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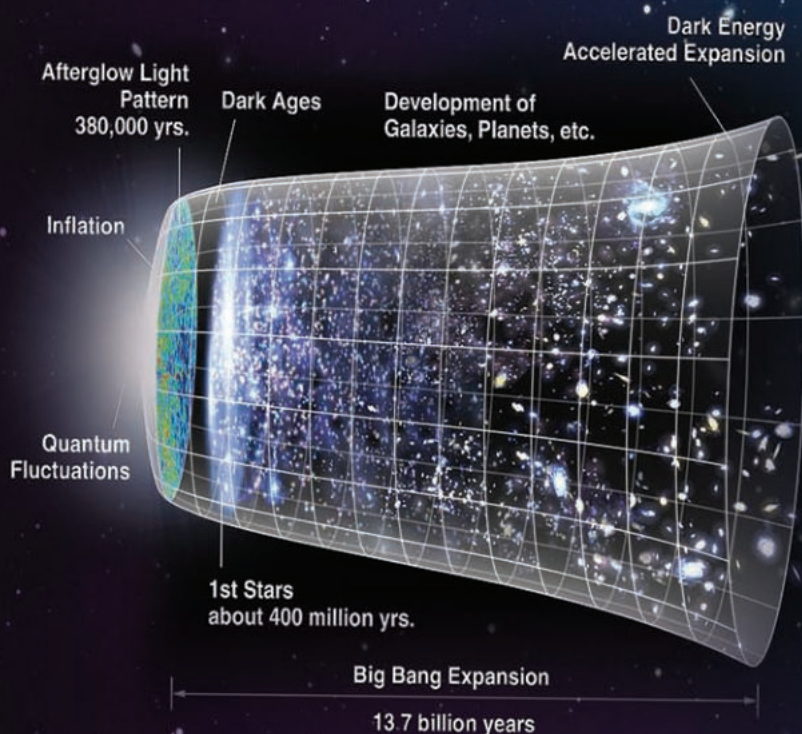
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International Year of Light 2015

The puzzle of dark energy



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Going back to square one: Just inform



Dr. R. Gopichandran

The last two editorials were about some insights our fellow citizens gave me about the practice of scientific temper in our common community spaces. Thanks to their robust behaviour and my inclement imbibing abilities, I need more time to contemplate on the learnings they offer, before I start writing about them again. Meanwhile I thought I will slip back into square one and present this editorial based on others writings. I will therefore present some useful leads I gathered from some insightful literature recently. They are about the 'what' and 'how' of science communication.

The Stellenbosch University (Ref 1) announced its programme on science communication for this year. The six main reasons for the course, objectives, learning outcomes and people who can enrol are lucidly stated. Can we notice the similarities in approaches our initiatives stand for here in India?

We can derive valuable lessons from the stated curriculum on 'cognition and communication' announced by the University of Copenhagen (Ref 2). Look closely at the spread and depth of topics and the framework for competence and objectives. The framework that can guide assessments of scientific literacy is an equally important aspect. It twins knowledge of science with 'science based technology' and the synchronised evolution (or the lack of it) for citizen's benefits. The authors argue for a synthesis of knowledge of concepts and theories of science with procedures and practice of inquiry.

The Royal Society, 2006 (Ref 3) nearly a decade ago articulated factors that appear to affect science communication. Perceptions held by scientists, their preparedness to engage with the public and structures and platforms for such engagement are also defined.

Karen Bultitude, 2011 (Ref 4) defines the utilitarian, economic, cultural and democratic motivations in the interface of science communication with citizens. These could be aligned with person and context – specific motivations for the individuals. This creates the setting for assessments of determinants of impacts of science communications individually or synergistically. Some of the other important sources of information I came across in my efforts this morning while preparing this editorial include the following. You will enjoy studying the contents therein. The sources are:

- <http://www.oecd.org/pisa/pisaproducts/Draft%20PISA%202015%20Science%20Framework%20.pdf>
- http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf
- http://www.iai.uni-bonn.de/III/lehre/vorlesungen/IntelligentIS/SeminarIIS_SS14/ScientificWork_A.pdf

- <http://onlinelibrary.wiley.com/doi/10.1002/2014EO240003/pdf>
- http://www.researchgate.net/journal/1050-3293_Communication_Theory
- <http://www.tandfonline.com/doi/abs/10.1080/03057267.2013.831972#.VStIRPmUcQE>
- <http://www.arl.army.mil/www/pages/172/docs/ARL-S&T-Campaign-Plans-FINAL.pdf>
- http://www.loicz.org/imperia/md/content/loicz/print/rsreports/loicz_r_s_report_31_-_science_communication_print_version.pdf
- <http://as.wiley.com/WileyCDA/WileyTitle/productCd-1118413369.html>
- <http://traineebattle.nl/xm/science-centres-and-science-events-a-science-communication-handbook/>
- <http://onlinelibrary.wiley.com/doi/10.1002/tea.21186/abstract>

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5. https://www.ucl.ac.uk/sts/staff/bultitude/KB_TB/Karen_Bultitude_Science_Communication_Why_and_How.pdf

