar)**

# VIDYARTHI VIGYAN MANTHAN 2019-20

## INDIA'S LARGEST SCIENCE TALENT SEARCH FOR NEW INDIA USING DIGITAL DEVICES

Vidyarthi Vigyan Manthan (VVM) is a national science talent search programme for New India organised by VIBHA (Vijnana Bharati), in collaboration with Vigyan Prasar-an autonomous organisation under the Department of Science and Technology, Government of India and NCERT- Ministry of Human Resource Development. VVM is a National program for educating and popularizing science among school students of VI to XI standards. VVM aims to identify and nurture the bright minds among the student community, who are keen on subjects related to science.

**STRUCTURE OF VVM (JUNIOR AND SENIOR):**

1. **School Level Examination:** VVM is a unique online examination to be conducted at national level. The registered students will take the exam using his/her own device namely a laptop/ tablet / smart phone (mobile with any OS - Except Apple devices) AND HIS/HER OWN INTERNET CONNECTIVITY. The school level examination will be conducted nationwide, on 24 November, 2019 and/or on 30 November, 2019 (option to choose) at the given time. Evaluation of student will be based on their individual performance at every level.
2. **State Level Camp (SLC) :** Top 20 rankers per class per state will be identified to participate in the one or two days State Level Camp (SLC). The camp will be organised anywhere within the state.
3. **National Camp (NC) :** From each State Camp, top two students from each class i.e. total 12 students per state, will be invited to a two-day National Camp.

**SYLLABUS FOR VVM:**

| Content | Contribution Junior & Senior (Class VI to XI) (Multiple Choice Questions) | | | Curriculum |
|---|---|---|---|---|
| | Questions | Marks | Duration | |
| Science and Mathematics from text books | 50 (1 marks each) | 50 | 120 minutes | NCERT Curriculum |
| Indian Contributions to Science | 20 (1 marks each) | 20 | | VVM Study Material* |
| Life stories of Jagadish Chandra Bose and E. K. Janaki Ammal | 20 (1 marks each) | 20 | | VVM Study Material* |
| Logic & Reasoning | 10 (1 marks each) | 10 | | General Reading |
| **Total** | 100 | 100 | | |

*VVM Study Materials will be made available in PDF format on www.vvm.org.in by 01 August 2019. No printed copies will be provided

**KEY POINTS:**

1. **Eligibility** - Students from classes VI to XI studying under CBSE, ICSE, and State Boards.
2. **Language of Exam** - English, Hindi and 9 major regional languages
3. **Exam Centre** - Registered School & specified centres
4. **Fee** - Rs. 100/- (without late fee), Rs. 120/- (with late fee)
5. **Registration** - Online on www.vvm.org.in
6. **Mode of Payment** - 1) ONLINE payment on website 2) RTGS / NEFT/ CHALLAN PAYMENT

* No Cash / DD / Cheque will be accepted

For more information you can log on to website www.vvm.org.in

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