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Nobel Prize in Science 2017

# Nobel Prizes in Science 2017




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

EDITORIAL

# Some priorities for science communication management in India

***Dr. R. Gopichandran***

A compendium of good practices in science communication must be developed at the earliest. This is to bring to light the good work that is happening, especially at the grassroots level with implications for changes in the quality of life. This implies communication regarding natural resources management, energy, health and sanitation, crop protection and eco-system-specific bio-resources management in particular. I have deliberately chosen the entry point as reflected in the topics stated above. Science communication in this context means understanding the feasibility of using alternatives and enabling the implementation of measures for timely delivery of solutions; through robust knowledge management practices.

Theorisation of science communication practices in India is conspicuous by its absence. The role of communication barriers in translating the intents of communication into benefits and integrated information, education, and communication strategies to overcome them will be essential component of the proposed theorisation framework. Most importantly, the agenda behind communication has to be interpreted to establish that there was no ulterior with respect to an idea/philosophy and therefore, the centrality of transparency within the communication framework.

Collection of audio-visual, print and other knowledge products developed by communicators will help understand the richness of such interventions. The three priorities stated have to be addressed simultaneously. The larger objective is to demonstrate the fact that science communication has always been an integral aspect of citizen engagement in India. The fourth element with crosscutting relevance that will decide the success of communication strategies, i.e., about the interplay of regulations, market mechanisms and institutional mechanisms that brings stakeholders together. The impacts of science communication cannot be interpreted in isolation. We might end up trivialising science communication if these three parameters are not taken into account. My final call is about the urgent need to not trivialise science communication. It is probably the most robust unifying platform for knowledge centered engagement with citizens.

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# Swarnakumari Devi: The woman who led the scientific reawakening of India

***Dr Rakesh Kumar Dubey***

*Swarnakumari Devi was the first Indian woman to write effusively on subjects related to science. A perusal of her work makes it clear that Swarnakumari not only enriched common literature, but also the scientific intelligentsia of her time. She was instrumental in bringing the wonders of science to the masses, in a language that they could relate to. Swarnakumari continues to hold her place as one of the foremost reformers of the reawakening period of India.*

In the annals of Indian society's scientific reawakening, Swarnakumari Devi is a name written in golden letters. She was the first Indian woman to write effusively on subjects related to science. This was in addition to Swarnakumari's prowess as a prolific writer on social, political and cultural themes. She chose Bangla as the language of her expression. This made her writings accessible to the common folks in Bengal under the British Raj, including a large number of women. Swarnakumari managed to usher in a new movement introducing masses to science, a significant feat considering the odd circumstances of that era.

The process of revitalisation of the Indian society began from Bengal. The Renaissance originated in 14th century Europe, but it culminated in the land of Banga in 19th century India. The Bengali intelligentsia took up this baton of knowledge and brought the cresset of modern scientific thought for the first time to the sub-continent. The Bengalis had begun to take the lead in this respect from the early 19th century. This part of India had already taken early leads in religious and social reforms. Bengali was being enriched. Along with the idea of nationalism, scientific temper was also gaining ground. Among the leading lights of this ushering change was Swarnakumari Devi. Lack of high education and formal training never stood in her way. Hard work and perseverance make her a distinguished leader of her era.

*Swarnakumari Devi*

Swarnakumari Devi was born on 28 August 1855. She was the fourth amongst the daughters of Debendranath Tagore (1817-1905) and Sharda Devi. Schools were still a taboo for girls in those days. However, Debendranath Tagore appointed teachers at home. Swarnakumari learnt the polemics of Sanskrit, English, literature, painting, music, science, religion, political science and academics. She made up for the lack of degrees through self-study and diligence.

In 1868, Swarnakumari Devi was married to Janakinath Ghoshal, a well-educated landlord of Nadia district. The couple had two daughters and a son. Sarala Devi Chaudhurani, one of Swarnakumari's daughters, matched her fame as author and editor. Janakinath Ghoshal was among the

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*Kadambini Ganguly*

founders of the Indian National Congress. She joined the party in 1890 and took active participation in its sixth session held under the presidentship of Pherozeshah Mehta. It was the first conglomerate of the nascent party that was marked by women's presence. Kadambini Ganguly (18 July 1861-3 October 1923), India's first female graduate and physician, addressed this conference.

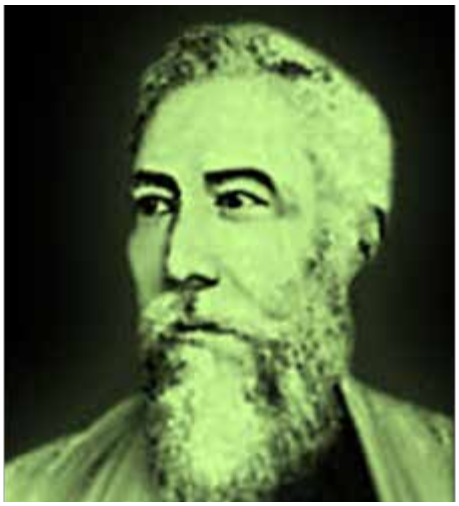
Swarnakumari's scientific aptitude was a family legacy. Debendranath Tagore was an ardent supporter of Western rational values. He had announced an annual grant of Rs. 1,000 to promote higher education in Bengal. Four Indian medical students were sent to England for higher education in 1845. Tagore bore the expenses of two of them. Out of these four, Bholanath Bose became the first Indian to earn an MD degree from the London University.

Swarnakumari Devi began her intellectual journey as a novelist and poet. Her first novel *Dipnirban* (The snuffing out of the light) was published in 1876. It was the first fiction to come out of the pen of a woman in modern Indian literature. Among her other novels are *Mibar Raj*, *Chhinna Mukul*, *Hughlir Imam Badi*, *Malati*, *Bidroha*, *Snehalata*, *Kahake*, *Phuler Mala*, *Bichitra*, *Swapnabani*, and *Milanrati*. She is also credited with plays *Koney Badal*, *Pak Chakra*, *Rajkanya*, and *Rajkamal*. Her poetry collections *Basanta Utsab*, *Gatha*, and *Gitiguchchha* were equally notable. Swarnakumari also wrote an essay collection titled *Prithibi*.

Apart from being a writer par excellence, Swarnakumari was also an adroit editor with a special focus on the emancipation of women. *Bharati*, a monthly magazine was in some ways a family venture. Jyotirindranath Tagore started it in 1877. Dwijendranath Tagore edited the magazine for first seven years. It was the ace journal of its time in Bangla literary world. In 1884, Swarnakumari Devi took charge as *Bharati*'s editor. For the next 11 years, the magazine reached new heights and her efforts played a key part in this journey. The daughter Sarala Devi Chaudhurani took the responsibility in 1895 and carried forward the good work for the next 12 years. Thereafter, the job was back to Swarnakumari for eight years. Besides regular writings of Swarnakumari, the magazine boasted of contributions from many leading female contemporary intellectuals in Bengali arena including Girindra Mohini, Sharat Kumari Chaudhurani and Anurupa Devi.

Swarnakumari Devi was as good a poet, novelist and social activist as a beacon of scientific ideas in the country. Her first essay on popular science, 'Bhugarbha', was serially published in four installments in *Bharati* (1880). After taking over the reins of the magazine in 1884, she gave prominence to articles related to science as part of her editorial policy. It was to introduce such women to the world of science who could not understand English. Swarnakumari wrote 17 scientific essays in *Bharati* from 1880-1889. In addition, she penned similar articles for *Tatvabodhini Patrika* magazine on a regular basis. Swarnakumari authored two dozen articles on scientific subjects during her career. Out of these, seven were related to geology and rest of them addressed contemporary trends in astronomy, natural sciences and physics. Her writings on these subjects were far ahead of her era. At a time when even literacy was out-of-bounds for most women, Swarnakumari's intellectual prowess and grasp over scientific topics were unrivalled.

