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The Midnight Kingdom

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

EDITORIAL

Some interesting lessons for predators and parasites from nature

Dr. R. Gopichandran

I am writing this editorial as a chemical ecologist. In this context, I can be seen as an accidental communicator. However, I had the advantage of working closely with leading ecologists and specialists engaged in the development and implementation of policies for sustainable development. This has been consistently so for more than two decades and a half. However, an important mainstay has been communication and therefore, I thought I should extend the logic of lessons from chemical and microbial ecology to the dynamics of impact of science communication in the science and society interface. Two interesting examples of lessons from nature that have guided the evolution of industry landscape around the world are about industrial metabolism and eco-industrial networking. Mutually beneficial exchange and use of materials and energy considered as wastes, for further recovery and reuse are essential elements of this framework. This implies a dynamic equilibrium between generators of waste and the ability of end users of waste to optimise on energy and material-related metabolism. Another typical example in biological systems is about the coevolution of resistance in hosts and its influence on concurrent adaptive abilities of predators and parasites. This implies robust host searching behaviours and deriving nutritional and other protection benefits from the host. The host in turn continues to evolve safeguards and not succumb entirely to survival pressures exerted by the predators and the parasites. Is it possible for institutions to learn useful lessons about coexistence and tackle pressure exerted by zealots, in this context?

Let me go back to the same phenomena of biochemical and physically expressed resistance mechanisms of the host. This is with special reference to plant hosts and I derive my inspiration from my understanding of insect-plant interactions. Several genotypic and phenotypic adaptations are seen in these bio-systems and they are aligned with rapid induced resistance and delayed induced manifestations. Interestingly the host and the phytophagous elements/parasites continue to coexist. Importantly, chemical ecologists may or may not often be able to capture the implications of such continually co-evolving resistance mechanisms at the very instance they evolve. They can define the occurrence of such resistance either as an event in the past or expected to evolve in the future. Cross-resistance phenomena baffle our management strategies further. The most important take-away for institutions in this context is the wisdom that hosts are always sensitive to the infection and infestations they are exposed to. They do everything to optimise on energy systems to protect themselves and often accommodate the parasite, and in the case of predators, only partly succumb to predatory pressures. The latter is evident with a decrease in the population size of the host; nevertheless seeds sprout again and newer generations of hosts emerge.

Let me extend this ability of plant hosts to coexist to the framework of institutions, especially in the field of science communication. It is important to ask if institutions engaged in science communication are resilient enough to accommodate exaggerations and understand controversies. Are they also able to acknowledge the open-endedness of science and ask if they know about things and aspects and knowledge systems they do not know? Is it okay for communicators to engage in self-aggrandisement and in this process not be inclusive enough to understand or acknowledge the wisdom co-communicators can bring into the landscape of science communication. Zealots should not become overenthusiastic (!!!) and assume they can transform institutions in a jiffy. Mutual respect is therefore the name of the game and this respect should be evident in understanding each other's limits and limitations while serving the larger agenda of truth and inclusiveness for the benefit of fellow citizens in our country. The agenda of science and the agenda of inclusiveness are more important than the agenda of propagation one's own assumed wisdom or the lack of it.

These undercurrents of the dynamics of science communication, I believe, are extremely important to create and foster healthy respect for each other. This will also demonstrate the true spirit of inclusiveness that science stands for. Co-evolution is the other facet of such a coming together. Nature is truly benevolent. She also teaches us that it is possible and rather essential to co-exist.

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INTERVIEW

Scientific research is a challenging job: Mashelkar

Manish Mohan Gore

We need to inculcate a scientific worldview in the society as well as within ourselves. This is a pre-requisite if we want to become a developed country. We should always keep in mind that we cannot move forward until we adopt a rational approach.

Dr Raghunath Anant Mashelkar is an eminent Indian scientist and a former Director General of the Council of Scientific & Industrial Research (CSIR). Dream-2047 presents to its readers his views on an array of topics related to science, technology, innovation and development of scientific aptitude in the country. The following interview is based on Dr Mashelkar's conversation with Manish Mohan Gore of Vigyan Prasar.

Manish Mohan Gore (MMG): You are a renowned scientist with an impressive record of research work in polymer science. Working in several important capacities including the Director General of CSIR and the Director of the National Chemical Laboratory (NCL), you have served the country well. Tell our readers about your childhood, education and family.

Raghunath Anant Mashelkar (RAM): Born into a poor family, I lost the father at the age of six. My mother was illiterate. However, she was convinced that education is the only key to a bright future. She endured many hardships and took up small jobs in Bombay (now Mumbai) to support my studies. Whatever the circumstances, mother ensured that my education was never affected. Although left unlettered herself due to many harsh adversities, she dreamt of providing world's best education to her son. I completely owe my PhD and Post-Doctorate to her efforts.

MMG: What motivated you to become a scientist?

RAM: Mr Bhave was the principal of my school. He also taught science. He was an exceptional teacher. He focussed more on learning through experience than mere cramming answers that could fetch marks in examinations. He once took us to a soap factory to show its functioning. Demonstrating how ordinary sunrays focussed through a lens could burn paper, Bhave taught the importance of mental focus in achieving success. I took his lessons to heart and fascinated as I was, by the power of science, I resolved to become a scientist.

MMG: What do we need to do to have more scientists like you in India?

RAM: Teachers play a pivotal role in developing any nation and producing great scientists. They are the fundamental source

Dr. Manish Mohan Gore is a popular science writer. He has been serving Vigyan Prasar since 2007. E-mail: mmgore@vigyanprasar.gov.in.

of good education and inspire the students to dream big. Therefore, the role of the teachers in this regard can never be over emphasised.

MMG: How did you promote innovation during one-and-a-half decade-long tenure at the CSIR?

RAM: I found it strange that no two laboratories of CSIR communicated with each other. They all worked in isolation. This was surely not the way to promote scientific research. After assuming the responsibility of the Director-General, I adopted various ways to increase coordination among these labs. I united them into 'team CSIR.' My efforts were bearing fruit by the time my tenure was ending. It was a matter of great satisfaction to see CSIR labs working in tandem.

MMG: India has a long history of scientific enquiry. What path of research should Indian scientists adopt to fuel the country's growth?

RAM: The whole world acknowledges India's contribution to science and technology. We have enriched this field in many aspects. Our scientists are exceptionally talented. We must guide them to adopt latest streams of research. They must strive to make new discoveries and invent new technologies to enhance India's standing among other countries.

MMG: Any scientific research involves certain risks. It has its own highs and lows. How to make sure our scientists overcome these vicissitudes to carry out cutting-edge research?

RAM: This is an important question. Due to its uncertain nature, scientific research requires great patience. Failures are as much a part of this process as the successes. A true scientist remains unfazed in all these situations. The government needs to support them at every level. We can succeed only when we are ready to take risks. Trying to avoid these perils would also keep you away from achieving your goal. The scientists are encouraged to innovate and set new benchmarks when the government is willing to share their risks.

MMG: Tell our readers about your philosophy of perilous nature of scientific research and giving new ideas to the world?

RAM: As the Director-General of the CSIR, I tried to motivate scientists by challenging them to test their limits. Working under the New Millennium Development Goals, I encouraged them to take risks. I told my scientists to try to introduce a hitherto new idea to the world. I assured to back them even in their failures. This approach had yielded results and the country benefitted through many new ideas.

MMG: How can your concept of 'Gandhian Engineering' contribute to the society's development?

RAM: The idea of 'Gandhian Engineering' is simple; to meet maximum results through frugal means. We should use our country's modest resources in a wise manner. Our inventions and innovations should be for uplifting the living standards of rural as well as urban population.

MMG: India was among the first nations to introduce a Science Policy in 1958. This was followed by implementation of several other programmes related to science, technology and innovation. How do such policies and programmes affect the lives of common citizens, directly or indirectly?

RAM: Look, every policy drives a country and its society towards a direction. It guides investment into that particular sector. But, ultimately it changes lives only when implemented in the right and judicious manner.

MMG: How do you see current innovation in the contemporary scientific research?

RAM: Any scientific research transforms money into knowledge. However, with innovation, you can convert knowledge into money. Every prestigious university imparts education, teaches science and innovation at the same time. In India, we believe Sarasvati (the Hindu goddess of knowledge) and Lakshmi (the Hindu goddess of prosperity) should be worshipped separately. We can attain both knowledge and prosperity by combining education, science, technology and innovation. Our current Prime Minister has taken an ambitious initiative like the 'Start-Up India campaign. It provides an excellent opportunity to integrate employment with skill development.

