Notes and News

Indian Muon Telescope Detects Extreme Thundercloud Voltage

Lightning during thunderstorms is a common phenomenon. Cloud-to-ground lightning bolts are also quite common – about 100 strike Earth's surface every single second – and their power is extraordinary. Till now it was difficult to experimentally determine the voltage that develops within thunderclouds. Over the past several decades, researchers have flown airplanes and balloons into the centres of thunderstorms to study their electrical structure, but they could only probe a small region and not the entire cloud. Now, in a new effort, researchers have developed a way to capture one critical measurement of an entire storm – its electric potential. A team of scientists from several institutions in India and Japan has found that it is possible to use a muon detector to measure electric potential in thunderstorms and their finding is an astounding 1.3 billion volts (GV), which is 10 times greater than the largest value ever reported (Physical Review Letters, 15 March 2019 | DOI: 10.1103/ PhysRevLett.122.105101).

The new method of measuring thundercloud voltage was devised by Sunil Gupta of Tata Institute of Fundamental Research in Mumbai and colleagues and is based on probing the effect of thunderstorms on particle detections by the GRAPES-3 Muon Telescope (G3MT) – a muon telescope which is part of the GRAPES-3 cosmic-ray detection facility. Gupta says, "We realised that GRAPES-3 is an ideal tool for measuring thunderstorm potentials, in particular for the biggest storms".

From measurements of muon flux, Gupta and his colleagues could estimate the thunderstorm potential using computer simulations based on a simplified description of the thunderstorm, which they treat as a giant capacitor made of two parallel plates kept two kilometres apart generating an upward-pointing electric field.

The new finding may help researchers solve another atmospheric puzzle, says Gupta. Since 1994, satellite measurements have revealed gamma-ray flashes coming from altitudes of tens of kilometres. Researchers speculate that these flashes could be produced by electrons accelerated by thunderstorms, but previous measurements had not found sufficiently large thunderstorm potentials. However, the newly observed potentials in the gigavolt range are much closer to the values required to produce the observed gamma rays. ❐

Adapted from the article of Biman Basu in Dream 2047, June 2019, Vol. 21, No.9

Building Blocks of DNA and RNA May Pre-Date Life on Earth

Scientists for the first time have found strong evidence that RNA and DNA could have arisen from the same set of precursor molecules even before life evolved on Earth about four billion years ago. Ramanarayanan Krishnamurthy, associate professor of chemistry at Scripps Research (earlier known as the Scripps Research Institute) and his lab worked with the lab of John Sutherland, of the UK Medical Research Council's Laboratory of Molecular Biology at Cambridge, as part of the New Yorkbased Simons Foundation's Collaboration on the Origins of Life (Nature Chemistry, 1 April 2019 | DOI: 10.1038/ s41557-019-0225-x)

In an earlier study published in 2017, Krishnamurthy and colleagues at Scripps Research identified a sulphur-containing compound called thiouridine that was probably present on the pre-biotic Earth and could have performed the crucial task of linking RNA building blocks into larger, chain-like RNA strands – and could have done the same for the building blocks of DNA and proteins.

In the new study, researchers combined insights from that investigation with recent findings from Sutherland and his lab on thiouridine. They say the latter was likely present on Earth before life arose and could have been a chemical precursor of the nucleoside building blocks of early RNAs. The team showed that in a few chemical-reaction steps, which plausibly could have occurred in a pre-biotic world, they could convert this precursor of an RNA building-block into a DNA buildingblock known as deoxyadenosine, which is the DNA nucleoside A, which pairs with deoxythymidine in double-stranded DNA. Alternatively, they could convert thiouridine into deoxyribose, which is very closely related to deoxyadenosine and may also have been a precursor of early DNA building blocks.