*Sarala Devi Chaudhurani*



*Debendranath Tagore*

Swarnakumari Devi was among the earliest proponents of the movement to bring scientific knowledge to the masses in their own language. Several other Bengali journals of her time shared the same purpose. Most notable of them were *Kaumudi* (1860), *Vigyan Rahasya* (1871), *Vigyan Vikas* (1873), *Vigyan Darpan* (1876), *Sachitra Vigyan Darpan* (1882), and *Chikitsa Darshan* (1887). Scientific research was still an alien concept during this period in India. Therefore, these magazines could only publish translations from the western scientific publications. All they reported were news and views from the western scientific world. Besides, several popular Bengali magazines like *Tatvabodhini Patrika*, *Somprakash*, and *SamvadPrabhakar* also covered happenings of the world of science with an aim to instill a scientific temper among the people. Swarnakumari played a remarkable role in this endeavour through *Bharati* and *Tatvabodhini Patrika*.

In 1882, *Prithibi*, Swarnakumari Devi's collection of essays on science was published. It was a story of Earth's journey. The book was a tribute to her farther Debendranath Tagore. The titles of these essays themselves spoke for their progressive approach. These were 'Upakramanika-Bigyanshiksha' (Preface-Science Education), 'Sauroparibarborti Prithivi' (Earth—a Member of the Solar-Family), 'Prithibir Gatipranali' (Motions of the Earth), 'Prithibir Utpatti' (The Origins of the Earth), 'Bhupanjar I-IV Prastab' (The Earth's Surface

— I-IV Propositions), 'Bhugarbha' (Earth's Interiors), and 'Prithibir Parinam' (The Future of the Earth). In the introductory essay 'Science Education', she defined the inductive and deductive attributes of science, clearly distinguishing between the two. Swarnakumari's expression was lucid even while explaining the complexities of geology and astronomy. She used hand-drawn diagrams, commentaries and clear analysis to explain for the layperson the intricacies of the solar system, the Milky Way, the origin of the earth, nature and its formation.

Her presentation was free from science jargons, her words not burdened by the cumbersome theories. Swarnakumari's essays aimed at making inextricable scientific theories comprehensible to even the most ordinary mind. She took pains to find corresponding words in Bengali as all Indian languages were still untouched by modern science. She also used diagrams to complement her words. Following the evolutionary concept of 'the survival of the fittest', she believed in using the popular language to make a place among readers. She was the first Indian woman to develop, use and popularise scientific terminology in the country; that too, without any formal education and training.

The versatile writer sought to initiate and inspire scientific aptitude, not only in men but also the other half of the population. Formal studies in science were still out-of-bounds for women in those days. This situation continued even post-independence. No country has ever attained prosperity without the welfare of its women. Swarnakumari understood this fact earlier than the most people in modern India did.

Swarnakumari's scientific knowledge was bolstered by her voracious studying habits. Delving on various states of matter in 'The Fourth State of the Matter or Radiant Matter', she writes, "We experience matter only in solid, liquid and gaseous form. This was all scientists knew about matter till recently. However, English chemist and physicist Sir William Crookes claim to have discovered the fourth state of the matter." Explaining Sir Crookes' experiments on cathode rays, she elaborates, "No machine could create a complete vacuum in a glass tube till now, but, Sir Crookes has invented the method to suck out more air from the tube than ever before. He could reduce the


ভারতী

ভূমিকা।

*Bharti Patrika, First Volume, April 1877*

number of air atoms within this experimental tube to such an amount that wave paths could not only be recorded but also seen with naked eyes. Such a state of matter, when atoms are sparsely distributed, is the fourth state of the matter, better known as the radiant matter. The word 'radiant' here does not refer to any rays. However, the fourth state matters give off light as they are governed by special natural laws. Sir Crookes has derived the term 'radiant matter' from this glow discharge".

Another prominent work of Swarnakumari Devi was a review of Ramendrasundar Trivedi's work, *Prakriti*. Ramendrasundar Trivedi (1864-1919) was one of Bengal's well-known writers in the field of science. His body of work on popular science and scientific philosophy was significant. He also worked incessantly for the growth of the Bangiya Sahitya Parishad, one of the oldest literary societies in Bengal. Trivedi wrote *Jigmasa* (Collected essays on science) and *Prakriti* (Collected essays on philosophy). Swarnakumari's critique of the latter book was much appreciated among the literary circles. To comment upon the work of an intellectual of Trivedi's repute for a woman with no formal education was astounding.

Swarnakumari held a distinguished stature among the Indians who understood the importance of science in those days. She was politically active during the catastrophic division of Bengal in 1905. She ensured her participation in the swadeshi and boycott movement that followed. She vouched for women's education, Swadeshi and popularisation of science. She believed that if science is not improved then the true National improvement is never possible. According to her, India lags behind the western world in development due to a lack of practical training in science. She viewed poverty as the main obstacle to nation's progress and emphasised that it is solely by the power of science that this poverty can be eradicated. In Swarnakumari's opinion, the day science would bless us, that day we will make progress in all respects.

A perusal of her work makes it clear that Swarnakumari not only enriched common literature, but also the scientific intelligentsia of her time. She was instrumental in bringing the wonders of science to the masses, in a language that they could relate to. The way she contributed to develop science in India despite her academic shortcomings makes her an immortal name in the history of science. She was an embodiment of what women could achieve and earned respect for their creative capabilities. Analysing Swarnakumari's work, Brajendranath Bandyopadhyay wrote in his essay 'Sahitya-Sadhak-Charitmala', "Swarnakumari, a self-taught woman who lacked formal education and thus proper scientific training, is perhaps the first Bengali woman to write scientific essays." Deshbandhu Chitranjan Das has termed her as "one of the great nation-builders." The University of Calcutta honoured her with the Jagattarini Gold medal in 1927. Swarnakumari continues to hold her place as one of the foremost reformers of the reawakening period of India.

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**(Translation: Deepak Sharma)**

# Karl Schwarzschild and his last gift

*Dr. Utpal Mukhopadhyay*

*Schwarzschild has left this world a century ago. But his last gift in terms of seminal scientific work during his illness has made him immortal. Work of Schwarzschild has produced many new ideas such as Schwarzschild coordinates, Schwarzschild radius, Schwarzschild black hole etc. in the field of astrophysics. Even today, a beginner in the field of general relativity will have to know about Schwarzschild solution and its related topics.*

"*I do not think of the misery, but I think of the beauty that still remains*" – these lines were written by teen-ager Anne Frank, famous for his diary written while sitting under the spectre of death, hiding herself from the Nazis in a secret room, waiting for death which ultimately came within a short period. Like Anne, Karl Schwarzschild also, daunting the pain of his incurable disease, wrote three research papers, one of them being related to the solution of field equations of Einstein. Those pioneering papers have not only enriched the scientific world but also have paved the way for significant future research works.

## A biographical sketch

Karl Schwarzschild, son of Mojes Martin Schwarzschild and Henrietta Sabel, was born on 9 October 1873 in a wealthy and cultured Jewish family of Frankfurt, Germany. Karl, the eldest among five brothers and a sister, entered a primary school for Jewish citizens at an age of eleven. Then he entered the famous school Frankfurt Gymnasium. Karl showed his legendary talent very early when he wrote two research papers on the orbits of binary stars while he was barely sixteen years of age. In this connection we may recall that James Clerk Maxwell (1831-1879), a towering figure of science, wrote a research paper on the mechanical construction of Cartesian oval when he was fourteen years only. Anyway, while studying in the Gymnasium, Karl had an intimate friendship with Paul Epstein (1871-1939), who became a renowned mathematician afterwards. This friendship had a lasting effect on Karl who learnt techniques of using a telescope as well as some topics of higher mathematics from Epstein. Karl also constructed a small telescopeon his own when he was sixteen. After completing his studies in school, he studied in Strasbourgh University during 1891-93. Here, as well as in Munich University, Karl learnt theoretical and practical astronomy. He obtained a doctorate degree from Munich University by working on Poincare's theory under the supervision of Hugo Von Seliger. The title of his thesis was – *An application of Poincare's theory of stable configuration of rotating bodies to tidal*

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*deformation of moons and to Laplace's origin of the solar system*.