MMG: The government, as well as non-government agencies, are making many efforts to popularise science. Do you think they are sufficient to change people's mentality and thought process?

RAM: First, We need to inculcate a scientific worldview in the society as well as within ourselves. This is a pre-requisite if we want to become a developed country. We should always keep in mind that we cannot move forward until we adopt a rational approach. How many dilemmas do we have in our thinking? For example, we are proud of our *Mangalyaan* (Mars Orbiter Mission), yet believe that *Mangalik* people are not fit for marriage. Such thinking only reflects a lack of scientific temper. How can such a society prosper? I would like to emphasise the missing scientific viewpoint in our society. We need to nurture it.

MMG: Please shed some light on the role of the science communications industry in this goal?

RAM: We derive several of our customs from science. Yet many of them are irrational as well. Therefore, the role of organisations like the *Andh Shradha Nirmoolan Samiti* becomes significant. They should create awareness against superstition by educating the society through scientific tools like practical experiments and demonstrations.

MMG: What is your message to country's future scientists?

RAM: I had the chance of a brief meeting with the Former US President Barack Obama during his visit to India. He asked me what type of science I do. My answer to Obama would be my message to all aspiring researchers. I told President Obama, "I do science that is for the welfare of all." It is my sincere wish that scientists work for this cause and contribute to the human progress.

MMG: Our gratitude for sharing your valuable thoughts with the readers of Vigyan Prasar's popular science magazine 'Dream-2047.'

RAM: My best wishes to you, Vigyan Prasar and the 'Dream-2047' magazine.

(Translated by: Deepak Sharma)

The Midnight Kingdom



Jayashree Das, Saleem K, Pradipta Banerjee

Deep-sea hydrothermal vent organisms are often cited as examples of adaptation to extreme environmental conditions. The list of organisms that thrive in the environment is vast, ranging from crabs, shrimps, snail, mussels, fish and tube worms and numerous bacteria. If adaptation is the key to survival, then the vent dwellers have definitely excelled in it.

Adaptation is the key to survival. Over the ages the Earth has experienced a wide variation of environments ranging from extremely arid to moist, oxygen-rich environment and even to complete freezing of its oceans. Yet, life persists. And the key to the persistence of life to cling on to this lump of rock circling a large dense fusion reactor star is a method termed as adaptation.

Be it primates or bacteria, most life on Earth, either directly or otherwise, is heavily dependent on the Sun for energy. Be it evergreen forests with majestically rising pine cones, lush savanna with tall brown grass swaying to the wind, the merciless dry and unforgiving heat of the Kalahari desert, or the intense near-frozen waters of the arctic, living beings draw their energy from the Sun. However, there are desolate corners in our Earth where the light of Sun never shines and stark alien environmental conditions prevail. Imagine then a dark sunless world within the heart of a deep and cold ocean, where ambient temperature ranges more than 400°C, with pressures that could easily crush a human lung into a thin bed sheet and where the only gas for breathing is the deadly hydrogen sulphide (H_2S); conditions sufficient enough to kill aerobic organisms within minutes, but life thrives even here. Welcome to the hydrothermal vent, home of a unique ecosystem running in the depths of ocean completely independent of the sun and teeming with life.

A hydrothermal vent, as seen in Fig. 1a, is a fissure in a planet's surface from

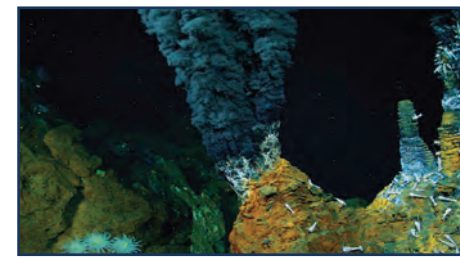

Fig. 1(a). The kingdom of sulphur. a. A black smoker. On the left hand side, two deep-sea anemones are visible and the right vent is teeming with eyeless shrimps. (Photograph courtesy Woods Hole Oceanographic Institute)

which geothermally heated water issues. They occur at a depth of 2,000 to 5,000 metres, where the pressure ranges from 200 to 500 atmospheres. They were first discovered in 1977 and are commonly found near volcanically active places or areas where tectonic plates are moving apart. Earth is technically a hot planet; it still has a core with temperature matching the surface of the Sun. According to the tectonic plate theory, continents are actually giant rocks floating on a sea of molten magma. In places where the continents are drifting apart, a ridge is created that allows the extremely hot magma to come very close to sea water.

When the cold seawater, normally at 2°C, sinks down through the cracks in the crust, energy radiating up from molten rock deep beneath the ocean floor raises the water's temperature to around 350-400°C. The huge crushing pressures at these depths prevent the water from converting into vapour state. As the water heats up, it loses oxygen and gets

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enriched in sodium, calcium and potassium. As it sinks further and comes close to the magma, the water reaches extremely high temperatures and starts dissolving copper, zinc, lead and iron along with sulphur salts from the rocks. Hot liquids are less dense and therefore more buoyant than cold liquids. So the hot hydrothermal fluids carrying dissolved material rises up through the crust and spews out from cracks. As the hot gas mix with cold oxygen rich sea water, metals and sulphur combine to form various sulphide salts that resemble smoke coming out of an industrial chimney. Hence these vents are also termed as "black smokers". The entire process is depicted in Fig. 1b

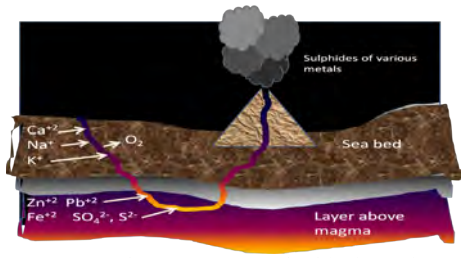


Fig. 1(b). Formation of a black smoker. As the water percolates through cracks in the sea bed it leaches out mineral from the rocks. When it becomes superheated, it rises out of the rocks through other cracks and releases the mineral-rich water on the sea bed. The water cools and the minerals deposit around the point of issue, slowly forming a vent.

So on one side we have super-heated water saturated with toxic chemicals rising up from a crack in the ocean floor and slightly away from it the dark, cold immensity of the ocean depths, both un-supportive of life by themselves. Therefore, the inhabitants of this underwater sulphur kingdom cling to a thin "comfort zone" between being burnt alive and starving to death. Deep-sea hydrothermal vent organisms are often cited as examples of adaptation to extreme environmental conditions. The list of organisms that thrive in the environment is vast, ranging from crabs, shrimps, snail, mussels, fish and tube worms and numerous bacteria. What morphological and biochemical adaptations allow a group of creatures to survive environments this extreme?

The first adaptation in this realm of sulphur is the most common one – to acquire sustenance. The easiest way of getting food in the tumultuous environment is to carry a cook with you all the time. This is exactly what the vent residents do. Its numerous inhabitants live in a symbiotic give-and-take relation with a number of guests that they carry around – microorganisms. It is a win-win situation for both the host species and the guest microbes. The fragile microbiota gets a place to thrive and proliferate in a harsh environment along with a constant supply of raw materials, while the host species ensures that it gets a sizable portion of the food prepared by the bacteria.

Take for example, the "Yeti crab" (*Kiwa hirsute*), a resident of a depth of 7,200 feet, living near vents close to Easter Island in the Pacific (Fig. 2). The name of

Fig. 2(a). The Yeti crab. (Photographs courtesy of Thatje et al. 2015, Plos One and Weissmann, 2007 FASEB journal. a. Complete top profile of the crab showing the carapace with "smiley".

Fig. 2(b). A male crab crawling on bed of the vent near sea anemones.

Fig. 2(c). A detailed and magnified view of the crab's claw.

the crab is derived from *Kiwa*, the goddess of shellfish in Easter Island mythology. But among marine biologists, the crab is known as the "Yeti crab," after the hirsute snowman of Himalaya legend. One look at the picture and you can guess why – the crabs have their body covered with a special fur like bristles that host a class of symbiotic bacteria clinging on to individual strands of the fur. Armed with large claws and body covered in bacteria, the Yeti crab moves about in a field of worms and mussels, always on the lookout for an unsuspecting prey.