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Painting with Light

On a cold, icy afternoon on 7 January 1839, Monsieur François Arago, Director of the Paris Observatory and a reputed astronomer of his times, was speaking before a distinguished gathering of people at the Paris Academy of Sciences. The assembly hall, packed to capacity, listened in rapt attention with a mixture of wonder and disbelief as Arago explained the intricacies of a physical and chemical process that could give “Nature the ability to reproduce herself”. Sometime before that, the magazine *Journal Des Artistes* had reported a process called ‘Daguerreotype’, developed by an artist in his early fifties, who was also a physicist by the name of Louis-Jacques-Mandé Daguerre. He had claimed that the technique had allowed him to receive upon a plate prepared by him “the image produced by the camera obscura (a darkened enclosure in which inverted images of outside objects are projected through a small aperture or lens onto a facing surface), so that a portrait, a landscape or view of any kind, could be captured, making the most perfect of drawings. A preparation applied to the plate preserves it for an indefinite period. Physical science has, perhaps, never offered such a marvel.”

Arago concluded his lecture by saying that more investigation was needed into the process and if found practical and useful, he would recommend it to the Government for purchase. A few months later, Daguerre was granted an annuity of 6,000 francs to work on the project. On 19 August 1839, before a joint open meeting of the Academy of Sciences and the Academy of Fine Arts, technical details of the process were made public, along with some Daguerreotypes, showing, in incredible details, “all the minutest indentations and divisions of the ground, or the building, the goods lying on the wharf, even the small stones under the water at the edge of the stream, and the different degrees of transparency given to the water...”

One gentleman who had attended Arago’s lecture on 7 January 1839, was a British inventor by the name of William Henry Fox Talbot who had already been experimenting with similar techniques since 1834 – only in place of a metal plate as used by Daguerre, he was trying to use a special paper plate coated with certain chemicals,

following the works of two pioneers, John Herchel and Thomas Wedgwood. The lecture took him completely by surprise, as he wrote, “I was placed in a very unusual dilemma scarcely paralleled in the history of science, for I was threatened with the loss of all my labours, in case M. Daguerre’s process proved identical with mine.” Fortunately it did not. Within days, he wrote to the Royal Institution in London, enclosing some of his plates and revealing details of his process. On 25 January 1839, at the regular Friday meeting of the members of the Institution, Michael Faraday showed these plates that comprised “flowers and leaves; a pattern of laces; figures taken from painted glass; a view of Venice copied from an engraving; some images formed by the solar microscope.... made with the camera *obscura*.”

On 31 January 1839, Talbot’s paper, “Some Account of the Art of Photogenic Drawing” was read before the Royal Society, again before a packed audience that greeted it with unqualified admiration. That was a defining moment of photography, for while Daguerre produced a laterally reversed image on a metal plate, what Talbot did was to produce an image on paper that was tonally as well as laterally reversed – a negative. When placed in contact with another chemically treated surface and exposed to sunlight, the negative was reversed again, ‘resulting in a picture with normal spatial and tonal values’, which was called a Calotype or Talbotype. Though the origin of photography can be traced back to much earlier time, it was because of these two significant developments that the year 1839 is reckoned as the year in which ‘Photography’ as we know it was invented.

As we all know, the word photography means ‘drawing by light’. Before long the new technique would be employed to catch fleeting moments of history and freeze them permanently in time. Photography would become a medium of artistic expression as well as a powerful scientific tool. In due course, it would be used extensively in all kinds of scientific investigations – to probe the nature of the macroscopic



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world of galaxies, stars and the large-scale structure of the Universe and also to peep into the mysteries of the microscopic world for studying molecular and cell biology. It would be employed in practically all human activities one can think of – journalism and media reporting, designing of web content, forensic and criminal investigation, product promotion, trade and commerce, travel and tourism, besides, of course, in preserving our precious moments in the journey of life. Today the world is unthinkable without photography.

Earliest photographs

Use of the camera *obscura* was known since ancient times, but it was not until 1826 that Nicéphore Niépce, a French inventor, had created a permanent image by combining the camera *obscura* with a photosensitive plate – a thin plate of pewter coated with light-sensitive bitumen after giving an 8-hour exposure. Titled ‘View from the Window at Le Gras’, this was the world’s first photograph and remains the oldest surviving camera photograph. Next big leap was the Daguerreotype, developed in 1839, we have already described. Between 1839 and 1890, the initial years of photography when the science was being perfected, many photographers contributed to its development and also towards its recognition as an art form. Oscar Gustav



Joseph Nicéphore Niépce’s ‘View from the Window at Le Gras’, 1826



Louis Jaques Mandé Daguerre's 'Boulevard du Temple, Paris', 1838, Daguerreotype

Rejlander's allegorical photograph *'The Two Ways of Life'*, created by grafting 30 negatives together depicting the virtues and vices of life in an abstract way was among the earliest successful attempts at pictorial photography, or practice of photography as an art form. Rejlander was a painter, but is remembered today for his photographs rather than his paintings.