Karl was deeply influenced by the beautiful technique of teaching of Seliger which lasted throughout his life. After completing his research work, from October 1896 to 1899,Karl worked as an assistant in Kufnar Observatory situated at Ottering in the outskirts of Vienna. During his stay there, he worked on brightness of stars and discovered two variable stars. He deduced a formula for measuring the optical brightness of photographic material which was very useful for determining the brightness of deep-space celestial bodies.While he was in Kufnar, he wrote a thesis entitled *Bertridgezurphotographischephotometric der Gestrine*. After leaving Kufnar, he started working as a 'Privedozent' in Munich University. Around 1900, Karl pondered about the non-Euclidean character of the universe. In a paper at that time, he showed that the lower limit of the radius of curvature of the universe will be 64 light years if the universe is hyperbolic in nature; on the other hand the same limit would be at least 1600 light years if it is of elliptical nature. Relying on the assumption that the tail of a comet is made of spherical particles, he calculated the diameter of those particle as between 0.07 to 1.5 microns.

During 1901 to 1909, Schwarzschild was in the post of an Extraordinary Professor in Gottingen University. He also remained in the post of Director of Gottingen Observatory at that time. In Gottingen he had the opportunity to work with world famous scientists like David Hilbert (1862-1943), Felix Klein (1849-1925), Herman Minkowski (1864-1909) and others. In 1909, he became the Director of Astrophysical Observatory in Potsdam,which was the most prestigious post for any astronomer of Germany. On 22 October of that year, Karl married Else Posenbach, daughter of a Professor of Surgery of Gottingen. Karl and Else had three children– Agatha, Martin, and Alfred. Afterwards, Martin became Professor of Astronomy in Princeton University.

When First World War broke out in Europe, Karl went to the battlefield as a soldier of Germany. He had to go to both eastern and western front and he became a lieutenant. In 1915, while in the Russian front, he contracted a rare and painful autoimmune skin disease pemphigus vulgarisand consequently, at the end of 1915, had to return from the war front and in spite of his illness he wrote three remarkable research papers which can be considered as three jewels of the scientific world.

## Three gems of Schwarzschild

Near the end of 1915, the basic equations of general theory of relativity of Einstein were published. Before that Schwarzschild had returned from the war front due to his illness. However, in spite of his illness, he derived exact solutions of Einstein's equations for a spherically symmetric, non-rotating and uncharged body. Schwarzschildwas the first person in the world to achieve that success. Einstein himself could not imagine that his equations could be solved exactly because while dealing with the problem of perihelion precession of Mercury, he could find only approximate solution of his own equations. Einstein found approximate solution by using rectilinear coordinate system. But Schwarzschild arrived at the exact solution by judiciously employing generalised polar coordinate system. For this reason, when Schwarzschild sent his solution to Einstein, the latter, being amazed at the success of Schwarzschild, in a letter in 1916 wrote to him – "*I have read your paper with utmost interest. I had not expected that one could formulate the exact solution of the problem in such a simple way. I liked very much your mathematical treatment of the subject. Next Thursday I shall present the work to the Academy with a few words of explanation*." Einstein sent this paper of Schwarzschild to the Berlin Academy of Science on 13 January, 1916 (K. Schwarzschild; *Berliner Sitzungsber (1916),* page 189). This paper of Schwarzschild helps us to understand the gravitational field around a spherically symmetric mass. This very solution of Schwarzschild is called 'Schwarzschild exterior solution'. The solution is of immense importance in later research work related to black holes. This solution tells us that if the radius of a spherical body becomes less than a particular length, it is not possible to resist the gravitational collapse of that body and it will reduce to a black hole. That particular radius is called Schwarzschild radius.

If the mass of a body is M and its Schwarzschild radius is $R_s$, then$R_s$ = 2GM/$c^2$, where, G is the universal gravitational constant and c isthe velocity of light in vacuum.

It is clear from the above relation that Schwarzschild radius of an object depends on its mass. For instance, the Schwarzschild radius of the Sun is 3 kilometres. This means that if, due to contraction, the radius of the Sun becomes 3 kilometres then it will reduce to a black hole. Consequently, it will be invisible to an outside observer because its gravitational pull will be so strong that even light will not be able to escape overcoming this attraction. For our Earth, the value of the Schwarzschild radius is only 1 centimetre.

After publication of the paper mentioned earlier, in anotherpaper(Karl Schwarzschild; *Berliner Sitzungsber (1916),* page 414) Schwarzschild solved Einstein equation for a fluid of uniform density. This solution is called Schwarzschild interior solution. After these two seminal papers, Schwarzschild did another important work on Stark effect–the splitting and displacement of the spectral lines of atoms and molecules due to influence of external electric field. For this discovery, Johannes Stark (1874-1957) received the Nobel Prize in physics in 1919. Using Bohr-Sommerfeld quantum theory, Schwarzschild derived linear and quadratic equations of Stark effect for hydrogen. This paper of Schwarzschild was published posthumously (Karl Schwarzschild; *Berliner Sitzungsber (1916),* page548). Incidentally, Stark effect can be compared with Zeeman Effect where the splitting of spectral lines of atoms and molecules occur due to influence of external magnetic field. Undaunted byhis painful disease, Schwarzschild presented the scientific world three remarkable papers which can be considered as three jewels. Ultimately he succumbed to his ailment, leaving behind these three precious gifts. After Schwarzschild's demise, renowned astrophysicist Sir Arthur Stanley Eddington wrote in 1916 in *The Observatory* – "*The world loses an astronomer of exceptional genius, who was one of the leaders in recent advances both in observational methods and theoretical researches*."

## Legacy of Schwarzschild

It has been mentioned already that the idea of black hole can be found

*Continued on page 28*

# Nobel prizes in science 2017

***Biman Basu***


*The Nobel Prize is a annual international awards bestowed in several categories by Swedish and Norwegian institutions in recognition of academic, cultural or scientific advances. Nobel prize awarded in 2017 in Physics, Chemistry and Physiology or Medicine are mentioned in this article.*

Nine scientists, including seven from the United States, share the 2017 Nobel Prizes in science. Two lareates are from Switzerland and the UK.

The Nobel Physics Prize will be shared by astrophysicists Rainer Weiss of MIT, Cambridge, USA, and Barry C. Barish and Kip S. Thorne of California Institute of Technology, Pasadena, USA, "*for decisive contributions to the LIGO detector and the observation of gravitational waves*". Weiss will receive one half of the prize amount while the other half will be jointly received by Barry C. Barish and Kip S. Thorne.

Gravitational waves were predicted by Albert Einstein more than 100 years ago in his general theory of relativity. In 1916, Einstein had predicted that rapid movement of massive objects would create ripples in the fabric of space-time that would propagate at the speed of light throughout the universe. He also predicted that ripples caused by the motion of large masses like binary neutron stars or black holes should be large enough for us to detect them across light years on Earth. Scientists have been trying to detect the elusive ripples for several decades but without success till they were first detected by the Advanced Laser Interferometer Gravitational-wave Observatory, or LIGO, in USA.

The waves detected by the laureates came from the collision of two black holes some 1.3 billion light years away. A light year is about 9.5 trillion km. The Royal Swedish Academy of Sciences described the feat as "something completely new and different, opening up unseen worlds," "A wealth of discoveries awaits those who succeed in capturing the waves and interpreting their message," it added.

*Rainer Weiss* *Barry C. Barish* *Kip S. Thorne*

The Chemistry Nobel for 2017 has been awarded jointly to Jacques Dubochet of the University of Lausanne, Switzerland, Joachim Frank of Columbia University, New York, USA, and Richard Henderson of MRC Laboratory of Molecular Biology, Cambridge, UK, "*for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution*". Cryo-electron microscopy is a technique that makes it possible to portray biomolecules after freezing them very quickly so their natural shape is preserved. "The method simplifies and improves the imaging of biomolecules and has moved biochemistry into a new era", the Nobel committee said in a statement. The prizewinning work may lead to what the prize committee said were "detailed images of life's complex machineries in atomic resolution."

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*Jacques Dubochet* *Joachim Frank* *Richard Henderson*

Electron microscopes were long believed to only be suitable for imaging dead matter, because the powerful electron beam destroys biological material. But the laureates brought about modifications that allowed the biomolecules to retain their natural shape even in a vacuum, making it possible to image them using electron microscopy.