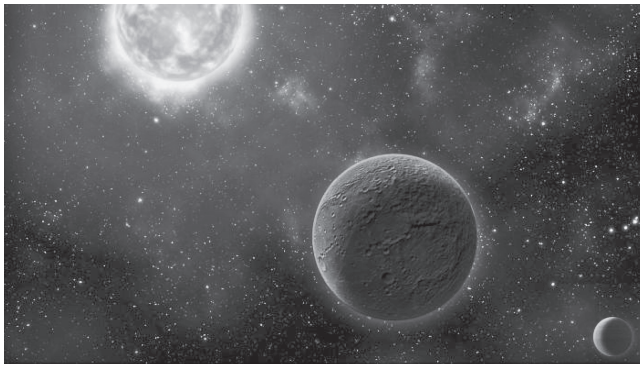
According to the researchers, the finding should make it easier for scientists to accept the possibility that DNA and RNA arose together and were included in the first life forms. Some researchers including Sutherland have suggested that RNA and DNA might even have been mixed together to make the first genes. No such organism is known to occur naturally now, but a recent paper by Scripps Research's Peter Schultz and colleagues described an engineered bacterium that can survive with genes made of an RNA/DNA mix. ❐

Adapted from the article of Biman Basu in Dream 2047, June 2019, Vol. 21, No.9

First Earth-sized Exoplanet Found by Planet-Hunting telescope of NASA

In an article titled "TESS Delivers Its First Earth-sized Planet and a Warm Sub-Neptune," published in *The Astrophysical Journal Letters* (Diana Dragomir *et al*., vol. 875, no. 2, L7, 2019; DOI: https://doi.org/10.3847/2041-8213/ab12ed), scientists at MIT and Carnegie Institution for Science have just reported that NASA's Transiting Exoplanets Survey Satellite (TESS) has detected the presence of an earth-sized exoplanet HD 21749c along with a sub-Neptune-sized world HD 21749b, both orbiting a K-type dwarf star HD 21749. According to an exoplanetologist of MIT Kavli Institute, who is also a lead author of the article, "*It's a milestone for TESS. It sets the path for finding smaller planets around even smaller stars, and those planets may potentially be habitable*."

The planet-hunting spacecraft TESS was launched aboard a SpaceX Falcon 9 rocket on April 18, 2018 to survey the whole of the sky with its 0.4 million stars in order to find out earth-sized and even smaller exoplanets transiting around the respective host stars. In order to follow-up the data sent by TESS, a 6.5 meter long telescope (Magellan II) situated at Carnegie's Las Campanas Observatory in Chile was used. It has a Planet Finder Spectrograph (PFS) which confirmed that the signals from TESS were indeed from an exoplanet and determined the mass of the planet. To determine the mass of a planet, PFS uses the radial velocity method which is as follows. A star (HD 21749 in this case) exerts a strong influence on its planets. But since gravity works both ways, the gravitational pull of the planet imparts a slight 'wobble' to the star, and PFS can detect this wobble – the larger the wobble of the host star, the higher the mass of the planet. The mass of a planet helps determine its density and composition.



Centre: HD 21749b; Bottom right: HD 21749c

The main objective of TESS was to enable the astronomers to measure the masses, atmospheric compositions and other properties of small exoplanets for the first time. According to a researcher of the Carnegie Institution for Science, who is also a co-author of the article, "*TESS is already a game-changer in the planet-hunting business*."

The host star, around which both the planets orbit, is 53 light-years away (from our solar system) in the southern constellation Reticulum and has the equivalent of 80% of the mass of our sun. The exoplanet HD 21749c, likely to be a rocky world having a surface temperature of 427°C, takes about 7.8 days to orbit the host star and is similar in size to earth at 89% its diameter. The PFS could not determine the mass of this planet.

However, the PFS was able to determine the mass of the sub-Neptune-sized warm world HD 21749b which is nearly 23 times earth's mass; it has a radius of around 2.7 times that of earth and orbits the host star every 36 days. The discovery of this smaller world is somewhat surprising since TESS, they say, is not designed to detect any planet that takes longer than 10 days to orbit its star. This sub-Neptune world had indeed been reported earlier, but its details have been made available only now by TESS. The measured density suggests that this planet is not rocky and has a substantial atmosphere, which renders it potentially habitable.

TESS, likely to last for 2-10 years, has the potential to find thousands of exoplanets, but NASA expects TESS to catalogue more than 1,500 exoplanets, of which 300 are anticipated to be earth-sized exoplanets or double-earth-sized 'super earths' that are the best candidates for supporting life outside our solar system. To be precise, these planets are small, rocky, usually within the habitable

zones of their stars, i.e. liquid water may exist on their surface.