In 1847, Louis Désiré Blanquart-Evrard of USA used sensitised paper coated with egg albumen creating the 'albumen paper'. This was the first semi-transparent negative paper used in photography. Four years later, a sculptor in London by the name Frederick Scott Archer improved upon this process by discovering the wet-collodion or the 'wet plate' process. It involved pouring a mixture of collodion, i.e., a mixture of cellulose nitrate dissolved in ether and alcohol that formed a transparent layer with potassium iodide over a glass plate; then dipping this plate into a solution of silver nitrate; and finally putting the wet plate inside the camera immediately before exposure. The plate also needed to be developed immediately. The process was messy, but it produced excellent definition of photographs, was cheaper and easily replicable, unlike the Daguerreotypes. It also reduced exposure times to only a few seconds.

Dry plate, the forerunner of the roll films, was discovered by Richard Leach

Maddox in 1871 by suggesting the use of silver bromide in gelatine suspension in preference to collodion on glass plate, but it would not be until eight years later, when George Eastman started producing them commercially that they would almost universally replace the wet plates. It brought the flexibility and convenience of storing the plate long before and after exposure, unlike the wet plates, heralding the era of modern photography.

All these processes depended on the unusual property of certain substances to react with light, the so-called photosensitive materials. The light-sensitive material used in photography is a silver halide which comes in the form of crystals

of light produces what is called the 'latent image' of the object on the photographic emulsion that can be converted into metallic silver by treating the emulsion with certain chemicals. During 'development' in the darkroom metallic silver gets deposited as black grains now rendered insensitive to light, thus converting the 'latent image' into a visible image. But the part of the emulsion that was not exposed to light from the object still remains sensitive to light and has to be washed away with a solution of sodium thiosulphate, commonly known as 'hypo', through a process called 'fixing', after which the negative is ready for use. A positive print can now be made from the negative.

Colour photography

The decade of the 1860s marked the beginning of colour photography. Human eye can distinguish hundreds of thousands of different colours, but only around 100 shades of grey. A colour image therefore reveals a great deal more information contained in the colours than a black and white image.

In 1802, Thomas Young had postulated that the human eye contains only three types of colour receptors, called 'cone cells' and is sensitive

to the three primary colours – blue, green and red. By combining these three colours in different proportions, all the colours of the spectrum can be produced. When mixed equally, they produce white light. This forms the basis of the additive colour process. The subtractive process starts with white light and uses coloured dyes or pigments to subtract from white light the constituent colours selectively. Three colours – yellow, magenta

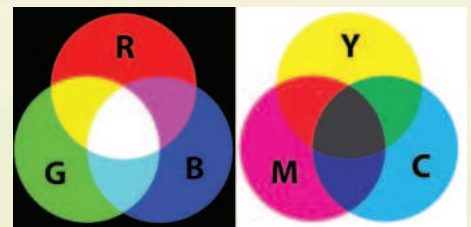


Oscar Gustav Rejlander's 'The Two Ways of Life', 1857, The Royal Photographic Society, London

and is coated as a gelatinous suspension on a transparent base. The decomposition of silver halide into ionic silver by the action



William Henry Fox Talbot's 'The Nelson Column, Trafalgar Square, London, under Construction', 1843, Print from Calotype Negative



Additive process (white at centre)

Subtractive process (black at centre)

and cyan are used, which are complimentary to blue, green, and red respectively in the sense that they will absorb or 'subtract' their complementary colours. Thus yellow absorbs blue, magenta absorbs green and cyan absorbs red, thereby producing the primary colours and black from white light by subtracting the complementary colours.

In 1861, before a gathering of the Royal Institution of London on 17 May 1861, the Scottish physicist James Clerk Maxwell demonstrated for the first time the principles of colour photography. He made three glass plate negatives by photographing a coloured ribbon after exposing it through red, green and blue-coloured filters. These were then turned into lantern slides and projected onto a screen in combination with the same colour filters, when a colour image somewhat close to the original in colour was formed on the screen by the 'colour additive' process.



First additive colour photograph of a ribbon taken in 1861. Actually James Clark Maxwell gave the lecture on the additive method, while Thomas Sutton took the picture of the ribbon. (Reproduction print from projection)

In 1869, Louis Arthur Ducos du Hauron in France announced a subtractive colour process discovered by him to produce colour prints before the Societe Francaise de Photographie, Paris. It was a pioneering discovery that would change the landscape of photography for ever. The method consisted in using colour separation negatives to produce three positive images which were then dyed with the complementary colours cyan, magenta and yellow. Each complementary colour absorbs a primary colour; thus cyan absorbs red light and reflects a mixture of blue and green. By correctly superimposing these complementary colours, the full range of

colours can be reproduced. The colour in subtractive processes comes from dyes rather than colour filters. This later formed the basis of colour films used in the camera for obtaining colour negatives.