The vent snail (*Crysomallon squamiferum*) has little similarity with the rest of the mollusk kingdom inhabitants. Unlike its brothers dwelling on the surface which has a soft underbelly, the feet of the vent snail is armoured with scales made of iron,

Fig. 3(a). The "armoured" vent snail. a. A close up of the snail showing the thick iron sulphide crystals sticking to the muscular foot.

Fig. 3(b). he body of the vent snail with tentacles and mouth is visible. The ventral side (the foot) of the body is flat with no iron crystals.

as is evident in Fig. 3. Some of them contain so much iron in the outer layer that they are actually attracted to magnets. Even the shell is unusual in that its structure is composed of three layers. The inner layer is made of a calcium ore, the middle layer is organic and the third layer made of iron sulphides, which acts as a shock absorbent. When the shell is subjected to a high pressure, like an attack from a hungry crab, it cracks around the mineral particles, absorbing energy, thereby blunting and deforming the predators' claws. The snail hosts a class of bacteria called proteobacter inside its tissues which take up sulphates from the vent and use it to prepare simple carbohydrates releasing H_2S in the process.

But the most amazing inhabitant of the vent would be the Pompeii worm (*Alvinella pompejana*), depicted in Fig. 4. It is a polychaetous annelid (ringed or

Fig. 4(a). Pompeii worm. The mouth is covered with tentacle like structure that actually work as gills. The red colour arises due to the presence of haemoglobin. The body is covered with bacteria that detoxify the sulphide giving the worm a protective mat.

segmented worm) inhabiting the surface of deep sea hydrothermal chimneys in the Pacific ridge. It is considered the most heat-resistant worm known to mankind as it can survive effortlessly in temperatures of 50°C. To survive in such extreme environments, the Pompeii worm makes paper-like tube colonies attached to hydrothermal vent chimneys that are heat resistant. The material which the worm uses to build its tube consists of the extracellular protein

Fig. 4(b). PA Pompeii worm coming out of its tube-like shell built on the walls of the vent.

collagen and long chains of sugar molecules with added sulphur and amine groups along with minerals. Armed with this, the worm grows a centimetre thick thermal blanket across its back that is composed of colonies of filamentous bacteria that detoxify the poisonous H_2S gas surrounding the vent.

Most of these symbiotic species depend on sulphur for their sustenance, and for good reason. Sulphur is an element that can exist in a wide range of oxidative states. The sulphur biogeochemical cycle, with its broad range in valence (–2 to +6), exhibits a complex interplay between biotic and abiotic processes in hydrothermal vent ecology. The sulphates (SO_4^{2-}) from the hydrothermal vents are taken up by the symbiotic bacteria and are reduced step by step to sulphides (S^{2-}). Each reduction helps in production of ATP and carbohydrates by the bacteria which it shares with its host. The end product consists of H_2S, which add up to the H_2S released by the vent. As the gas traverses up and reaches oxygen-rich sea water, it oxidises to sulphate. Though this medium of energy production is common amongst many inhabitants, it is certainly not the only one.

Arguably, one of the most remarkable vent animals is the giant tube worm (*Riftia*

Fig. 5(a). Giant tube worms swaying their plumes near a vent. The worm can withdraw its plume into the white chitin covering when a predator approaches.

Fig. 5(b). The plume functions like a gill which traps CO_2, H_2S and O_2. The plume is red because of high concentration of haemoglobin. The white part is made out of chitin and holds the fragile body of the worm.

pachyptila), depicted in Fig. 5, from the Galápagos Rift and East Pacific Rise. *Riftia* lack a mouth and a digestive system, and depend completely for growth and reproduction on organic matter produced by their endosymbiotic chemosynthetic bacteria. These bacteria are found densely packed in an organ that spans the interior of the animal's body, called the trophosome. The tubeworm absorbs hydrogen sulphide, carbon dioxide, and oxygen through its well irrigated plume, which acts like a gill and transports them to the trophosome (an organ that houses bacteria that completely nourish their host) via the vascular system.

Unlike other life forms, *Riftia* takes up H_2S, a common end product of other bacteria and oxidise it to produce sugars that it shares with its host. The catch is that sulphide is actually toxic to most life forms and therefore H_2S absorption could be fatal to the host worm. However, evolution has provided *Riftia* with specialised haemoglobin that can bind both oxygen and sulphide tightly and directly deliver it to the microbes where they are metabolised. The symbiotic bacteria, which belong to a subdivision of the proteobacteria, oxidise the H_2S to sulphur (S) and then to sulphate (SO_4^{2-}). The oxidation occurring at each step helps in production of ATP and NADH, both of which fuel other metabolic cycles and produce energy. Both processes involving sulphides and sulphates

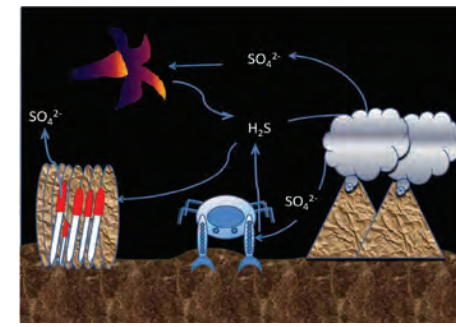


Fig. 6. A cartoon depicting sulphur utilisation by various vent inhabitants. The Pompeii worm (top left) and the Yeti crab harbour bacteria which convert SO_4^{2-} into H_2S, while the giant roundworm contain microbes that converts H_2S into SO_4^{2-}. Both processes help in building energy and synthesising food.

for energy production are depicted in Fig. 6.

Every discovery paves the way to newer questions and further discoveries. Strange creatures come to limelight almost every year with each new excursion into these treacherous depths. Here, in these midnight zones, the complete absence of light means that the inhabitants have no use for vision and are limit their communication through touch only. The dwellers of the deep hurdle on, unaware of season changes, of storms or sunshine, or of underwater strong currents, a conglomeration of blind beings, prey and predator alike, living side by side on a thin stretch of heaven separated by a hair's breadth from certain death. If adaptation is the key to survival then the vent dwellers, moving from one bottleneck event to another, have definitely excelled.

Anecdotes from the life of scientists

Ravindra Vaze

We know about scientists from the inventions and discoveries made by them. Path breaking inventions and discoveries need hard work, dedication and scientific methodology. However, in pursuit of science, there are interesting incidences and humorous moments in life of many scientists. The article provides a few glimpses.

Louis Fieser was a major figure in organic chemistry in the 20th century. With the approach of the Second World War, he was drawn increasingly into the war-related projects. Koji Nakanishi, a distinguished Japanese scientist and a student of Louis Fieser, relates a humorous anecdote of Fieser during the Second World War. He recalls, "Fieser had a stuffed bat in the office lab, and one day, he told me what it was about. Bats go into the dormant state in thin air and cold temperature. Utilising this fact, Fieser obtained a contract from the army in the early 1940's to attach tiny incendiary time bombs under the wings of bats which would be carried in bombers high up into the air. Upon being dropped over Tokyo, the bats would wake up from dormancy, flap their wings and set off the time switch. By habit, the bats would fly under the roofs of wooden houses in Tokyo and set Tokyo on fire. The last stage of the project was tested in the deserts of New Mexico. All went well except that the bats flew into the military hanger, blew it up and destroyed the planes. This was the end of the project".

Louis Fieser

• • •

In 1820, one Monsieur Pelletan from Paris made a journey to Manchester, UK, with the sole intention to meet the distinguished founder of the atomic theory. He was under the impression that Dalton must be holding a high public position, surrounded by students and collaborators. But on the contrary, in search of his giant of science, he found him in the company of a boy.

John Dalton

The visitor in some doubt, asked him," Am I addressing Mr. Dalton?"

"Yes. Please wait till I put this boy right about this sum!" came the reply.

• • •

Way back in 1930's, Oppenheimer's story achieved a wide notoriety. It involved him and Melba Phillips, his first doctoral student.

Oppenheimer along with Melba was on a tour to Berkeley Hills. After some time had elapsed, the Berkeley Police had found Melba fast asleep in the car. When awakened she said Oppie had driven her up there and she had no idea of his whereabouts. After a search they found him asleep in his room at the faculty club. The story was picked up

Oppenheimer

Dr RavindraVaze is a guest faculty of Mumbai University Sub-Centre, Ratnagiri. One of his articles has been cited as reference by Dr. C.N.R. Rao in his recent book "Lives and times of great pioneers in chemistry" published by World Scientific publishing Co,2016. Email: ravindravaze@rediffmail.com

by the media as an example of an absent minded scientist. But Oppenheimer was defensive and said that he had told Melba that he was going to walk home and that she could drive the car back. It appears that she dozed off and did not hear him!