TESS has been deservedly dubbed as the "*bridge to the future*." HD 21749c is the 10th confirmed planet discovered by TESS, and many more are being studied right now. ❐

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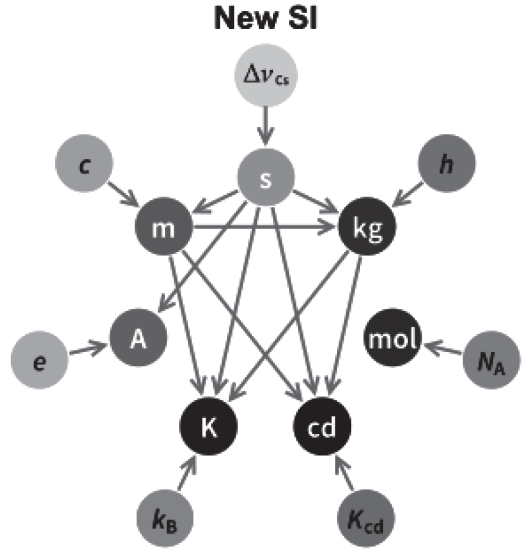
The Kilogram Redefined: Le Grand K Dethroned

With effect from the World Metrology Day, the 20th May, 2019, the kilogram has been redefined. For the last 130 years – since 1889 – the kilogram (kg) has been defined as the mass of a cylinder made of platinum (90%)-iridium (10%) alloy and housed at the International Bureau of Weights and Measures in Sèvres, France. It is called the International Prototype Kilogram (a.k.a. Big K, or Le Grand K). According to the new definition, the kg is an abstract, unchanging measurement based on numerous light particles (photons) and Planck's constant. The kg is now fixed forever and can't change with time.

Big K, or Le Grand K

Forty exact replicas of the Big K prototype, kept in countries of the member nations, were used to calibrate scales in one universal system. All the replicas were reunited only thrice so far. Each time, the Big K and its replicas were delicately wiped with alcohol and ether, steam-cleaned and weighed. In 1992, the scientists found out that the Big K has become lighter by 50 µg than its replicas. The difference, albeit very small, was unacceptable in precise fields of science, technology, engineering and medicine.



New SI System after 2019 Redefinition

By 2005, the Kibble balance, an electromechanical system of precise measurement of weights, was improved enough to drive a group of researchers, known as the 'the Gang of Four' to the metrologists, to publish a paper titled "*Redefinition of the kilogram: a decision whose time has come*," which played a pivotal role in the eventual redefinition of the kg. In 2011, the General Conference on Weights and Measures (CGPM), established in 1889 as the custodian of the international prototype kilogram (and metre), unanimously decided to redefine the kg in terms of a physical constant, viz. the Planck's constant, instead of a physical object since a fundamental physical constant does not change. The target date was 2018.

The metric system, which evolved into the International System of Units (SI), was designed to be "*for all times, for all people*." Surely, this aim could not be materialised with a fluctuating kg. When the 26th CGPM in Versailles, France unanimously voted for the redefinition of four of the seven SI base units in November, 2018, the Members were indeed realising the founding dream of the metric system. The four SI units, viz. kilogram (the unit of weights), ampere (the unit of electric current), Kelvin (the unit of temperature) and mole (the unit for an amount of a substance) were redefined in terms of the four respective fundamental physical constants, viz. the Planck's constant (h), the elementary electric charge (e), the Boltzmann constant (k) and the Avogadro's number (N_A). These changes had been suggested by the CIPM (International Committee for Weights and Measures) earlier in 1918. In the new definition, the kg is based on the fundamental

relationship between mass and energy that are interconvertible. Compared to mass, energy is easier to measure and define. The new kg is defined by taking the numerical value of the Planck's constant to be exactly $6.62607015 \times 10^{-34}$ J.s or $m^2.kg/s$, where the metre (m) and second (s) are defined in terms of c and $\Delta\nu_{Cs}$, respectively. According to the National Institute of Standards and Technology (NIST), a 'second' is considered as the time that is taken by a cesium-133 atom to go through 9,192,631,770 cycles of releasing microwave irradiation. A 'metre' is the distance that light travels in 1/299,792,458th of a second. In other words, the kg is redefined as the mass of 1.4755214×10^{40} photons that are oscillating at the same frequency as the cesium-133 atoms used in atomic clocks. Clearly, the new definition of the kg is dependent on the new definitions of metre and second as well.