The subtractive process scored over the additive process by enabling rich full-colour prints to be made on photographic paper and also by dispensing with cumbersome equipment needed for viewing colour slides. But initially it had the disadvantages of impractically long exposures, besides many other technological hurdles. Subtractive processes initially used separation negatives produced on three separate photographic plates accommodated within a single camera. Later, all three films or plates were combined into a single element that became known as known as 'tripack film' that would finally pave the way for the development of colour processes like Kodachrome used extensively during the last century. With these techniques, colour photography would really come of age.

The years 1880-1945 ushered in new technology and new vision. It was the era of modernism in photography. As the historian of photography Egmont Arens had said "The new camera counts the stars and discovers a new planet sister to our Earth, it peers down a drop of water and discovers microcosms. The camera searches out the texture of flower petals and moth wings as well as the surface of concrete. It has things to reveal about the curve of a girl's cheek and the internal structure of steel." It was during this period that pictorial or art photography flourished in all its grandeur.

Camera revolution

As the chemistry of photography developed, so did the design and efficiency of cameras – from the vintage-design box camera to folding camera to reflex camera to miniature cameras, giving increasingly sophisticated controls over aperture and shutter speed to make perfect exposures. Side by side, the optics of the lenses also increased in sophistication, from the normal lens of 50-mm focal length to telephoto lenses up to 800-mm focal length with a field of vision as narrow as 1-3 degrees at one end to 4-mm fish-eye lens with a field of view close



'View of Agen' by Louis Arthur du Hauron, 1877, a famous subtractive colour photograph. The overlapping yellow, magenta and cyan colours can be seen in the top.

to 180 degrees at the other. Autofocus lenses introduced in 1985 and finally the digital camera would take photography into a new plane altogether with the help of technology, sounding the death knell of traditional negative-positive photography, but that is another story to be told at another time.

Technology and techniques are ever changing, but photography will always capture the tapestries of life's experiences and weave them together with the thread of our memories – sometimes bitter, sometimes sweet, sometimes sad and sometimes joyous. Like life itself, mellowing our anger, frustration, despair as well as our energy and enthusiasm as we realise the ultimate impermanence of our existence.

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8. <http://www.nationalmediamuseum.org.uk>

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Planetariums in Girls' Schools in India



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School planetariums have long been playing a crucial role in refining the astronomical concepts of students all over the world. In India, visionary decisions were taken by a few eminent scientists, educationists, industrialists and philanthropists after independence who strove for a better environment where education would be an inevitable part of everyone including women. The first planetarium of India, the Kusumbai Motichand Planetarium in Pune's New English School was established in 1954. Second was the planetarium set up at the National Physical Laboratory, New Delhi, in 1956. Both the planetariums were suitable for small groups of audience, say about 80-100. At present there are 50 planetariums in India, but until now, only two planetariums have been established in girls' schools – one is the Arya Kanya Gurukul in Porbandar, which was installed 50 years ago in 1965 and the other is in Modern High School for Girls in Kolkata, opened 25 years ago in 1989. These planetariums, therefore, are now celebrating Golden Jubilee and Silver Jubilee of their operation, respectively.

Planetarium at Arya Kanya Gurukul

Arya Kanya Gurukul, Porbandar is the first girls' school in India to have a planetarium.



A life size statue of Pandit Jawaharlal Nehru at the entrance of the planetarium building.

This premier boarding school was established in 1937 by Shri Nanji Kalidas Mehta (1887-1969), founder of the Mehta Group of Industries. He was an entrepreneur by profession and a philanthropist by heart



Shri Jawaharlal Nehru Akash Griha (Planetarium).

who took the liberty of breaking the blind shackles of orthodoxy and featured his Group of Industries to establish educational and charitable institutions for the people. The Gurukul endeavours to create the acumen in students to grasp and analyse every discipline and also enrich them in the field of astronomy, which is included in their charter of education. This is perhaps the key reason for setting up a planetarium in the girls' school campus so that the girls of the Gurukul can pay a visit every now and then to the Gurukul Planetarium.

The planning and construction of the planetarium, named Shri Jawaharlal Nehru Akash Griha, started in January 1965 and within 11 months, total edifice was made ready. The planetarium was inaugurated on 27 November 1965 by the then Union Railway Minister Shri Sadashiv Kanoji Patil. Former Prime Minister Smt.

Indira Gandhi during her visit to Arya Kanya Gurukul and the planetarium on 19 February 1967 wrote the following message in the Distinguished Visitors' Book. "The importance of education for girls was emphasised by both Gandhiji and Nehruji. They opened many a new door for women of India. It is the duty of the women of India to come forward and participate in the country's progress. For this, there is a need of education, health, discipline and arts. They should develop the feeling of patriotism and knowledge of the rich cultural heritage of our country".

The Porbandar planetarium has a dome of 8-metre diameter and 100 people can sit and watch a show at a time. It has a Zeiss ZKP1 planetarium projector, which can display about 5,000 stars and planets with the help of multiple projectors. The projector's 'star ball' has 32 lenses and each lens forms a sky



Smt. Indira Gandhi, Prime Minister of India at Arya Kanya Gurukul, Porbandar in 1967.

area of approximately 150 stars. The ball is connected to a truss containing projectors for planets and other moving celestial objects. All these individual projectors are to be set manually and therefore require sufficient astronomical knowledge of the planetarium staff. The shows thus provide exciting



Audience under the planetarium dome.

astronomy education. The planetarium holds about 300 shows a year rounding up around 30,000 visitors to view its fantastic shows on our Universe.