Following the work of the three laureates, it can be said that "every nut and bolt of the electron microscope have been optimised". The desired atomic resolution was reached in 2013, and researchers can now routinely produce three-dimensional structures of biomolecules. In the past few years, scientific literature has been filled with images of everything from proteins that cause antibiotic resistance, to the surface of the Zika virus.

The 2017 Nobel Prize in Physiology or Medicine will be shared by three Americans – Jeffrey C. Hall of the University of Maine, Michael Rosbash of Brandeis University in Waltham, and Michael W. Young of Rockefeller University in New York, USA, "*for their discoveries of molecular mechanisms controlling the circadian rhythm*". Circadian rhythms are 24-hour cycles driven by an organism's internal biological clock, also known as the circadian clock. The work of the three laureates explains how plants, animals and humans adapt their biological rhythm so that it is synchronised with the Earth's revolutions.

The three laureates used fruit flies as a model organism, and isolated a gene that controls the normal daily biological rhythm. They showed that this gene encodes a protein that accumulates in the cell during the night, and is then degraded during the day. Subsequently, they identified additional protein components of this machinery that revealed the mechanism governing the self-sustaining clockwork inside the cell. It is now recognised that biological clocks function by the same principles in cells of all multicellular organisms, including humans.

Our body's biological clock is involved in many aspects of our complex physiology. We now know that all multicellular organisms, including humans, utilise a similar mechanism to control circadian rhythms. A large proportion of our genes are regulated by the biological clock and, consequently, a carefully calibrated circadian rhythm adapts our physiology to the different phases of the day. Since the seminal discoveries by the three laureates, circadian biology has developed into a vast and highly dynamic research field, with implications for our health and wellbeing.

*Jeffrey C. Hall* *Michael Rosbash* *Michael W. Young*

## Karl Schwarzschild and his last gift *(Continued from page 30)*

from Schwarzschild solution. However, Schwarzschild himself didn't believe in the existence of black hole and regarded his own solution as meaningless so far as the real world is concerned. But, following the line of Schwarzschild solution, famous astrophysicist Subrahmanyan Chandrasekhar (1910-1995) showed in 1930 that if the mass of a star exceeds 1.5 times the solar mass, then instead of ending its life as a white dwarf, it would contract further. In 1934, Walter Baade (1893-1960) and Fritz Zwicky (1898-1974) gave the idea of a neutron star. Then around 1939, Robert Oppenheimer (1904-1967) and George Volkoff (1914-2000) worked on the possible structure of a neutron star. Many years after that, Roy Kerr (born 1934) propounded the idea of a rotating black hole.

After the discovery of quasar in 1963, Edwin Salpeter (1924-2008) of Cornell University, USA,thought about possible existence of super-massive black hole at the centre of a quasar.Pulsar was discovered in 1967. Thomas Gold (1920-2004) proposed that pulsar is a rapidly rotating neutron star. In 1968 John Wheeler (1911-2008) used the term 'black hole'in his article *Our Universe: the known and unknown*. Afterwards, many theoretical researches were done on the nature of black hole. A black hole is characterised by its three specialities, viz.,its mass, angular momentum and electric charge. Schwarzschild black hole is static and electrically neutral, i.e., its angular momentum and charge are both zero. Kerr black hole has rotation, but it is neutral, i.e., its charge is zero. On the other hand, Reisner-Nordstroom black hole has no rotation, but it is charged. Kerr-Newman black hole has all the three characteristics – mass, angular momentum and charge. For this reason, Kerr-Newman black hole is regarded as the most general form of black hole.

### Last gift of Schwarzschild

Schwarzschild has left this world a century ago. But his last gift in terms of seminal scientific work during his illness has made him immortal. Work of Schwarzschild has produced many new ideas such as Schwarzschild coordinates, Schwarzschild radius, Schwarzschild black hole etc. in the field of astrophysics.Even today, a beginner in the field of general relativity will have to know about Schwarzschild solution and its related topics. This is the greatest achievement of a creative person.

# Dead zones: An increasing concern

***Susheela Srinivas***

*A number of factors contribute to formation of dead zones. Dead zones are formed naturally and intermittently along the coasts in many of the seas. These are seasonal and with change in the season, nature soon restores the balance of marine life. Marine life, however, is under potential threat due to various human activities on land which are in many ways affecting the seas. The past fifty years has seen a drastic rise in the mass destruction of marine ecology and formation of frequent dead zones*

More than 70% of the Earth's surface is covered by water. Of this, 95% is oceanic water and a huge portion of this heavy saline waters remains in the deep sea – undiscovered and mysterious. The oceanic water column extends from the surface to the presently known depths of around 11,000 m. This vast expanse is host to a diverse and fascinating spectrum of life forms; depending on the region the seas can be frigid, pulverising and deadly. In all, a staggering part of the deep seas, however, hosts life forms which brave against these harsh environments to survive and procreate. Fascinatingly, the creatures have adapted themselves in unique ways – be it in the form of tentacular extensions, modified respiratory systems, jaws, calcareous shells or gelatinous (liquid like) muscles, and other adaptations.

*Moray eel*
*(Credit: Wikipedia)*

While the Earth's atmosphere contains around 20% of oxygen to provide source of life, the oceanic life depends on the dissolved oxygen in water. This is found to be as low as 1% and fluctuating slightly depending on the photosynthetic organisms and the depth of the sea. The part these life forms play is extremely essential and holds the key to maintain the delicate balance of the marine life.

Amidst all this the role of the humans is critical and vital to preserve the ecology and biodiversity. Sadly, this is not happening; rather there is growing concern as the marine life is under potential threat due to various human activities on land which are in many ways affecting the seas. The past fifty years has seen a drastic rise in the mass destruction of marine ecology which is detrimental to marine life.

A look into the topology of oceans gives us a better picture of the different mechanisms that are interwoven to keep the waters teeming with life.

*Deep sea giant Isopod*
*(Credit: Flickr)*

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*Phytoplankton (Credit: Wikimedia Commons)*

## Different regions

The oceanic water column is broadly divided into two major zones: the Pelagic and the Benthic zones.

**Pelagic zone**: This is the open waters where swimming and floating organisms live. The surface layers of this region, where the water and land meet, has slopes under water, access to the abundance of sunlight seeping through the surface, and also sufficient amounts of dissolved oxygen for marine forms to exist.

As the depth increases, the availability of life sources reduces drastically. Marine biologists further divide this into regions depending on the depth from the surface, namely

Epipelagic (surface to 200 m, with plenty of sunlight available and possibility of photosynthesis),

Mesopelagic or twilight zone (200 to 1,000 m, where sunlight is scanty and no photosynthesis),

Bathypelagic (1,000-4,000 m, or the midnight zone),

Abyssopelagic (4,000 – 6,000 m), and

Hadopelagic (6,000-11,000 m, made up of mostly deep trenches in the ocean).

The last three regions get no sunlight at all.

**Benthic region**: This is the seabed which consists of sediments and other surfaces. Many life forms exist here too, which either swim slowly just above the seabed or are attached, rooted or burrowed to the seabed. Biologists divide this too into zones. The base sediment is found to contain a great amount of organic matter which is composed of dead and decayed organisms from the upper pelagic regions. Rich in nutrients, this is the main source of food to many organisms. This zone is also home to tectonic plates and intense activity – under-sea volcanoes. There are also hydrothermal vents or chimneys which witness certain chemical reactions. These vents spew mineral-laden water up around which certain bacteria and microbes grow, feeding on the supply. The larger animals feed on these bacteria in the food chain. A vast portion of this area still remains unexplored.

## Challenges faced by deep sea creatures

In the benthic region the life forms meet many crushing challenges and struggle to exist – the absence of sunlight, no plant life in the food chain, pulverising pressures around 500- 1,000 atm., frigid temperatures, polar currents, and very little oxygen in the water. Along with these non-biotic components, the organisms have to contend with predators, competitors and also find potential mates. Due to these harsh surroundings, the benthic creatures are found to be slow-moving or rooted to the seabed; many exhibit bio-luminescence, or

*Algal bloom (La Jolla Red tide near California) caused due to Eutrophication hypoxia (Credit: Flickr)*

have unique body adaptations to combat the intense water pressures and temperature. All these factors help them in sensing, feeding, procreating and surviving.