• • •

As judged by academic standards, Moseley was an unsuccessful student at Oxford. Moseley himself said that at the time of graduation from Oxford his mind was so full of cobwebs that he could not think of serious research. But at Manchester, Lord Rutherford saw the spark in him and hired him as a demonstrator. Moseley was assigned the project of counting particles emitted by radium, which earned him a research fellowship. He along with Charles Galton Darwin (grandson of the famous naturalist Charles Darwin) decided to work on the behaviour of X-rays. For this, he took lessons from William Bragg.

Moseley

Moseley plunged into this project with almost manic intensity. Darwin writes "He was the hardest worker I have ever known. He often worked throughout the night and learned how to find a meal in Manchester at three in the morning."

Once Darwin told him that at this time of night he should be in bed. Moseley's reply was, when he was feeling well, he wanted to take a walk in the country. But when he was tired, he wanted to do laboratory work!

• • •

Niels Bohr gave a welcoming address to each new group of research students and their spouses arriving at Copenhagen Institute. The wife of one of the newcomers related how she sat through the welcoming address by Bohr, noted the enthusiastic applause from the audience and then turned to her neighbour at the lecture to tell him how eager she was to hear the English translation. He looked at her a moment and gave her the bad news. That was the English translation!

Niels Bohr

Bohr as a public speaker was spectacularly brilliant. His low voice did not carry far and his accent was an added problem. He often switched from language to language, without warning.

• • •

Carl William Scheele, a Swedish chemist of the 18th century discovered a number of new chemical substances in a short lifetime of just 44 years. He was known for his work in scientific circles all over the world.

Once, King Gustav III of Sweden happened to visit Paris. A deputation of French scientists met him and applauded the work of Scheele. Although King Gustav had little interest in science; he ordered that Scheele should be immediately raised to the dignity of a Count.

Carl William Scheele

His minister who also knew nothing of Scheele, ordered his secretary to find Scheele. The secretary promptly brought the following details about Scheele: "A brilliant lieutenant in our army with a first rate hand at billiards!"

The minister immediately summoned the lieutenant to court and was felicitated as Count.

Ironically, Scheele the renowned chemist was nowhere in the picture, but a lieutenant bearing the same name received an unexpected reward!

• • •

Sir C.V. Raman was the first Indian physicist who was awarded the Nobel Prize in physics for his work on scattering of light. He is well known for the discovery which came to be known as Raman Effect

Sir C.V. Raman

Raman was a teetotaller throughout his life. At a party in Europe he was offered a drink. Raman declined and quipped: "Gentleman, you can study the Raman Effect on alcohol but not the effect of alcohol on Raman"!

• • •

Sir J.J. Thomson, discoverer of electron was a professor of experimental physics at the University of Cambridge. He was a workaholic and had little time for anything else. One of his co-workers persuaded him to buy a new pair of trousers. Thomson did so, went back to his home, wore it and returned to his office. In the meantime Mrs. Thomson was out for shopping and on her return found the old trousers lying on the bed. She promptly telephoned the office and informed that her absent minded husband had gone back to his office without any trousers on!!

Sir J.J. Thomson

• • •

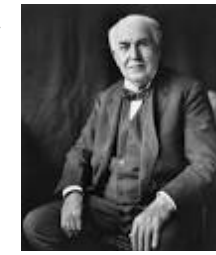
Sir Henry Cavendish an English chemist of the 18th century was one of the greatest scientists of his time. He is well known for his researches in gaseous chemistry and the theory of electricity. He was the richest man and owned several houses in London.

Although an ardent devotee of science, he was socially an awkward and eccentric person. He never married and could not stand the sight of women.

Returning home one day he found his maid on the staircase with a broom. He was so disgusted that he immediately decided to put another staircase on the back side of his residence. He used to exchange words with the maid from the opposite side of a closed door!

• • •

Thomas Alva Edison was one of the greatest American inventors credited with the invention of the phonograph, electric bulb and motion picture camera.



Thomas Alva Edison

Once he was invited at a social function. Getting weary of the boring proceedings, he decided to leave. Quietly as he moved to the exit door, the host interrupted and said-"Sir, it is a great honour to have your presence here. Could you tell us about the invention you are presently working on?"

Edison retorted: "At this moment I am working on my exit from here!"

Of Poisonous Snakes and Snakebites—Identifying the medically-important species

Dr. Yatish Agarwal

A good clinical management of snake bite victims must rely upon correct identification of the species of snakes, apt first aid, robust assessment and diagnosis of clinical signs, and appropriate use of supportive treatment and anti venom serum in victims who truly require the anti venom treatment.

Known to be a home to more than 270 species of snakes, thousands of snake charmers and millions of snake worshippers, present day India carries the highest mortality in the world due to snake bites. Though estimates vary, more than 50,000 Indians lose their lives to snake bites each year, and considerably many times more suffer a bite.

Of the large number of snake species found in the country, just 15 are poisonous; among them, four, namely the cobras, the Russell's viper, the saw-scaled vipers, and the kraits are the deadliest and most common.

A severe life-threatening medical crisis in the countryside and peri-urban parts, snake bite fatalities mostly occur due to lack of proper first aid, and the non-availability of effective medical care. In fact, many of the victims are unable to receive proper medical treatment as they do not reach a modern well-equipped hospital in time.

A good clinical management of snake bite victims must rely upon correct identification of the species of snakes, apt first aid, robust assessment and diagnosis of clinical signs, and appropriate use of supportive treatment and anti venom serum in victims who truly require the anti venom treatment. Since a large majority of snakes are non-poisonous, their bites generally cause little harm apart from panic reaction and local injury.

Geographic distribution of poisonous snakes

Each geographic region of the country has a preponderance of specific snake species. While kraits are common in the hilly terrains of the northern Himalayas, saw-scaled viper is the most notorious snake in western Indian states of Rajasthan and Maharashtra. In the eastern parts like West Bengal, Russell's viper, kraits and cobras produce most of the snake bites. The hump-nose pit viper is the deadliest culprit in the states of Kerala, Tamil Nadu and Maharashtra, whereas Russell's viper dominates in Kerala, and all four species namely, the cobras, the Russell's viper, the saw-scaled viper and the kraits are known to cause deaths in Tamil Nadu.

Identifying the poisonous snakes

Unfortunately, there is no simple rule for identifying a poisonous snake. In fact, some harmless snakes have evolved to look almost identical to poisonous snakes. Examples are various species of harmless snakes such as wolf snake, and Blanford Bridle snake that mimic the appearance of the kraits, and the many-spotted cat snake that mimics Eastern Russel's viper.

However, recognising the species of the snake which has struck can be most useful in its clinical management. While some of the poisonous snakes disrupt the nervous system of the human body, others

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have a deadly effect on the blood coagulation and blood pressure regulation apparatus of the body.

Some venomous snakes can be recognised by their size, shape, colour, and patterns of markings, and behaviour and the sound they make when they feel threatened. For example, the defensive behaviour of the cobras is well known: they rear up, spread a hood, hiss and make repeated strikes towards the aggressor.

Their colour can vary a lot. However, some patterns, like the large white, dark-rimmed annular (ring) spots of the Russell's vipers or the alternating black and yellow circumferential bands of the banded krait are distinctive. The blowing hiss of the Russell's viper and the grating rasp of the saw-scaled viper are warning and identifying sounds.

The Indian cobra

Found throughout India, the Indian cobra, also known as "nag" is a highly poisonous snake. It prefers open forest edges, fields, and the areas around villages as its habitat. The Naja naja primarily feeds on rodents, lizards, and frogs.

The Indian cobra varies much in colour and pattern. It has transversely elongated scales that extend down the underside of the body from the neck to the tail. The belly can be grey, yellow, tan, brown, reddish or black in colour. Salt-and-pepper speckles, especially in adult cobras, are seen on the dorsal scales. Adult cobras also often exhibit a significant amount of mottling on the throat and on the belly.

Many specimens exhibit a hood mark. This hood mark is located at the rear of the Indian cobra's hood. When the hood mark is present, two circular eye spot patterns connected with a curved line, evoke the image of spectacles.