Planetarium at Modern High School for Girls

The Modern High School for Girls is reputed to be one of the best institutions in Kolkata. The school was founded in 1952 at 28, Camac Street. A year later, the senior school moved to a new location at 33, Theatre Road, now known as Shakespeare Sarani.

In 1954, Ghanshyam Das Birla, an eminent industrialist, decided to donate their palatial residential building at Birla Park on Gurusaday Road in Kolkata to Government



Inauguration of planetarium at Modern High School for Girls by Dr Sisir Bose.

opened its door to public in May 1959. Earlier, in a letter addressed to Pt. Jawaharlal Nehru, the then Prime Minister of India, Shri G.D. Birla had expressed his desire to shift the Modern High School for Girls close to BITM to transform Birla Park into an educational centre of the city of Kolkata.

The foundation stone of present building of Modern High School for Girls, on Syed Amir Ali Avenue, adjacent to BITM was laid by Dr. Bidhan Chandra Roy, the then Chief Minister of West Bengal, on 9 December 1957. The senior school was shifted to this building in March 1960.

Between 1962 and 1989, the Birla family had established four planetariums in the country. The first major planetarium, the Birla Planetarium in Kolkata, was established by Shri G.D. Birla's nephew Shri Madhav Prasad Birla in 1962. It was inaugurated by Pt Jawaharlal Nehru on 2 July 1963. Next was the B.M. Birla Planetarium in Hyderabad, which was inaugurated on 8 September 1985 by Shri N.T. Rama Rao, Chief Minister of Andhra Pradesh. Then came the B.M. Birla Planetarium, Chennai, funded by Shri Ganga Prasad Birla (son of Shri B.M. Birla), which was inaugurated on 11 May 1988 by Shri R. Venkataraman, President of India. Lastly, it was the B.M. Birla Planetarium,

Jaipur, inaugurated on 17 March 1989 by Shri G.P. Birla.

All these mammoth tasks to make way for the development of a child's intellect was done with the hope of strengthening the country's present and future. Complying with this notion, Smt. Nirmala Birla, wife of Shri G.P. Birla, thought about setting up a planetarium in the premises of the Modern High School for Girls. Eventually, the plan was executed and the planetarium was built in 1988. The planetarium was inaugurated in late 1989 by Dr. Sisir Kr. Bose who was a pediatrician and a Member of Parliament. Gracing the occasion was Shri G.P. Birla, Smt. Nirmala Birla, Smt. Krishna Bose, and Mrs. I.L. Wilson de Roze, the then Headmistress of the school.

The planetarium at Modern High School for Girls is a small one, with a dome diameter of 5 metres which can accommodate about 40 students. The projector of the planetarium, Model E-5 of GOTO Optical Mfg. Co. was imported from Japan.



Planetarium projector Goto E-5

The Goto projector in the planetarium can simulate the night sky, as also complicated planetary movements that occur during Earth's annual motion. The 30-cm globe projects 750 stars down to 5th magnitude and the 'planet cage' mechanism reproduces intricate movements of the Sun, the Moon, Mercury, Venus, Mars, Jupiter and Saturn accurately. There is a rear illuminated control panel for making skillful operation the projector in the dark.

The two planetariums in girls' schools described here would continue to serve to become a wondrous start for mental nourishment of girl children and also would let them ponder over the varied themes of astronomy.

Dr Jayanta Sthanapati is currently engaged as Project Investigator to study the 'History of Science Museums and Planetariums in India', a research project sponsored by the Indian National Science Academy.

About gravity and microgravity



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Gravity is universal. It is a force pulling together all matter. Every object in the universe attracts every other object with a force directed along the line joining the centres of the two objects. This force of attraction is dependent upon the masses of both objects and also on the distance that separates their centers.



Aryabhatta

Sir Isaac Newton

The more massive an object the more of gravitational pull it exerts. As we stand on the surface of the Earth, it pulls on us, and we pull back. But since the Earth is so much more massive than we are, the pull from us is not strong enough to move the Earth. However, when we jump up we come back to the ground, attracted by Earth's gravity. With our physical bodies we cannot fly from Earth into space because of the gravitational pull of the Earth. Objects on the Earth fall and tend to remain on the ground because the gravitational force of the Earth is pulling on them. The Moon is less massive than Earth; therefore the gravity on Moon is less than the gravity on Earth.

The gravitational force is directly proportional to the product of the masses of the two interacting objects. As the mass of either object increases, the force of gravitational attraction between them also increases. If the mass of one of the objects is doubled, then the force of gravity between them is doubled. If the mass of one of the objects is tripled, then the force of gravity between them is tripled. If the masses of both of the objects are doubled, then the force of gravity between them is quadrupled; and so on.