The major source of oxygen for deep sea animals comes from thermohaline currents. These are a part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes. They originate from the shallow polar seas which form the principal feeders of the cold, dense waters of the deep sea. The thermohaline currents are found to travel all over the globe at these depths. Since cold water dissolves more oxygen, it sinks to the bottom. However, the dissolved oxygen is limited by the high salinity of the waters. Since there is absence of biomass (plant life), the oxygen supply is limited with low concentrations; this amount is barely sufficient to support animal life. Many mobile animals migrate to oxygenated waters in such a situation while the immobile organisms tend to perish.

## Dead zones

Nitrogen and phosphorus are the building blocks of many single-celled organisms like phyto- plankton. These phytoplankton or algae form the basis of the food chain in oceans since they are capable of photosynthesis. This also ensures the oxygen replenishment to the waters. During daytime these algae photosynthesise to increase the dissolved oxygen in the water, but respire during night time consuming some of the dissolved oxygen.

The deep sea hosts unique bacteria which depend on the detritus – decay of plant and animals from upper regions which naturally sink down – for nutrition. In this process they use up the oxygen for respiring.

Sometimes seasonal changes bring about an increase in the nutrient content of the ocean waters near the coast. For example, the spring months and rains feed the rivers and lakes with additional nutrients which are carried to the sea. This increase in the nutrients helps the algae to multiply rapidly. Though they are not visible to the naked eye, when large colonies of algae form, called algal bloom, they appear as blue-green to red layers on the water. This excessive growth on the surface blocks sunlight for the other creatures below. Also, most of the oxygen is used up by the algae which lead to hypoxia (little or no-oxygen content in a water body). This can suffocate other creatures leading to mass kills.

When the algae die, the detritus from the algal bloom increases the growth of bacteria under sea which feed on them; this insurmountable bacterial growth depletes the oxygen in the deep sea as well as threatening the survival of other organisms. Hence the algal bloom becomes a cause for the creation of a 'dead zone' in the sea. Under hypoxia conditions natural life suffocates leading to dead zones or biological deserts.

Physical, chemical and biological factors contribute to formation of dead zones. Dead zones are formed naturally and

*Mass destruction in marine life due to hypoxia (Credit: Wikimedia Commons)*

intermittently along the coasts in many of the seas. However, these are seasonal and with change in the season, nature soon restores the balance of marine life.

Spring season brings increased nutrient-rich water from rains, rivers and other water bodies. This leads to sudden spurt in algal growth forming a dead zone in the waters below. Sometimes a combination of algal bloom and absence of thermohaline currents together can cause a natural dead zone. However, the tropical storms of the following autumn season, breaks this dead zone restoring the balance of the ecosystem.

## Human activity and the oceans

Mankind has depended on the sea and its resources for ages: for food, exploration, trade and transport. As human populations increased around the coastlines, these activities have escalated. There is a huge demand for agricultural activities, fishing and other oceanic activities to meet his growing demands.

With the spike in human activities and demands around the edge of seas, the bay areas are bearing the brunt of seeping chemicals, pollutants, excessive fishing, and air pollution and a host of other factors. While waste water and chemical effluents from industries constitute the run-offs in developed countries, developing and under-developed countries are diverting the sewage into the water bodies. In addition the air pollution too has contributed to the contamination of water bodies. Air pollution alters the chemical composition of the air and gets carried to the ocean through the water cycle.

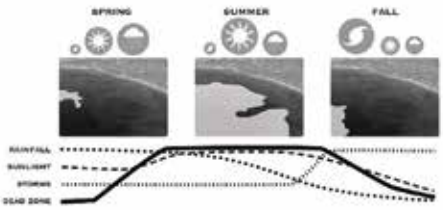
Global warming and the use of nitrogen-based fertilisers for aggressive agricultural practises have led to the ocean waters witnessing an increase in the levels of nitrogen. This additional nutrient influx is called eutrophication.

Human contribution to eutrophication is triggering more frequent algal blooms. Since the nutrient flow is continuous, the dead zones formed are rapid and persistent, permanently damaging the ecological balance of the ocean.

## A growing concern

Till recently, these types of dead zones were noticed all over the coasts of North and South Americas, the Mediterranean Sea, African coast, and the Arabian Sea. The waters of the Bay of Bengal were found to be free of such formations. An estimation given in 2008 indicates that the oceans have around 405 recorded dead zones – a figure which has risen drastically in the past few decades.

In a recent discovery in 2016, scientists from Max Planck Institute and the National Institute of Oceanography, Goa, observed an alarming situation in the Bay of Bengal.




*Marine debris (Credit: Wikipedia)*

Their study revealed a crazy situation where the waters were poised to form a potential dead zone; this was developing in the area spreading around 60,000 sq km where the waters were becoming hypoxic and the presence of bacteria had given rise to a tipping condition where any moment a dead zone can form. Their reports were published in the journal *Nature Geosciences*.

The lead scientists Laura Bristow and Wajih Naqvi say that the Bay of Bengal hosts an enigmatic condition. Though there is hypoxia in its waters, no known notable nitrogen loss has been observed unlike the other dead zones around the world.

Explaining the situation they estimate that there were trace amounts of oxygen present in the water here but the concentrations were undetectable by the standard techniques. They demonstrated that the hypoxic waters had 10,000 times lesser concentration of oxygen than the air-saturated surface waters. They also showed that the Bay of Bengal contains microbial communities which are capable of removing nitrogen and convert it into a dead zone. However, currently this process is occurring slowly and any day the situation may topple over. Moreover, the Bay of Bengal is a heavily populated area with continuous maritime activities.

## Effect of hypoxia

What could be the outcome of hypoxia in ocean waters? The larger and mobile creatures like big fish, crabs, etc., try to migrate to other waters with more oxygen content, while the immobile and benthic creatures like sea grass, worms and clams are hard hit and perish due to hypoxia.

But mass exodus of marine creatures will seriously damage the ecological balance of the oceans. Even in the case of mobile creatures, the migration is not always successful as they soon become suffocated and unconscious, perishing in the waters.

Research also indicates that hypoxia leads to severe physiological changes in the animals. Their movement gets slower and the reproductive organs are found to shrink drastically. Hormonal changes occur which are making them infertile.

So a habitat which is teeming with life soon becomes a biological desert.

It is not far away that the impact will be felt on human survival too. Since the oceans are the primary source of life on Earth and the principal suppliers in the water cycle. Excessive pollutants in air and on land are a precursor to global disruptions to the water cycle. Ocean ports are also regions of additional activities like power harnessing, mining, drilling, and tourism – all causing further damage. Other factors influencing this massive destruction are marine debris like plastic waste and other items that are dumped on the shores causing pollution which is endangering many marine species.

Excessive fishing activities in the deep sea can put human life in danger too. Future changes in oxygen levels in water bodies could seriously impede the delicate ecosystems in the oceans leading to mass fish mortality; as a consequence the social and economic growth of humans may also get affected since we depend on the oceans for goods and services. Hence, pertinent measures are needed immediately to preserve the ecological balance on Earth.

# Irritable bowel syndrome — Causes, triggers, red flags and more

*Dr. Yatish Agarwal*

*Although many adults experience signs and symptoms of irritable bowel syndrome, fewer than 1 in 5 who have symptoms seek medical help. If a person has a persistent change in bowel habits or some other unexplained signs or symptoms, it is important that s/he sees a doctor because these symptoms may indicate a more serious condition, such as colon cancer.*

A common bowel disorder that affects the large intestine known as irritable bowel syndrome is a long-lasting problem that can change the way how people live their life. Known more popularly by its acronym IBS, its signs and symptoms can be gut wrenching, making a person severely uncomfortable. However, the good news is: it is not life-threatening, and unlike some of the other large bowel conditions like ulcerative colitis, it does not cause changes in bowel tissue or increase the risk of colorectal cancer.