The Indian cobra can easily be identified by its relatively large and quite impressive hood, which it expands when threatened. The majority of adult cobras range from 1 to 1.5 metres in length. The king cobra enjoys an average length of 4-5 metres

When on the attack, the cobras raise the front part of their body off the ground and spread and flatten the neck to form a hood. Several species of cobra can spit their venom for one metre or more towards the eyes of perceived enemies.

Indian Krait

Found in the deep jungles, the Bungarus, commonly referred to as the krait, is one of the deadliest snakes of the world. Their average length is 1 metre, but they can grow up to 1.5-1.8 metres. Males are longer, with proportionately longer tails. The body is cylindrical, tapering towards the tail. The tail is short and rounded. The eyes are rather small, with rounded pupils.

The common krait is generally black or bluish-black in colour, with about 40 thin, white crossbars which may be indistinct or absent on its anterior surface. The pattern, however, is complete and well defined in the young, which are marked with conspicuous crossbars. In old individuals, the narrow white lines may be found as a series of connected spots, with a prominent spot on the vertebral region. A white spot may be present in front of the eyes; and the upper lips and the belly are white.

Russell's Viper (Daboia)

Found all over India, the Russell's viper has a local name of Koriwala or Daboia. It is one of the most venomous snakes, and next to the krait causes thousands of human deaths each year. The smallest of the big four most dangerous snakes of India, it has an average length of 1.2 metres and is dark brown, deep yellow, tan, or brownish-gray in colour, with three series of dark brown spots that run down the length of the body. Each of these spots has a black ring around it, the outer border of which is intensified with a rim of white or yellow. The spots on the back, which usually number 23–30, may grow together, while the side spots may break apart.

A Russell's viper head has a pair of distinct dark patches; one on each temple, together with a pinkish, salmon, or brownish V or X marking that forms an apex towards the snout. The head is flattened, triangular, and distinct from the neck. The snout is blunt, rounded, and raised. The nostrils are large, each in the middle of a large, single nasal scale. The crown of the head is covered with irregular, strongly fragmented scales. The two upper jaw bones support at least two and at the most five or six pairs of fangs at a time: the first are active and the rest replacements. The fangs attain a length of 16.5 millimetres in an average-sized viper. The body of Russell's viper is stout, the cross-section of which is rounded to circular.

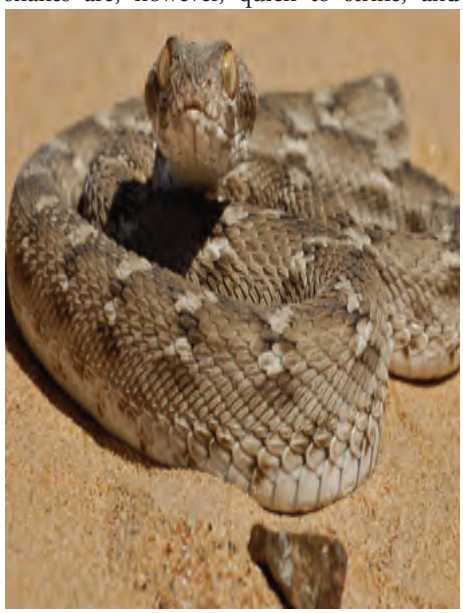
Saw-scaled Viper

The Indian saw-scaled viper is a small viper from an eight member viper family. A fully mature saw-scaled viper is 0.3 to 0.9 metre long, and may be covered in various shades of brown, gray, or orange with darker dorsal blotches and lateral spots.

Characterised by a stout body with a pear-shaped head that is distinct from the neck, it possesses a short thin tail. On both sides of its body, there are several rows of obliquely arranged serrated scales.

Saw-scaled vipers move by side-winding movement. They are nocturnal, and come out at the time of twilight to hunt for food, which includes mammals, birds, snakes, lizards, amphibians, and invertebrates such as scorpions and centipedes.

Saw-scaled vipers are small, yet their high irritability, aggressive behaviour, and lethal venom makes them extremely dangerous. When alarmed, saw-scaled vipers move slowly with the body looped into S-shaped folds. The oblique scales are rubbed against each other to produce a hissing sound, which is a defensive alarm used to warn potential predators. These snakes are, however, quick to strike, and



mortality rates for those bitten are high. In the regions where they occur, it is believed that saw-scaled vipers are responsible for more human deaths than all other snake species combined.

Indian Pit Vipers

Found in most of the peninsular India's hills, the Indian Green Pit Viper, also known as bamboo snake or tree viper, is one of the most common members of the pit viper family. An adult pit viper is 70 to 110 centimetres long. It can easily be identified by its triangular head which is much broader than the neck and is covered with very small scales, a green dorsal surface marked with rich or faint black markings, and a yellow belly.

The top of the head is pattern-less, and the eyes have a vertical pupil. The body is somewhat slender, and is covered with lightly keeled scales. The colour of the upper body ranges from yellowish-green to bluish-green and is marked with rich or faint black irregular markings. Juvenile members have more prominent markings as compared to adults. The belly is mostly yellow in colour, though sometimes it may be greenish-white without any pattern. It has a short tail which ends with a pointed tip.

The Indian Green Pit Viper is slow to move. It is usually calm, shy in behaviour, non-offensive and its first instinct is to try and escape. Only if provoked or threatened, it throws half of fore body into loose loops with head on the top, and draws into a mock attack. If it is approached from close, it may inflict a bite. The green pit viper feeds on frogs, lizards and insects.

A native of Western Ghats of India, the Malabar pit viper is another member of the pit viper family. It is also highly venomous. Other vipers found in India include the bamboo pit viper, and the hump-nosed pit viper.

Sea Snakes

Found in the Indo-Pacific waters, the banded sea krait, also known as the yellow-lipped sea krait, is one of the highly venomous sea snake found in India. It regularly takes to land to drink fresh water. This snake's tail is often mistaken for its head by oncoming prey, which it uses to its advantage. A beautiful and shy animal, this slim snake releases venom more potent than many of the land snake species.

Significance of identification

Since each of the poisonous snake releases a different kind of venon, identifying the memebr which has struck, can help initiate the most effectiv e line odf treatment. In a tight medical situation, this can prove life saving.

(In the next issue: Of Snakebite Poisons - The First Aid Measuewa and Warning Signs)

Recent Developments in Science and Technology

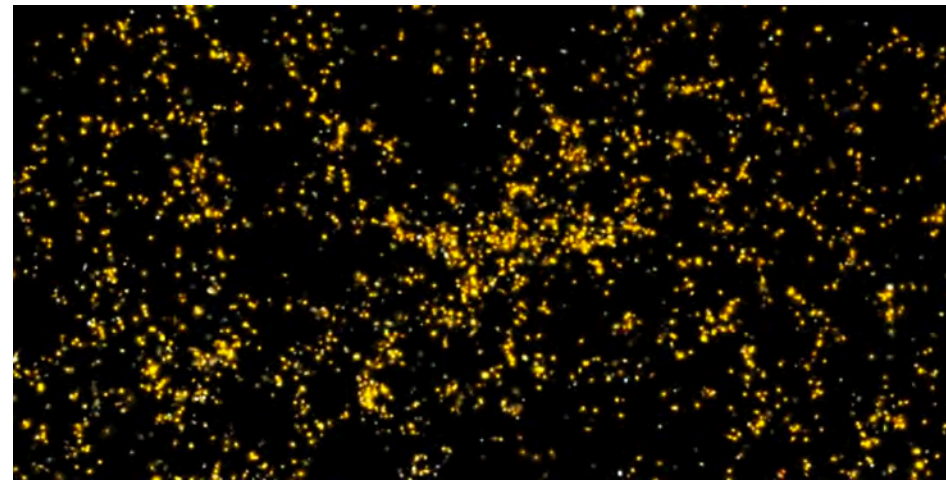
Biman Basu

Till 2008, when India's first lunar probe Chandrayaan-1 went into orbit around Moon, the Earth's closest neighbour was believed to be bone-dry, with no trace of water. But Chandrayaan-1 changed all that. The Moon Mineralogy Mapper or M3 on-board Chandrayaan-1 has confirmed existence of water on Moon.