To be practical, the new kg weighs, to within a few parts per billion, exactly as much as the old kg did. But the new definition enables one to carry the concept of mass anywhere in the universe without bothering to carry a cylinder with oneself. To quote a physicist of the NIST, "*Now a kilogram will have the same mass whether you are on Earth, on Mars or in the Andromeda galaxy*." The redefined kg will only matter in precise scientific measurements and calculations in, for example, 5G networks, quantum technologies, etc. Since the new definition is a physics-based approach, it would improve the quality of science. According to a report in vox.com, the new kilogram "*represents an impressive achievement: a victory of humankind against the chaos that pervades the universe*."

Adieu, Le Grand K and welcome, the new kilogram. ❐

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One-hundredth Year of Recognition of Discovery of Complement Protein

Different cells and molecules in mammalian body, *viz*. ciliated epithelial cells, macrophages, digestive enzymes, lysozyme, bacteriolysin, transferin, C-reactive protein, complement protein (CP) constitute the first line of defense against pathogens and are components of innate immune system. Complement system (CS) consists of 35 distinct soluble and membrane-associated proteins, circulate in blood and tissue fluids and play crucial role in host defense. Immediately after the pathogen is encountered, in classical pathway, antigen-antibody complex activates the CS; recognition of pathogen-associated molecular pattern (PAMP) by lectins activates CS in lectin pathway and it is activated by cell wall components of pathogen in alternate pathway. Activated components of CS are involved in bacterial lysis, chemotaxis and pathogen opsonization. Once pathogen-specific antibodies are generated, CS aids in clearance of immune complexes and pathogen elimination. Bridging innate and adaptive immune responses functionally, CS allows an integrated defense to invading pathogens, can elicit highly-efficient immune responses, both inflammation and to pathogenic organisms, 'complementing' the antibacterial properties of antibody.

The first Nobel Prize (NP) in Physiology/Medicine after World War I was awarded to Belgian immunologist Prof. Jules Bordet (1870-1961) in 1919, who revealed the identity and behaviour of CP at just 25 years of age. While working under Sir Elie Metchnikoff (awarded NP in 1908) at Pasteur Institute in Paris, Prof. Bordet explained that cholera bacterium *Vibrio cholerae*, if introduced into peritoneal cavity of a guineapig immunized against cholera, will be killed (sero-agglutination) within minutes and two components in guineapig's serum co-operate in this bacteriolysis ability; 1st one derived from immunity acquired through previous exposure to *V. cholerae*, *i.e*., specific antibody and 2nd one already present in serum of both immunized and non-immunized animal. This distinct 2nd component, called CP, was discovered by Prof. Bordet in 1895 and it added a new facet to immunology. It does not survive heat, so cholera immunoserum from the guineapig will be unable to kill *V. cholerae* in *in-vitro* conditions if heat-treated or preserved and antibody alone cannot perform the function.

It was thus deciphered that bactericidal property (and also marked protective effect) of immune antibodies created and released into blood stream to specifically target an invading bacterium is dependent upon and attributed to presence of immunity factor CP in body fluid. CP worked in each case together with specific antibodies against first one and then another bacterium. Prof. Bordet confirmed that CP does not react with antibody in free solution, but only after binding to the antigen on sensitized cell. In a similar manner to bacteriolysis, Prof. Bordet experimentally showed that if RBCs of a different animal are introduced into host, it induces to form specific antibody in host and foreign RBCs are lysed (blood hemolysis) in presence of

CP. Thus, like bacteria, body cells foreign to a host can be used for immunization and for studying immunological properties. This discovery and observation were of enormous practical benefit and paved the way to further research works on immunology. His research work was vital to diagnosis and treatment of many contagious diseases. Examining the specific way in which CPs bind to antibodies and with a view that fixation of the CP with known microbes can be used to determine true nature of a disease, Prof. Bordet developed a medical test, termed 'complement-fixation test' for detecting disease-causing agents in human blood. By detecting antibody to specific pathogens, diagnosis of quite a few infections like typhoid fever, tuberculosis, syphilis has become possible. As recognition to the discovery of CS/CP, Prof. Bordet was awarded NP and year 2019 happens to be the 100th year of his Nobel award. He was Director of the Pasteur Institute, Brussels from 1900 until 1940 and Professor of Bacteriology at the University of Brussels during 1907-1935 (honorary after 1935).