Gravitational force is also inversely proportional to the square of the distance

between two objects; as the distance increases the gravitational attraction becomes weaker. If the distance between two objects is doubled, then the force of gravitational attraction decreases by a factor of 4. If the distance is tripled, then the force of gravitational attraction decreases by a factor of 9. The magnitude of the gravitational force can be calculated using Newton's law of universal gravitation:

$$F = Gm_1m_2/r^2$$

Where m_1 and m_2 are the respective masses of the two objects, r is the distance between them, and G is a constant known as the gravitational constant ($G = 6.672 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$).

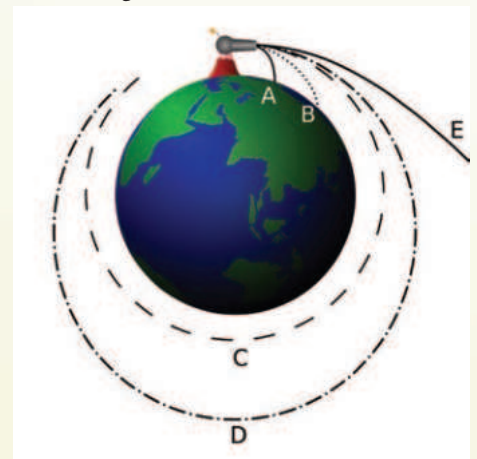
The effects of gravitation are attractive. A common example is the rise and fall of ocean tides. This was a mystery until Newton first developed his theory of gravity. Tides refer to the rise and fall of our oceans' surfaces caused by the attractive forces of the Moon and Sun's gravity as well as the centrifugal force due to the Earth's spin.

Newton had also speculated that the Moon goes round the Earth because of Earth's gravity. But how is gravity related to the orbital motion of celestial bodies? To get an explanation for this, Newton conducted a 'thought experiment'.

He imagined a mountain so high that its peak is above the atmosphere of the Earth where air resistance would be negligible. Then he imagined on top of that mountain a cannon that fires horizontally. When the cannon is fired, the cannonball follows a curve, falling faster and faster as a result of Earth's gravity, and hits the Earth at some distance away. Faster the initial horizontal speed of the cannon ball, greater is the distance the cannonball travels. As more and more charge is used with each shot, the speed of the cannonball will be greater, and it will impact the ground farther and farther away from the mountain. Finally, at a certain speed, the cannonball will keep falling but will not hit the ground. It will fall towards the Earth's surface just as fast as the latter curves away from it. In the absence of drag from the atmosphere it would continue falling forever as it circled the Earth; that

is, it will go into Earth's orbit! This thought experiment allowed Newton to extrapolate from the world of his everyday sense to things on the scale of the Earth or even the solar system. He concluded that Moon was continuously "falling" in its path around the Earth because of the acceleration due to Earth's gravity.

The diagram depicting Newton's thought experiment provided the theoretical basis for space travel and rocketry. It was drawn more than 250 years before the *Sputnik*, and nearly 100 years before the first balloon flight.



Projectiles A and B fall back to earth, C achieves a circular orbit, D an elliptical one, & E escapes

When a satellite is launched into orbit, the rocket boosts the spacecraft up to the height of a "very tall mountain" and also gives the spacecraft its forward speed, like the gunpowder gives the cannonball to the extent that it starts circling the Earth. So the spacecraft just falls all the way around the Earth, never hitting the surface. The curve of the spacecraft's path is about the same as the curvature of Earth's surface. Of course, to be in an orbit a satellite needs tremendous speeds. For example, to maintain an orbit of 380 km, the space shuttle travels approximately 7,680 m/s; that is, more than 23 times the speed of sound at sea level! Thus at a particular distance from the



The International Space Station (ISS)

centre of the Earth, a certain value of speed keeps the satellite in orbit. Such satellites are artificial satellites whereas the Moon is a natural satellite of the Earth.

If the speed of a proposed artificial satellite is less than the required speed, it falls back to the Earth. If its speed is one and half times more than the required, then it would leave the Earth's gravitational field and would fly off into space. This velocity is called the 'exit velocity' or 'escape velocity'. The escape velocity from the Earth's surface is about 11.2 km/sec (ignoring air resistance). This is the speed with which you would have to launch something from the surface of the Earth if you wanted it to completely escape from the Earth's gravitational pull.

Now, let us see how astronauts feel the gravity while in an orbiting spacecraft. Interestingly, they feel almost weightless and float around within the spacecraft. This is because the spacecraft along with astronauts and its contents are constantly falling towards the Earth, and any object in free fall becomes weightless.

The sensation of weightlessness is common at amusement parks for riders of roller coasters and other rides in which riders lose altitude fast and momentarily become airborne and lifted out of their seats. Actually, the perception of weight comes from the support force exerted upon a person by the floor, a cot, a chair, etc. If that support force is removed there is no external contact force pushing against a person's body. Imagine that a person is in a lift and the lift cable suddenly breaks. As the lift falls towards the ground, both the lift cabin and the person in it accelerate at the same rate 'g'. Since the lift cabin falls at the same rate as the person in it, the floor of the lift is unable to push him upward and as a result he would experience a weightless sensation although gravity is the

only force acting upon both.