Saraswati supercluster of galaxies discovered

Galaxies are like the building blocks of the universe, they contain a huge number of stars, often more than 100 billion. Our universe is made up of billions galaxies, but the galaxies are not distributed evenly; they are found in small groups known as clusters and very large groups called superclusters. The Milky Way is part of the Local Group galaxy cluster that contains more than 54 galaxies. It is a part of the Laniakea supercluster that extends over more than 500 million light years.

A supercluster is a cluster of smaller galaxy clusters and is among the largest-known structures of the cosmos. Recently a team of astronomers from the Inter-University Centre for astronomy and Astrophysics (IUCAA), Indian Institute of Science Education and Research (IISER), both in Pune, and two other Indian institutions – NIT, Jamshedpur and Newman College, Thodupuzha – have identified a previously unknown, extremely large supercluster of galaxies located in the direction of constellation Pisces. The supercluster has been named 'Saraswati'. At over 600 million light years across, the Saraswati supercluster of galaxies is one of the largest structures in the universe and is at a distance of 4,000 million light-years away from us (*The Astrophysical Journal*, 19 July 2017 | https://doi.org/10.3847/1538-4357/aa7949). Due its huge distance, the Saraswati supercluster as observed is actually as it was when the universe was 10 billion years old.



The distribution of galaxies, from Sloan Digital Sky Survey (SDSS), in Saraswati supercluster. It is clearly visible that the density of galaxies is very high in the Saraswati supercluster region. (Credit: IUCAA)

The author is a former editor of the popular science monthly *Science Reporter*, published by CSIR, He is a winner of the 1994 'NCSTC National Award for Science Popularisation'. He is the author of more than 45 popular science books. Email: bimanbasu@gmail.com

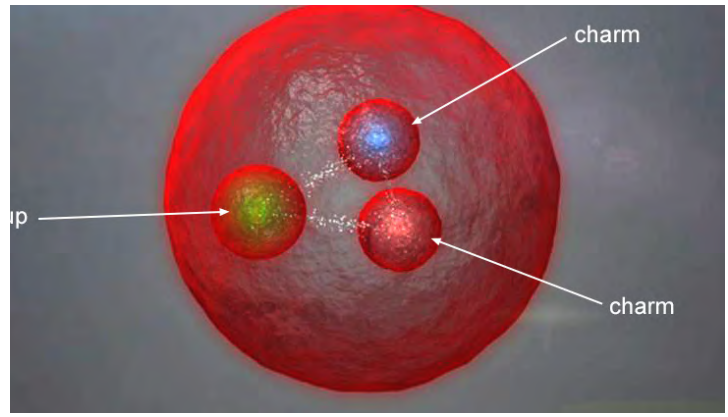
A supercluster is a chain of galaxies and galaxy clusters, bound by gravity that often stretches to several hundred times the size of clusters of galaxies, and consists of tens of thousands of galaxies. Within superclusters, clusters are connected by filaments and sheets of dark matter with galaxies embedded in them. The first supercluster of galaxies, the Shapley Supercluster, was discovered in 1989, and the second, the Sloan Great Wall in 2003. The Milky Way galaxy is part of the Laniakea Supercluster, which was discovered in 2014. According to its discoverers, the 'Saraswati' supercluster extends over a "great wall" about 600 million light-years across and is estimated to contain the mass equivalent of over 20,000 million million (20×10^{15}) Suns. It may be containing over 10,000 galaxies in 42 clusters.

According to Somak Raychaudhury, Director of IUCAA and a member of the research team that discovered the Saraswati supercluster, "We have a habit of naming galaxies after rivers; the Milky Way is referred to as Akash Ganga. So we thought of naming this supercluster after the ancient river Saraswati".

The researchers made the discovery while studying the particular region of the sky using data from the Sloan Digital Sky Survey (SDSS), which has created the most detailed three-dimensional maps of the universe ever made, with deep multi-colour images of one third of the sky, and spectra for more than three million astronomical objects. They found two clusters close by and suspected they were part of a larger group. Further studies revealed the presence of the supercluster. Joydeep Bagchi of IUCAA, the lead author of the *Astrophysical Journal* paper says, "We were very surprised to spot this giant wall-like supercluster of galaxies, visible in the SDSS. This supercluster is clearly embedded in a large network of cosmic filaments traced by clusters and large voids. Our work will help to shed light on the perplexing question; how such extreme large scale, prominent matter-density enhancements had formed billions of years in the past when the mysterious Dark Energy had just started to dominate structure formation."

Physicists find a particle with two charm quarks

Physicists using the Large Hadron Collider beauty (LHCb) experiment at CERN in Geneva, Switzerland, have discovered a new kind of heavy particle composed of two heavy 'charm' quarks and one much lighter 'up' quark. The LHCb (standing for 'Large Hadron Collider beauty') experiment is one of seven particle physics detector experiments collecting data at the LHC accelerator at CERN in Switzerland. The LHCb team led by Patrick Spradlin, a physicist at the University of Glasgow, found evidence of more than 300 of the new particles in data collected last year by the experiment. The mass of the newly identified particle is estimated at 3621 MeV, which is 3.8 times heavier than the most familiar baryon, the proton, a property that arises from its two charmed quarks. The new particle has been named Xi-cc++ (pronounced 'Ksī-CC plus-plus').



This illustration shows a new subatomic particle, Xi-cc++, in which a light 'up' quark circles a heavier 'dancing' pair of 'charm' quarks. (Credit: CERN/AP)

Quarks are elementary particles and fundamental constituents of matter. They come in six varieties, or "flavours," which have been given the names 'up', 'down', 'charm', 'strange', 'top', and 'bottom'. However, the meaning of these somewhat unusual names has nothing to do with the usual meaning of these terms. The six types of quark, together with their corresponding antiquarks, are necessary to account for all particles known as hadrons, which include the baryons and mesons. In hadrons the quarks are held together by the strong force. A baryon is a composite subatomic particle made up of three quarks, while mesons are composed of one quark and one antiquark. Protons and neutrons are the most common baryons. Nearly all the matter that we see around us is made of baryons.

Theoretically, many different potential combinations of the six quarks could form other kinds of baryons, but all baryons observed till now are composed of at most one heavy quark, although the existence of a particle with two heavy quarks had been predicted long ago. Says Spradlin, "The existence of these particles has been predicted by the Standard Model and their properties have also been predicted." Dr. Spradlin presented the findings at a European Physical Society conference in Venice on 6 July 2017 and a paper describing the work is to be published the journal *Physical Review Letters*.

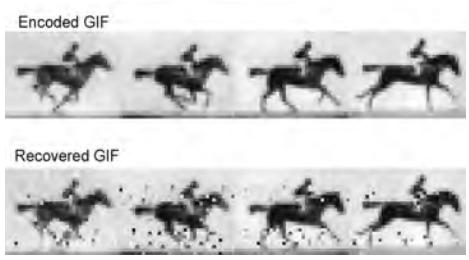
The researchers have also suggested a possible structure of the new particle. According to them, "in contrast to other baryons, in which the three light quarks perform an elaborate dance around each other, a baryon with two heavy quarks is expected to act like a planetary system, where the two heavy quarks play the role of heavy stars orbiting one around the other, with the lighter quark orbiting around this binary system".

According to the researchers, finding a doubly heavy quark baryon is of great interest, as it will provide a unique tool to further probe quantum chromodynamics (QCD) – the theory that describes the strong force, one of the four fundamental forces of nature. Moreover, further studies of the new particle – and other members of the doubly charmed particle family – could reinforce the Standard Model or lead to new vistas in particle physics. Either way, the new particle could be a tool to unlock a deeper understanding of the fundamental "strong" force that binds quarks together to form protons and neutrons, which in turn form atoms – as well as planets, stars, galaxies and people.

Scientists store a movie inside DNA

It is estimated that digital data will reach 44 trillion gigabytes by 2020, a ten-fold increase from figures in 2013. To store

such vast amounts of data scientists have trying to find alternative methods to store digital data. According to scientists, DNA is one of the best media for storing data. Last year, researchers from Microsoft and the University of Washington (UW) succeeded for the first time in using DNA as a storage medium. They developed a technique which allowed them to successfully encode four image files worth of digital data into the nucleotide sequences of small bits of synthetic DNA. That was just a beginning. Researchers have since crammed large amounts of information from books to digital images into tiny amounts of biological



At top are encoded frames of galloping horse from Eadweard Muybridge's photos. At bottom are the frames after multiple generations of bacterial growth, recovered by sequencing bacterial genomes. (Credit: Seth Shipman)

material. In theory, a gram of single-stranded DNA can encode 455 exabytes, (1 exabyte = 10^{18} bytes) or roughly data worth 100 billion DVDs.