Significantly, Prof. Bordet worked passionately to promote peace and limit weapons of mass destruction until his death. He was deeply aware of the social consequences of science. In 1924, he joined a group of scientists in lobbying the League of Nations regarding the dangers of poison gas use in future wars. In 1958, similar motivation led him to join other scientists in calling for suspension of nuclear bomb testing. In the 1st International Microbiological Congress in Paris in 1930, Prof. Bordet stated: '*We hope to reawaken a sense of profound interest in the welfare of humanity and to renew a consciousness of the imperious necessity of concerted defense against the causes of destruction which threaten it and of the growing need for people to adopt the supreme objective of their own preservation and the development of humankind*'. Prof. Bordet has been described as 'One of twentieth century's preeminent medical minds' and came to be regarded as world's leading immunologist. ❐

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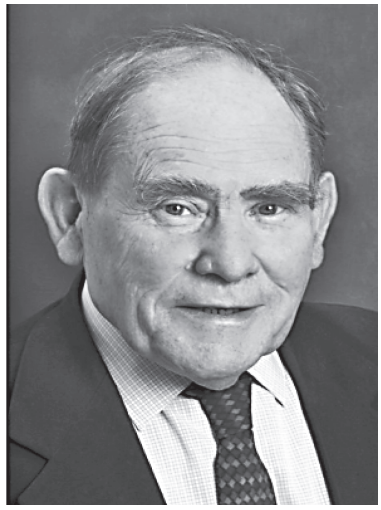
Sydney Brenner, NL - 'enfant terrible of Molecular Biology' - Passed Away at the Age of 92

Nobel Laureate Sydney Brenner, a pioneer in molecular biology, passed away on Friday, April 5, 2019 in Singapore where he permanently resided in a hotel. In collaboration with others, he discovered 'triplet codon' and mRNA and used a transparent soil roundworm to unveil information that shed light on the pathogenesis of diseases such as cancer, Alzheimer's and AIDS. The Nobel Prize in Physiology or Medicine 2002 was awarded jointly to Sydney Brenner, H. Robert Horvitz (MIT) and John E. Sulston (Wellcome Trust Sanger Institute, Cambridge, England) "*for their discoveries concerning genetic regulation of organ development and programmed cell death*."



Sydney Brenner (13.01.1927-05.04.2019)
Photograph: Jan Pitman/AP

Brenner was born on January 13, 1927 in Germiston, the then Transvaal, South Africa to Jewish parents - Morris Brenner, a cobbler migrating from Lithuania, and Lena Brenner (née Blacher) migrating from Riga, Latvia. He had his early education in Germiston High School. His progress in the school was very good, which fetched him a bursary from the town council at the age of 15 to enable him to study medicine at the University of the Witwatersrand, Johannesburg.

Caenorhabditis elegans
Photograph: MPG/EPA

While studying medicine, he simultaneously did a Bachelor's degree in Anatomy and Physiology, a two-year Honours degree and finally (1947) a Master's degree in Medical Biology. Brenner completed his medical degree in 1951 and moved to Exeter College, University of Oxford, U.K. in 1952 to carry out doctoral research under the supervision of Sir Cyril Hinshelwood (1956 NL in Chemistry) with a scholarship. In 1952, Brenner married May Balkind (née Covitz), a fellow South African divorcee with one child (Jonathan) and doing Ph.D. in psychology in London.

After Watson and Crick had just deciphered DNA double helix model, Brenner along with Dorothy Hodgkin and others drove to Cambridge in April, 1953 to see the model. This visit imbibed in Brenner a desire to work with Crick in molecular biology. After receiving his D. Phil degree from the University of Oxford in 1954, Brenner spent a brief postdoctoral research at the University of California, Berkeley and returned to South Africa in 1955 as a Lecturer in Physiology at the University of the Witwatersrand. Nearly three years later, Brenner returned to England to join the MRC Molecular Biology Research Unit (later restructured as MRC LMB) in Cambridge in January, 1957 to work with Crick. Since then Brenner settled in England.

In 1961, Brenner, in collaboration with Crick, discovered that DNA is read by organisms as a 'triplet codon', the code for each of the 20 amino acids being a sequence of three non-overlapping bases (out of A, C, G, T). In 1961, Brenner, in collaboration with Francois Jaçob (a French biologist) and Matthew Meselson (a US geneticist), proved the existence of short-lived 'messenger' RNA (mRNA) – molecules that carry the information from the triplet codons to ribosomes (cellular machines) which synthesise proteins.