Mass of an object is the amount of matter it contains while the weight of an object is the result of gravity. When we measure the weight of an object on Earth it is in fact the gravitational force of attraction between the object and the Earth that is being measured ($W = mg$). That is why the weight of a person on Moon is only one-sixth of his weight on Earth because Moon's gravity is only one-sixth that of Earth.

The International Space Station (ISS) is a joint project between international space agencies that is used as an orbiting research facility. The station is in a low earth orbit.



Ocean Tides

Its altitude varies from 319.6 km to 346.9 km above the Earth's surface. It travels at an average speed of 27,744 km per hour, completing 15.7 orbits per day. Astronauts in the ISS experience a gravitational force equal to is approximately one millionth (10^{-6}) of that on Earth and so become weightless. The term microgravity is also used to describe the state of weightlessness in space (micro means one-millionth).

On Earth, all types of motions are dominated by gravity, be a cricket ball thrown by a spinner, the hopping, jumping and sinking of pebbles thrown into a pond by rejoicing children, or even the cool breeze coming from the sea – everywhere and anywhere! Dense fluids sink, and light fluids rise. Here on Earth it will never happen in other way round!

However, in microgravity environment more subtle phenomena like surface tension rule over gravity. Intermolecular forces can hold globs of fluid tighter than, on Earth, would be torn apart by their own weight. Released from the rule of gravity on Earth, water lets its surface tension hang out. Each molecule is pulled with equal tension by its neighbours. The tight-knit group forms the smallest possible area – 'a sphere'. One can give a prod to these beautiful spheres in space and watch how they change. Fantastic! An astronaut can grab a big wayward sphere of water floating in weightlessness on board the ISS, using chopsticks to quench his thirst. Wonderful! Isn't it?


The effects of microgravity are also as attractive as those of gravity and scientists have set themselves on experimenting in microgravity environment. A number of research projects in various fields like fluid physics, protein crystal growth, etc., are in progress.

Dr. Chaganty Krishnakumari is a Telugu popular science writer, well-known for her unique creative presentation of complex scientific subjects in a captivating narrative style. She retired as Reader and Head, Department of Chemistry from Singareni Collieries Women's College, Kothagudem, Telangana. ■

Dream 2047

Articles invited

Vigyan Prasar invites original popular science articles for publication in its monthly science magazine *Dream 2047*. At present the magazine has 50,000 subscribers. The article may be limited to 3,000 words and can be written in English or Hindi. Regular columns on i) Health ii) Recent developments in science and technology are also welcome. Honorarium, as per Vigyan Prasar norm, is paid to the author(s) if the article is accepted for publication. For details please log-on to www.vigyanprasar.gov.in or e-mail to dream@vigyanprasar.gov.in



The puzzle of dark energy

The urge to know the universe has motivated astronomers to explore space. This tireless effort of human civilisation has led to the unravelling of many mysteries of the universe, but at the same time these successes have raised many further questions yet to be explained.

In the beginning of ninth decade of 20th century scientists were convinced that the energy density of universe is large



Amazing Universe (Courtesy: NASA)

enough to stop the ongoing expansion of the universe in the distant future. But in 1998, in course of a study of Type 1a supernova, the Hubble Space Telescope observed a phenomenon that completely rejected the abovementioned hypothesis. It found that the speed of expansion of the universe in the past was slower. It means, contrary to the recognised hypothesis, the expansion of universe is accelerating. This discovery amazed the scientists. In order to explain this phenomenon when they put these observations into the theories of Big Bang model, they found that the ordinary “seeable” energy and matter comprises only 5% of the universe. It was found that rest 95% part is made of forms of matter and energy which are unfamiliar to us. Initial calculations revealed that 70% of it is in the form of energy and 25% is in the form of matter. This energy and matter were called ‘dark energy’ and ‘dark matter’.

Introduction

Dark energy could be described as the most mystical thing of the universe. Unlike dark matter that could be identified by its

gravitational effect on normal matter, the nature of dark energy is still an absolute mystery. In early nineties, two teams of astronomers led by Saul Perlmutter of Supernova Cosmology Project for Lawrence Berkeley National Laboratory and the University of California at Berkeley, and Brian Schmidt of the High-Z Supernova Search Team independently started to study distant Type 1a supernovae (violently exploding stars) in order to find out the expansion rate of the universe.

Type 1a supernovae are useful for measuring cosmic distances because they are excellent ‘standard candles’ – objects for which the intrinsic brightness is known – the apparent brightness of which depends on distance. They allow the expansion history of the universe to be measured by looking at the relationship between the distance to an object and its redshift, which gives how fast it is receding from us. The relationship is roughly linear, according to Hubble’s law. The use of standard candles allows the object’s distance to be measured from its actual observed brightness. Type 1a supernovae are the best-known standard candles across cosmological distances because of their extreme and extremely consistent luminosity.