Millions of people suffer from irritable bowel syndrome. Most of them are women. People are most likely to get the condition in their late teens to early 40s. It commonly presents with belly discomfort, abdominal cramps or tummy pain, bloating, gas, and trouble with bowel habits producing either diarrhoea or constipation and having a thin, hard, or soft and liquid stool.

A chronic condition, only a small number of people with irritable bowel syndrome have severe signs and symptoms. Some people can control their symptoms simply by managing diet, lifestyle and stress. Still, in others, it can be life-altering. They may miss work or school more often, and may feel less able to take part in daily activities. Some people may need to change their work setting: shifting to working at home, changing hours, or even not working at all. Some will need medication and counselling.

## What causes irritable bowel syndrome?

It is not known exactly what causes irritable bowel syndrome, but a variety of factors play a role. The walls of the intestines are lined with layers of muscle that contract and relax in a coordinated rhythm as they move food from the stomach through the intestinal tract to the rectum. In a person with irritable bowel syndrome, these contractions may be stronger and last longer than normal, causing gas, bloating and diarrhoea. Or the opposite may occur, with weak intestinal contractions slowing food passage and leading to hard, dry stools.

Abnormalities in the gastrointestinal nervous system also may play a role, causing a person to experience greater than normal discomfort when the abdomen bloats with gas or stool. Poorly coordinated signals between the brain and the intestines can make the body overreact to the changes that normally occur in the digestive process. This overreaction can cause pain, cramps, distension, and diarrhoea or constipation.

### *Triggers*

Stimuli that do not bother other people can trigger symptoms in people with irritable bowel syndrome - but not all people with the condition react to the same stimuli. The common triggers include:

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### Stress

Most people with irritable bowel syndrome find that their signs and symptoms are worse or more frequent during periods of increased stress, such as finals week or the first weeks on a new job. However, while stress may aggravate symptoms, it is probably not the key trigger.

### Hormones

Since a large number of sufferers are women, medical researchers believe that hormonal changes potentially may play a significant role in this condition. Many women find that signs and symptoms are worse during or around their menstrual periods.

### Bacteria and gut infections

Sometimes another illness, such as an acute episode of infectious diarrhoea (gastroenteritis) or a bacterial overgrowth in the intestine, can trigger irritable bowel syndrome.

### Foods

The role of food allergy or intolerance in irritable bowel syndrome is not yet clearly understood, but many people have more severe symptoms when they eat certain things. A wide range of foods has been implicated - beans, cabbage, cauliflower, broccoli, spices, fats, fruits, milk, carbonated beverages, chocolate and alcohol to name a few.

### Who's at risk?

Many people have occasional signs and symptoms of irritable bowel, but irritable bowel syndrome is more likely to take root in the following people:

### Young adults

Irritable bowel syndrome tends to occur in people under age 45.

### Fair gender

Women are about twice as likely as men to develop irritable bowel syndrome.

### Family history

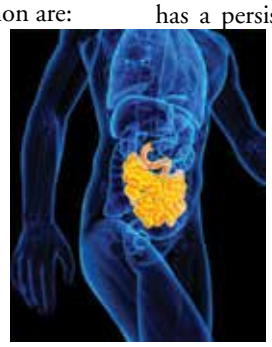
Studies suggest that people who have a family member with irritable bowel syndrome may be at increased risk of the condition. The influence of family history on the risk may be related to genes, shared factors in a family's environment or both.

### Psychological issues

Anxiety, depression, a personality disorder and a history of childhood sexual abuse are risk factors. For women, domestic abuse may be a risk factor as well.

## Recognising the signs and symptoms

The signs and symptoms of irritable bowel syndrome can vary widely between people and may resemble those of other diseases. Among the most common are:



- Diarrhoea (often described as violent episodes of diarrhoea)
- Constipation
- Constipation alternating with diarrhoea, but this is a sign that may represent a more serious condition and must stimulate a person to immediately seek a medical consultation
- Belly pains or cramps, usually in the lower half of the belly, that get worse after meals and feel better after a bowel movement
- A lot of gas or bloating
- Harder or looser stools than normal (pellets or flat ribbon stools)
- Mucus in the stool
- Worsening of haemorrhoids: Diarrhoea and constipation, both signs of irritable bowel syndrome, can also aggravate haemorrhoids.
- Stress can make symptoms worse.
- Some people also have urinary symptoms or sexual problems.

There are typically four types of the condition. There is IBS with constipation (IBS-C) and IBS with diarrhoea (IBS-D). Some people have an alternating pattern of constipation and diarrhoea. This is called mixed IBS (IBS-M). Other people don't fit into these categories easily, called unsubtyped IBS, or IBS-U.

### Outcome

For most people, irritable bowel syndrome is a chronic condition, although there will likely be times when the signs and symptoms are worse and times when they improve or even disappear completely.

However, the condition's impact on a person's overall quality of life may be the most significant complication. If a person begins to avoid certain foods due to IBS, they may not get enough of the nutrients they need, leading to malnourishment. These effects of IBS may cause them to feel they're not living life to the fullest, leading to discouragement or depression.

## When to see a doctor

Although many adults experience signs and symptoms of irritable bowel syndrome, fewer than 1 in 5 who have symptoms seek medical help. Still, if a person has a persistent change in bowel habits or some other unexplained signs or symptoms, it is important that s/he sees a doctor because these symptoms may indicate a more serious condition, such as colon cancer.

If the doctor is able to rule out the more serious conditions and can confirm the diagnosis of irritable bowel syndrome, he could help you find recipes to relieve symptoms as well as advise treatments that can avoid possible complications which may have arisen due to chronic diarrhoea.

### The red flags

Some signs and symptoms may point to a more serious condition. If you have any of these red flag symptoms, you must not delay going to a doctor. These symptoms include:

- New onset after age 50
- Weight loss
- Rectal bleeding
- Fever
- Nausea or recurrent vomiting
- Abdominal pain, especially if it is not completely relieved by a bowel movement, or occurs at night
- Diarrhoea that is persistent or awakens you from sleep
- Anaemia related to low iron

## Which doctor to see?

If you have symptoms of irritable bowel syndrome, you could make an appointment with your family doctor or an internist. Subsequent to an initial evaluation, the family doctor may refer you to a gastroenterologist. A gastroenterologist is a specialist who is well versed in treating digestive disorders.

### Preparing for an appointment

Before going for your appointment, it is best to write down any symptoms you're experiencing, and for how long, and if you have found any specific factor that

particularly triggers the symptoms. You must also write down key personal information, including any recent changes or stressors in your life. These factors can play a key role in the frequency and severity of irritable bowel syndrome symptoms. You should also think out and write down questions to ask your doctor. Creating your list of questions in advance can help you make the most of your time with your doctor. In addition to these questions, do not hesitate to ask any other questions that may come to your mind during your appointment.

Your doctor is likely to ask you a number of questions. Being ready to answer them may reserve time to go over any points you want to spend more time on. You will be asked about your symptoms, and their duration and severity; if the symptoms come and go or stay about the same; if you have noticed anything that seems to trigger your symptoms, including certain foods, stress or - in women - your menstrual period; if you have lost weight without trying; if you have noticed any blood in your stools; if you have such signs and symptoms as vomiting, or fever; if you have recently experienced significant stress, emotional difficulty or loss; what is your typical daily diet; if you have any family history of bowel disorders or colon cancer; and if you been diagnosed with any other medical conditions. These questions can help the doctor in reaching the correct diagnosis and ordering tests which would be appropriate to your condition.

## Making of a diagnosis

The diagnosis of irritable bowel syndrome largely depends upon a detailed medical history, clinical examination in a doctor's office and a battery of diagnostic tests that serve to rule out other conditions which may mimic irritable bowel syndrome and still be of more serious nature.

## Diagnostic criteria based on symptoms

Since there are no confirmatory physical signs to diagnose irritable bowel syndrome and other functional gastrointestinal disorders with perfection, medical researchers have developed two sets of extensive diagnostic criteria which are primarily based on symptoms a person has, with a caveat that other more serious conditions have been ruled out.