Now scientists have gone a step further. A team at Harvard Medical School in Boston, Massachusetts, led by Seth Shipman, has used the CRISPR genome-editing tool to encode short animated image (GIF) into DNA. The GIF was made up of a few frames of a classic series of photos of a running horse captured by Eadweard Muybridge in 1872. Shipman encoded a GIF of Muybridge's running horse into DNA, and then inserted those strands into living *Escherichia coli* bacterium using CRISPR, which is best known as a tool for editing genes by cutting strands of DNA at precise locations. But it has another trait that is often overlooked: It is an amazing tool for recording information.

To begin with, Shipman and his colleagues converted the image of a hand into DNA code. To accomplish this feat, they broke the digital image into their pixels and used DNA to create a code for each pixel. The code contained information about the colour of the pixel and its location within the image. Then, the researchers inserted short DNA fragments containing these codes that they had synthesised, into *E. coli* bacteria, which they grew overnight. They then sequenced the part of the microbes' genomes where CRISPR information is stored, and decoded those sequences back into digital data. This allowed them to successfully recover the picture of the palm of a hand (*Nature*, 12 July 2017 | doi: 10.1038/nature23017).

Encoding the running horse GIF was more challenging because here it was not only necessary to encode each frame, but also the order of the frames. Fortunately, CRISPR makes that easy. When bacteria grab viral DNA, they always insert new sequences after old ones. So, according to the researchers, the CRISPR system naturally orders the information from newest to oldest. Shipman's team took advantage of that. They offered their bacteria the DNA strands representing each frame of the GIF, one by one. Later, the scientists sequenced the bacterial DNA to reconstruct the movie with 90 percent accuracy.

But, as Shipman says, "The *E. coli* is just a proof of concept to show what cool things you can do with this CRISPR system. The point is not to store videos in bacteria". Instead, the researchers ultimately want to create "molecular recorders" capable of recording the events inside cells as they play out. This could give researchers insight into cellular events that are hard to observe in real time, like the processes that occur during brain development.

Fortified banana to fight vitamin A-deficiency

Vitamin A deficiency is a severe condition, particularly in malnourished children and women in developing countries. It is the leading cause of preventable blindness – and can significantly increase the risk of disease from severe infections. Approximately one third of the world's pre-school-age population is estimated to be vitamin A deficient; with highest prevalence (44-50%) being reported in regions of Africa and South-East Asia. According to a 2013 report published in the *Journal of Health, Population and Nutrition*, India has the highest prevalence of clinical and subclinical vitamin A deficiency among South Asian

The bananas have golden orange flesh because of the increased provitamin A. (Credit: Queensland University of Technology)

countries; 62% of pre-school children were reported to be deficient in vitamin A. These dramatic results suggested high mortality rate, leading to an annual 3,30,000 child deaths. Women of childbearing age were also reported to excessively suffer from night blindness.

Treatment for subclinical vitamin A deficiency includes the consumption of vitamin A-rich foods, such as liver, meat, chicken, eggs, fortified milk, carrots, mangoes, sweet potatoes, and leafy green vegetables. It may also be treated by daily oral supplements of vitamin A. Now there is simpler way of preventing vitamin A deficiency – by eating genetically modified banana fortified with provitamin-A, which is converted into a vitamin when digested. Scientists in Australia have developed the fortified 'super' banana, rich in pro-vitamin A, which they say could save the lives of the hundreds of thousands of children who die from this deficiency every year. The golden-fleshed fruit was created by researchers from Centre for Tropical Crops and Biocommodities, Queensland University of Technology, Brisbane, who have been growing the biofortified bananas for over the last 10 years.

The provitamin A-rich bananas were created through genetic engineering. The researchers took genes from a natural species of provitamin A-rich banana found in Papa New Guinea, which only grows in small bunches. The genes were then fused with the genes of native banana sold in the market. According to the researchers, the result is an unusual orange-coloured banana that could significantly increase the vitamin-A intake of the consumer (*Plant Biotechnology Journal*, April 2017 | DOI: 10.1111/pbi.12650).

Bananas are the world's most

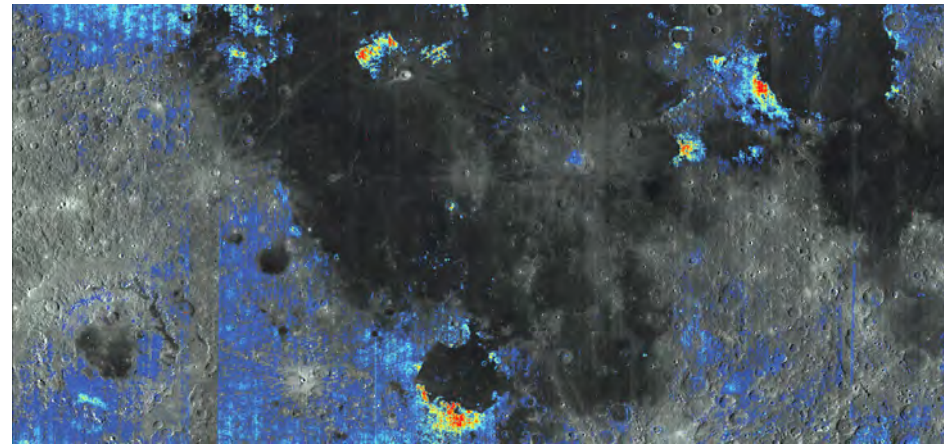
important fruit crop and one of the top 10 crops by production. They are widely grown in the wet tropics and subtropics forming an important dietary component both raw as a dessert fruit and cooked often as the major source of carbohydrate. In a number of countries, especially in rural Africa, cooked bananas is a staple food, so growing these provitamin A-rich bananas will help people meet the dietary requirement.

According to James Dale, who led the research, "Achieving these scientific results is a major milestone in our quest to deliver a more nutritional diet to some of the poorest subsistence communities in Africa. We tried and tested hundreds of different genetic variations here in our lab and in field trials in Queensland until we got the best results." Although the fortified banana was developed particularly keeping the people of Uganda in mind where vitamin A-deficiency among children is as high 38 percent, it will certainly be useful also in reducing the widespread vitamin A-deficiency in other developing countries including India.

Chandrayaan data show Moon's interior may be 'wet'

Till 2008, when India's first lunar probe *Chandrayaan*-1 went into orbit around Moon, the Earth's closest neighbour was believed to be bone-dry, with no trace of water. Analysis of moon rocks and lunar soil samples brought back by the Apollo astronauts did not find any evidence of presence of water in them. But *Chandrayaan*-1 changed all that. In 2009, by analysing the data collected from the lunar surface, NASA announced that the Moon Mineralogy Mapper or M3 on-board *Chandrayaan*-1 has confirmed existence of water on Moon.

The M3 instrument analysed how sunlight reflected off the lunar surface to identify water particles in which scientists observed chemical bonding similar to those found in water. However, the instrument can only see the very uppermost layers of the lunar soil – perhaps to a few centimetres below the surface. It cannot probe deeper. In 2013, NASA announced that what *Chandrayaan*-1 had detected was magmatic water, or water that originates from deep within the Moon's interior, but nothing was known about the amount of water in the moon's interior. Recent studies have shown that the Moon has as much water in its mantle as Earth's interior. Using satellite data, scientists have for the first time detected widespread water within ancient explosive volcanic deposits on the Moon, suggesting that its interior contains substantial amounts of indigenous water.



New research shows trace amounts of water trapped in ancient volcanic deposits on the Moon. The finding bolsters the idea that the Moon's mantle is surprisingly water-rich. Coloured areas indicate elevated water content compared with surrounding terrains. Yellows and reds indicate the richest water content. (Photo: Milliken Lab/Brown University)

The study was done by a team from Brown University in Rhode Island, USA, led by Ralph Milliken. The researchers analysed satellite data from the Moon Mineralogy Mapper, which measured reflected sunlight at visible and near-infrared wavelengths. In order to estimate the amount of trapped water in the volcanic deposits from the *Chandrayaan* data, the scientists had to isolate the reflected sunlight from the thermal energy emitted by the Moon's hot surface. Looking at wavelengths where the molecules of water (H_2O and -OH) absorb light, they found that there were larger absorptions, or less reflected sunlight, at these wavelengths for volcanic deposits, which indicates they contain -OH or H_2O. The new study found that numerous volcanic deposits distributed across the surface of the Moon contain unusually high amounts of trapped water compared with surrounding terrains. The researchers said that "the finding of water in these ancient deposits, which are believed to consist of glass beads formed by the explosive eruption of magma coming from the deep lunar interior, bolsters the idea that the lunar mantle is surprisingly water-rich" (*Nature Geoscience* 24 July 2017 | doi:10.1038/ngeo2993).