In the late 1960s, Brenner (then affiliated with Molecular Sciences Institute, Berkeley, California), Sulston and Horvitz used a millimetre-long, transparent soil roundworm *Caenorhabditis elegans* as a model to reveal how our cells are programmed to proliferate, specialise and die. This seminal work fetched the trio the Nobel Prize in 2002. Brenner dubbed this nematode as the "*Nature's gift to science*." The DNA of this worm helped them to understand how uncontrolled cell growth causes cancer and their death leads to neurodegenerative disorders, heart attacks and AIDS.

Brenner held many important assignments in U.K., U.S.A., Singapore and Japan. In his later life, Brenner advised Agency for Science, Technology and Research, Singapore (A*STAR) who recently announced Brenner's death. His autobiography "*Sydney Brenner: A Life in Science*" was published in 2001. His lectures (2017) on molecular biology were later published as a book "*In the Spirit of Science: Lectures by Sydney Brenner on DNA, Worms and Brains*" (WSPC, 2018). He received many awards and honours including the Lasker Award (1971), Royal Medal (1974), Companion of Honour (1987), Honorary Citizen of Singapore (2003), Grand Cordon of the Order of the Rising Sun, Japan (2017), etc.

Brenner used to write a monthly column entitled "Loose Ends" (later renamed "False Starts") in *Current Biology* in the pen name 'Uncle Syd', which bear testimony to his wicked sense of humour. He was variously known as 'chutzpah personified', 'enfant terrible of molecular biology', 'eminence grise', 'the father of the worm' and 'the funniest scientist who ever lived'. He strongly believed that ignorance is important in science.

Brenner is survived by three children – Stefan, Belinda and Carla. ❐

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EnviroConf 2019: Combating Air Pollution with Biological Resources

A conference, EnviroConf 2019, to commemorate the World Environment Day (WED) 2019 was organized by West Bengal State University as a part of its SHE initiative on June 4, 2019 in the Conference Room, the academic tower, with the theme being 'Sustainable Management of Biological Resources in Overcoming Public Health Challenges of 21st Century'. After the welcome address, delivered by the EnviroConf 2019 Convener, Dr. Shankarashis Mukherjee, the Guest of Honor, Dr. Asoke K. Sanyal, Chairman, West Bengal Biodiversity Board, was felicitated by Professor Basab Chaudhuri, the Vice Chancellor of the University, with an 'uttario'. EnviroConf 2019 was then formally inaugurated by the Hon'ble Vice Chancellor of the University, Professor Basab Chaudhuri with his address, in which he talked about the importance of the WED. He encouraged the students and research scholars for attending, participating and thanked the conference organizing committee. A large number of students studying different subjects – Anthropology, Botany, Chemistry, Commerce, Food and Nutrition, Human

Development, Physiology, and Zoology, in different colleges - spread across different parts of the district - affiliated to the university, along with their teachers, participated in the conference. Some of them also presented interesting posters on the theme of the conference, along with the research students from host university and other universities.

The keynote speaker Dr Asok K. Sanyal was introduced by the Vice Chancellor. In his thought provoking keynote address Dr. Asoke K. Sanyal, Chairman West Bengal Biodiversity Board, raised several issues ranging right from the publication of 'Silent Spring' by Rachel Carson to the enactment of several legislation for the protection of environment in India. He also elaborated on the impact of air pollution on biological resources including human beings, keeping in tune with the theme of the WED 2019. After his address the panel of adjudicators of the poster presentation, consisting of the Keynote Speaker Dr Sanyal and senior Professors of the University evaluated the posters, interacted with the presenters. After the evaluation session, the adjudicators held a meeting and announced the names of the awardees. The first prize was bagged by a researcher from University of Calcutta, the second prize was shared between a team of researchers led by two young teachers from Bhairab Ganguly College and Barrackpore Rastraguru Surendranath College, both affiliated to West Bengal State University. The third prize was collectively given to a team of undergraduate students from the Department of Botany, Acharya Prafulla Chandra College and Dr. APJ Abdul Kalam Govt College and a group of researchers led by a young teacher from Bashirhat College, affiliated to West Bengal State University. There were also in addition Special Mention Awards. The prizes were given by the Chairman, West Bengal Biodiversity Board. The conference came to an end with the formal Vote of Thanks offered by Dr. Shankarashis Mukherjee, the EnviroConf 2019 Convener. ❐

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