### *Rome criteria*

The Rome criteria factor in a number of specific signs and symptoms for a doctor to diagnose irritable bowel syndrome. The most important of these are abdominal pain and discomfort lasting at least three days a month and bothering the patient recurrently for at least last three months. Such symptoms must be associated with two or more of following: improvement with defecation, altered frequency of stool or altered consistency of stool.

### *Manning criteria*

The Manning criteria focus on the following symptoms: pain relieved by defecation, having incomplete bowel movements, mucus in the stool, and changes in stool consistency. The more symptoms present, the greater the likelihood of irritable bowel syndrome.

The doctor you consult will likely assess how you fit these criteria, as well as whether you have any other signs or symptoms that might suggest a more serious condition. If you fit the IBS criteria and do not have any red flag signs or symptoms, your doctor may suggest a course of treatment without doing additional testing. However, if you do not respond to treatment, or the doctor feels uncertain, you'll likely require more tests.

### *Diagnostic tests*

The treating doctor may recommend several tests, including stool studies to check for infection or problems with your intestine's ability to take in the nutrients from food, a condition that goes by the name of malabsorption.

### *Lactose intolerance test*

Lactase is an enzyme you need to digest the sugar found in dairy products. If you do not produce this enzyme, you may have problems similar to those caused by irritable bowel syndrome, including abdominal pain, gas and diarrhoea. To find out if this is the cause of your symptoms, your doctor may order a breath test or ask you to remove milk and milk products from your diet for several weeks.

### *Breath test*

Your doctor may perform a breath test to look for a condition called bacterial overgrowth, in which bacteria from the colon grow up into the small intestine, leading to bloating, abdominal discomfort and diarrhoea. This is more common among people who have had bowel surgery or who have diabetes or some other disease that slows down digestion.

### *Blood tests*

Celiac disease is sensitivity to wheat, barley and rye protein that may cause signs and symptoms like those of irritable bowel syndrome. Blood tests can help rule out this disorder. Children with IBS have a far greater risk of celiac disease than do children who don't have IBS. If your doctor suspects that you have celiac disease, he or she may perform an upper endoscopy to obtain a biopsy of your small intestine.

### *Stool tests*

If you have chronic diarrhoea, doctors may want to examine your stool for bacteria or parasites.

The doctor may also ask for the following imaging tests:

### *Flexible sigmoidoscopy*

This test examines the lower part of the colon (sigmoid) with a flexible, lighted tube, called the sigmoidoscope.

### *Colonoscopy*

In some cases, especially if you are age 50 or older or have other signs of a potentially more serious condition, your doctor may perform this diagnostic test in which a small, flexible tube is used to examine the entire length of the colon.

### *Computerised tomography (CT) scan*

CT scans produce cross-sectional X-ray images of internal organs. CT scans of your abdomen and pelvis may help your doctor rule out other causes of your symptoms, especially if you have abdominal pain.

### *Lower GI barium series*

In this test, doctors fill your large intestine with a liquid (barium solution) to make it easier to see any problems on the X-ray.

The idea behind conducting these tests is simply to rule out a more nature of disease. Once that's been done, the treatment focuses on the relief of symptoms so that you can live as normally as possible.

**(Next month: Winning over irritable bowel syndrome: the way forward)**

# Recent developments in science and technology

***Biman Basu***

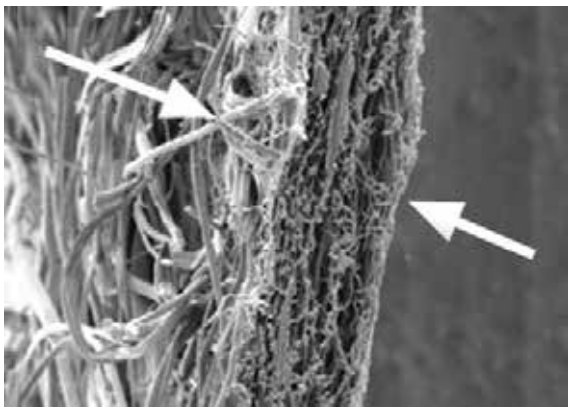
*Ultraviolet (UV) radiation is harmful for living beings. Despite UV radiation being dangerous, life survives on Earth mainly because of a protective layer of ozone gas in Earth's upper atmosphere. But a new study suggests that UV radiation may have played a critical role in the emergence of life on Earth, and could be a key for where to look for life elsewhere in the universe.*

## Silk mats developed to treat arthritis

Osteoarthritis, commonly known as wear-and-tear arthritis, is the most common type of arthritis. It is a condition in which the natural cushioning between joints – cartilage – wears away and makes the bones of the joints rub more closely against one another with less of the shock-absorbing benefits of cartilage. The rubbing results in pain, swelling, stiffness, and decreased ability to move. If left untreated, it can result in severe swelling, pain, and ultimately restrict the range of movement. Knee osteoarthritis is the most common bone and joint disease in India.

Current clinical treatment methods are limited by lack of viable tissue substitutes to aid the repair process. Replacement of the damaged knees with artificial knees is another option, but is quite expensive. Recently a team of researchers from Indian Institute of Technology Guwahati (IITG) and University College London, UK, led by Biman B. Mandal of IITG have developed a unique material based on Muga silk and bioactive glass fibres to treat osteoarthritis. According to the researchers, the synthesised mats can assist the growth of bone cells and repair worn-out joints in osteoarthritis arthritis patients (*ACS Applied Materials & Interfaces*, 9 February 2017 | DOI: 10.1021/acsami.6b16590).

In their effort to develop a suitable tissue substitute to repair the damaged tissue in osteoarthritis patients, the scientists looked into the natural bone-cartilage interface and tried to mimic it synthetically in lab conditions. Mandal said they used silk, a natural protein, to fabricate electrospun mats to mimic the cartilage portion and bio-active glass to develop a composite material similar to the natural tissue. For the mat, the scientists used Muga silk easily available in North-east India which they said is "endowed with properties that enhance the healing process".



*Scanning electron micrograph of a cross-section of mats formed by electrospun bioactive glass layer (left arrow), followed by silk layer (right arrow), exhibiting coherent well-integrated interface.*

The researchers adopted a clean fabrication approach called electrospinning for developing the silk composite mats. Electrospinning is a fibre production method which uses electric force to draw charged threads of polymer solutions or polymer melts up to fibre diameters of the order of some hundred nanometres.

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The process does not require the use of coagulation chemistry or high temperatures to produce solid threads from solution. This method makes the process clean by ensuring that no solvent can be carried over into the final product. According to Mandal, "It is similar to knitting, except that it utilises electric high voltage force to draw ultra-fine fibres." He said, a layer-by-layer approach was followed, where the bone layer was first formed, on top of which the cartilage layer was developed.

The resulting composite mat resembled the architecture of the natural bone-cartilage interface. The mats were tested under laboratory conditions, where artificial tissue formed efficiently during the two weeks of the study.When cultured with specific animal-derived immune cells, the mats did not induce any adverse immune responses, indicating biocompatibility. According to the researchers, the mats need to be tested in suitable animal models like rabbits and pigs, and finally in human trials, before they become available to patients.

To assist the regenerative process in osteoarthritis patients, the mats would be grafted in the damaged joint with cells harvested from the patient. "The mats would bond with the native tissue and act as an artificial tissue construct. Eventually the mats would degrade with time and new tissue formed in its place, repairing the damaged cartilage," Mandal said."The composite mats are a potential candidate as green materials to repair bone defects caused by osteoarthritis," he added.

## Flower colour changed by gene editing

Flowers come in many colours although there are many that are fragrant and bloom at night, which are mostly white. It has been known that flower colours are decided by genes and floriculturists have developed techniques to breed flowers of different colours through hybridisation. But no attempt has hitherto been made to change colour of a flower by tinkering with its gene. Now, in a worldfirst, researchers from the University of Tsukuba, the National Agriculture and Food Research Organisation, and Yokohama City University in Japan, have used the revolutionary CRISPR gene-editing tool, sometimes referred to as a molecular scissor,

*Researchers used cutting-edge gene-editing technology to turn Japanese morning glories white. (Photo: University of Tsukuba)*

to change the colour of a Japanese morning glory, a popular garden flower, from violet to white, by disrupting a single gene.