Says Milliken, "Our work shows that nearly all of the large volcanic deposits also contain water; so this seems to be a common characteristic of magmas that come from the deep lunar interior. Enhanced water content associated with lunar volcanic deposits and the widespread distribution and variable chemistry of these deposits on the lunar surface are consistent with significant water in the bulk lunar mantle. That is, most of the mantle of the Moon may be 'wet'".

In Memoriam: Prof. U.R. Rao & Prof. Yash Pal

Piyush Pandey

The Indian space programme is what it is today because of its four architects – Dr. Homi Bhabha, Dr. Vikram Sarabhai, Prof. Satish Dhawan, and Prof. U.R. Rao. Rao was the man who laid the foundation for the development of satellite technology in India. He is truly called the Father of India's satellite programme.

Within 24 hours India has lost two stalwarts in field of space science and education. *Dream 2047* pays its tribute to Prof. U.R. Rao and Prof. Yash Pal.

Prof. U.R. Rao

The Indian space programme is what it is today because of its four architects – Dr. Homi Bhabha, Dr. Vikram Sarabhai, Prof. Satish Dhawan, and Prof. U.R. Rao. Rao was the man who laid the foundation for the development of satellite technology in India. He is truly called the Father of India's satellite programme.

Udupi Ramachandra Rao was born in Adamaru village near Udupi in Karnataka on 10 March 1932. He did not attend school until he got admitted to class IV in his village school. He completed his secondary education from Christian High School, Udupi. He did his B.Sc. from Government Arts and Science College, Anantpur. In those days students from southern parts of India had to move northward in order to pursue higher education, particularly in science. He obtained his M.Sc. from Banaras Hindu University (BHU). His financial condition was very bad and he did not have eight rupees for paying the monthly fee at BHU. Only a scholarship later helped him. He did his Ph.D. from the Physical Research Laboratory, Ahmedabad under the guidance of Dr. Vikram Sarabhai.

He then went to Massachusetts Institute of Technology (MIT) at Boston, USA where he worked in the area of cosmic rays under Prof. Vikram Sarabhai. He also

Professor U.R. Rao (10 March 1932 - 24 July 2017)

served as assistant professor at University of Texas at Dallas. It was there that Rao got chance to carry out investigations as a prime experimenter on a few of the *Pioneer* and *Explorer* spacecraft. This eventually taught him how to make payloads for space missions, develop, construct and master spacecraft and satellite technology. Rao returned to India in 1966 as a professor at the Physical Research Laboratory, Ahmedabad. He took over the chairmanship of ISRO in 1984 and had a 10-year stint. During his period at helm work on development of rocket technology got the impetus. This resulted in the successful

The author is a Bengaluru based science writer. He is former Director of Nehru Planetarium, Mumbai, and founder Director of Jawahar Planetarium, Allahabad. He also worked with Birla Planetarium, Kolkata, and ARIES, Nainital in different capacities.Email: bokia@yahoo.com

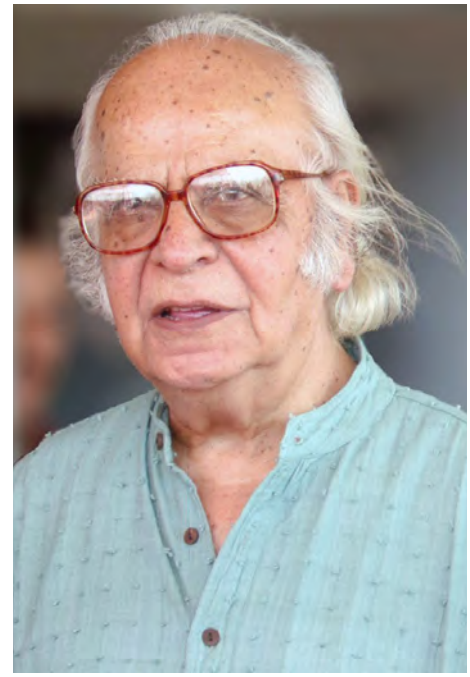
launch of ASLV rocket in 1992. He was also responsible for the development of the PSLV, GSLV and the development of cryogenic technology in 1991. During his stint at ISRO he was responsible for successful launch of *INSAT* satellites, which gave thrust to telecommunication in the country and helped India develop as an Information Technology hub. He was the first Chairman of Antrix Corporation – the commercial arm of ISRO. He was conferred Padma Bhushan in 1976 and Padma Vibhushan in 2017.

Rao published over 300 scientific and technical papers in various national and international journals. These covered cosmic rays, interplanetary physics, high-energy astrophysics, space applications and satellite and rocket technology. He has authored many books, such as, *Physics of the Communication*, *Space and Agenda 21 - Caring for the Planet Earth*, and *Space Technology for Sustainable Development*. He was inducted in International Astronautics Federation on 15 May 2016 - the first Indian to achieve this honour.

Rao was an elected Fellow of many scientific academies of the country and abroad. To name a few, Indian Academy of Sciences, Indian National Science Academy, National Academy of Sciences, Institute of Electronics and Telecommunications Engineers, International Academy of Astronautics and Third World Academy of Sciences, World Academy of Arts & Sciences. He was the General President of the Indian Science Congress Association for 1995-96. He was the Vice President of International Astronautical Federation (1984 to 1992) and till his death he continued to be the Chairman of the Committee for Liaison with Developing Countries (CLIODN) since 1986. He was elected as the Chairman of United Nations Committee On Peaceful Uses of Outer Space (UN-COPUOS) in June 1997 and also Chairman of UNISPACE-III Conference. He was the Co-Chairman of the National Centre for Antarctic and Ocean Research, Goa.

Prof. Yash Pal

Yash Pal Singh was born on 26 November 1926 in Jhang, which is now in Pakistan. As man of physics, he is known for his contributions to the study of cosmic rays. He will also be remembered as an educationist, institution-builder and science communicator. After doing M.Sc. From Panjab University (1949) and obtained his Ph.D. from MIT (USA) in 1958. He started his career at Tata Institute of Fundamental Research (TIFR) in the cosmic ray group.



Professor Yash Pal
(26 November 1926- 24 July 2017)

Prof. Yash Pal is credited with introducing the concept 'Learning without Burden'. As man of physics, he is known for his contributions to the study of cosmic rays. He will also be remembered as an educationist, institution-builder and science communicator.

The Department of Space was set up by the Government of India in 1972. This was the beginning of our space programme. Yash Pal became the first Director of the Space Applications Centre set up in Ahmedabad, in 1973, while he continued to be on the faculty of TIFR.

He had been the secretary general of the Second United Nations Conference on Peaceful Uses of Outer Space (1981-82). He had held the posts of chief consultant, Planning Commission (1983-84) and secretary, Department of Science and Technology (1984-1986), after which he was appointed chairman, University Grants Commission (1986-91). He was awarded Padma Bhushan in 1976 and Padma Vibhushan in 2013 for his contribution to science and space technology. In his later years, he became a leading science communicator of the country. In 2009, he received the Kalinga Prize, awarded by UNESCO for the popularisation of science.

During his tenure as UGC chairman, he advocated the setting up of Inter-University Centres funded by the UGC and the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune emerged from this vision.

He is also remembered for his involvement in betterment of school education. The path-breaking Hoshangabad Science Teaching Programme became possible due to his inspiration and vision.

He is also credited with introducing the concept 'Learning without Burden'. This he introduced while he was chairing the Steering Committee of National Council of Educational Research and Training (NCERT) in 2005 that had embarked upon the task of drawing a National Curriculum Framework.

The Ministry of Human Resource Development (MHRD) set up a Committee on Higher Education in order to reform higher education in India. The committee was called the Yash Pal Committee as he was its chairman. The committee gave several suggestions that included on how a university should function and advised some structural changes in higher education. It seems so far no government has taken any action on based on this report.