Last year, Japanese researchers had successfully decoded the entire Japanese morning glory (*Ipomoea nil*)genome. Subsequently, the researchers identified a single gene called dihydroflavonol-4-reductase-B, or DFR-B, which encodes an anthocyanin biosynthesis enzyme responsible for the colour of the plant's stems, leaves and flowers. Incidentally, two other, very closely related genes (DFR-A and DRF-C) are also found next to DFR-B. Therefore, the challenge was to specifically and accurately target the DFR-B gene without altering the other genes. The CRISPR/Cas9 system was used as it is currently the most precise method of gene editing.

For the present study, the researchers used a short DNA sequence in the Japanese morning glory DFR-B gene as the target for the CRISPR/Cas9 system. This sequence contains the active site of the enzyme produced by the DFR-B gene. The disruption of this sequence was expected to de-activate the enzyme, resulting in an absence of the colour pigment, anthocyanin, which indeed turned out to be true. When the CRISPR/Cas9 system was inserted into tissue-cultured embryos of Japanese morning glory plants using the DNA-transferring capabilities of the plant bacterium *Rhizobium*, the DFR-B enzyme was indeed found to be inactivated, resulting in approximately 75% of the transgenic plants having green stems and white flowers instead of the characteristic violet. In contrast, non-transformed plants with an active enzyme had violet stems and flowers. Subsequent genetic analyses confirmed that, as expected, the DNA target sequence had been altered in the transgenic plants, with either DNA insertions or deletions in both copies of the DFR-B gene, butthe DFR-A and DFR-C genes remained unaltered, demonstrating the extreme precision of the technique (*Scientific Reports*, 30 August 2017 |. DOI: 10.1038/s41598-017-10715-1).

According to the researchers, the CRISPR/Cas9 system they described is the 'reverse' genetic approach, used to find out what an organism looks like after a known gene is disrupted, and confirms that the DFR-B gene is the main gene responsible for colour in Japanese morning glory plants. They hope this research will greatly facilitate those interested in the modification of flower colours and shapes using the CRISPR/Cas9 system in ornamental flowers or vegetables.

## UV radiation key to life's origin

We know that life on Earth would not be possible without the Sun. Our nearest star not only provides light and heat but also causes the seasons, which make life thrive. But sunlight also has a dangerous component – ultraviolet (UV) radiation – that is extremely harmful for living beings. In fact, ultraviolet radiation is widely used to kill bacteria in water and for disinfecting materials and objects. Despite UV radiation being dangerous, however, life survives on Earth mainly because of a protective layer of ozone gas in Earth's upper atmosphere that cuts off the most dangerous ultraviolet radiation from the Sun.

Given this background, it may come as a surprise that the appearance of life on Earth was in fact triggered by UV radiation, as a new study shows. It was earlier believed that intense UV rays from a young Sun bombarded the early Earth and were thought

*Planets of red dwarf stars like TRAPPIST-1 are unlikely to harbour life because it might not emit enough UV radiation to kick-start the biological processes most familiar to our planet.*

likely to destroy any exposed organic molecules. But a new study by SukritRanjan of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Mass. USA, and colleagues suggests that UV radiation may have played a critical role in the emergence of life on Earth, and could be a key for where to look for life elsewhere in the universe. They contend that certain levels of UV might be necessary for the formation of ribonucleic acid (RNA), a molecule necessary for all forms of known life. The new study suggests that red dwarf stars – by far the most common sort of stars, and thought by some to be the best star systems in which to search for life – might not emit enough UV radiation to kick-start the biological processes most familiar to our planet (*The Astrophysical Journal*, 11 July 2017 | doi.org/10.3847/1538-4357/aa773e).

According to the researchers, before life began, radiation from the Sun was the primary source of energy on our planet, just as it is today. In the oxygen-poor, prebiotic world, solar UV radiation may have provided the jolt to transform simple organic molecules into more complex ones, which were used as the building blocks of biology and life.

The earliest life on Earth is widely thought to have been based on RNA, the chemical cousin of DNA in which the sugar deoxyribose is replaced by ribose. RNA is made of subunits called nucleotides, which link together to form long polymer chains. According to the scientists, certain levels of UV might be necessary for the formation of ribonucleic acid, a molecule necessary for all forms of known life.

"It would be like having a pile of wood and kindling and wanting to light a fire, but not having a match," says Ranjan. "Our research shows that the right amount of UV light might be one of the matches that gets life as we know it to ignite."

The CfA study was focussed on the study of red dwarf stars, which are smaller and less massive than the Sun, and the planets that orbit them. Recently, several planetary systems with potential habitable zones, where liquid water could exist, have been discovered around red dwarfs including Proxima Centauri, TRAPPIST-1, and LHS 1140, raising hopes of finding life there. But the recent study rules out such a possibility in view of insufficient UV intensity.

Using computer models and the known properties of red dwarfs, the authors estimate that the surface of rocky planets in the potentially habitable zones around red dwarfs would experience 100 to 1,000 times less of the UV radiation than the young Earth would have billions of years ago. Chemistry that depends on UV radiation might shut down at such low levels, and even if it does proceed, it could operate at a much slower rate than on the young Earth, possibly delaying the advent of life.

However, the study does not entirely rule out the possibility of life even if the UV output of a steady-state M-dwarf star is not sufficient to spark life, because transient elevated UV irradiation due to flares may be sufficient to trigger the process. Only further laboratory studies could establish whether such a possibility exists.

## Tropical forests become net emitters of carbon dioxide

For ages it had been assumed that tropical forests act as an enormous sink of carbon, removing substantial amounts of carbon dioxide during photosynthesis thus preventing uncontrolled rise in carbon dioxide level in the atmosphere. That is why conservation of forests has been given top priority to control global warming and climate change. Of course, forests absorb carbon dioxide only during the day; at night they release carbon dioxide. It has been estimated that every moment, the world's roughly 3 trillion trees either suck up carbon dioxide from the air or release it into the atmosphere. Scientists have been trying to quantify these carbon flows accurately in order to understand how forests help to regulate Earth's climate. Now, researchers have combined ground and satellite measurements of tropical Asia, Africa and the Americas and arrived at the surprising conclusion that tropical forests may be actually a net source of heat-trapping carbon emissions, rather than a carbon sink – they contribute more carbon dioxide to the atmosphere than they remove.

*Wanton destruction and degradation of tropical forests have made them emit more carbon dioxide than they soak up.*

The researchers led by Alessandro Baccini, a forest ecologist and remote sensing specialist at the Woods Hole Research Centre in Falmouth, Mass., USA, suggest that this may be due to the fact that tropical forests are drying out or being cleared, burned and logged so fast that they now spew out a lot more carbon than they trap by photosynthesis. According to them human activities such as starting fires and natural factors including droughts have dealt a severe blow to forests' ability to store carbon. The study went further than any of the earlier studies in measuring the impact of disturbance and degradation, the thinning of tree density and the culling of biodiversity below an apparently protected canopy – usually as a result of selective logging, fire and drought (*Science*, 28 September 2017 | doi: 10.1126/science.aam5962).

The researchers based their finding on 12 years (2003-2014) of data and images from satellites including NASA's Ice, Cloud, and Land Elevation Satellite (*ICESat*), a laser-equipped satellite that gathered data on forest height and vegetation layers around the globe, and NASA's *Terra* and *Aqua* satellites. They also made use of laser remote sensing technology and field measurements.

Most of the carbon emissions from forests – making up nearly 70 percent in the tropics of the Americas, Asia and Africa – the study found are linked to forest degradation. In total, the researchers found, tropical forests emit 861 million tons of carbon to the atmosphere annually and absorb only 436 million tons of carbon each year, thus leading to a net contribution of 425 million tons to Earth's atmosphere each year, which is more than the emissions from all vehicular traffic in the United States.

According to the researchers, much of the carbon contribution is due to forest degradation, namely deforestation and the conversion of forests to urban spaces such as farms or roads. But more than two-thirds comes from a less visible source, namely a decline in the number and diversity of trees in remaining forests