When the astronomers looked out six to seven billion light years away they found to their surprise that the supernovae were not as bright as they ought to be at the distance they would if the rate of expansion of the universe was slowing down. They were fainter and therefore not as near as expected. This discovery, which led to its discoverers winning the Noble Prize for Physics in 2011, was that the rate of expansion of the universe is not slowing down; rather it is increasing. An important implication of this discovery was that it is not gravity which is the determining force to seal the fate of universe, but that some exotic form of energy, which we are not familiar with, is the master right now.

Further, the measurements of cosmic background microwave radiation indicated that the geometrical shape of the universe should be flat. It once again implies that a certain kind of unknown force must be in existence as the total quantum of matter, including normal and dark matter, is not

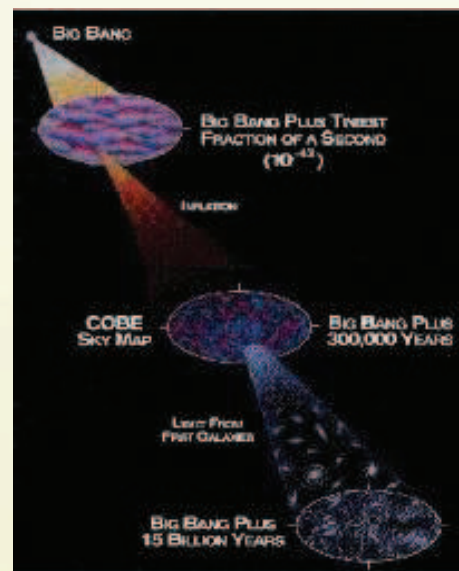


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enough to produce the flat geometry. To explain these phenomena the scientists put forward a theory of the existence of a strange type of energy that is embedded in the vacuum of space itself, subjecting the universe to a constant outward push that makes it expand ever faster with its unique properties. This energy was christened ‘dark energy’ by the famous cosmologist Michael Turner in 1998.

Though dark energy appears to make up 74% of the universe, astronomers understand very little about it. The nature of this energy is a matter of speculation as the evidence for dark energy is only indirectly coming from distance measurements of far flung supernovae and galaxies and their relation to redshift. Dark energy is thought to be very homogeneous, not very dense and is not known to interact through any of the fundamental forces other than gravity.



Big Bang (Courtesy: NASA)

Since it is quite rarefied, with energy density of roughly 10^{-29} g/cm³, it is unlikely to be detectable in laboratory experiments. It is sometimes called a vacuum energy because it has the energy density of empty vacuum. Dark energy can only have such a profound effect on the universe, making up 74%

of the universe, because it uniformly fills an otherwise empty space. Currently two models have been put forward to explain the nature of dark energy besides a number of other models with exotic possibilities.

Cosmological Constant model

This model correlates dark energy to Albert Einstein's cosmological constant. According to this model, the dark energy percolates from empty space. So, in the simplest terms, cosmological constant is the energy density of vacuum in space. This constant was introduced by Einstein in his original general theory of relativity to achieve the stationary universe. This theory states that in the line of classical thermodynamics, where the negative pressure occurs to account for the energy lost while doing work on a container, the cosmological constant has negative pressure equal to its energy density and so causes the expansion of the universe to accelerate. Further it predicts that dark energy is unchanging and of a prescribed strength.

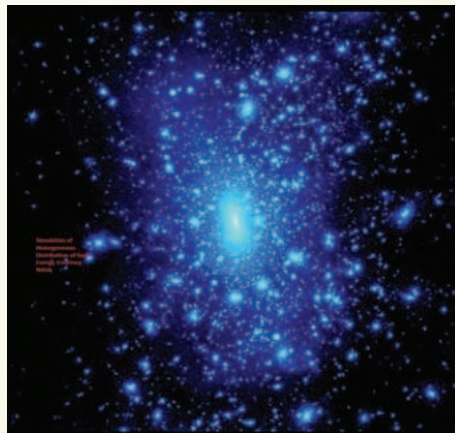
But this model has its own problems. This model predicts a value of cosmological constant that is many orders of magnitude higher than the observed value. It means according to this theory the rate of expansion should have been very much faster than observed. The successful integration of cosmological constant into current standard model of cosmology is another major problem. But, despite these shortcomings the Cosmological Constant model is the most favoured theory of dark energy which has been supported by the evidence from Hubble Space Telescope.

Quintessence model

These models, which are also known as 'dynamic dark energy' models, were postulated to explain the observed accelerating expansion of universe. According to this theory the accelerated expansion of universe is caused by the potential energy of a special (dynamic) type of field referred to as 'quintessence field', which is capable to vary in space and time unlike cosmological constant which does not vary at all with respect to time. This model predicts a slower acceleration of expansion than predicted by cosmological constant model. According to current theories, quintessence is a quantum field with both kinetic and potential energy. Depending on the ratio of the two energies

and the pressure they exert, quintessence can be either attractive or repulsive. Quintessence became a force to be reckoned with about 10 billion years ago, according to the theory. Additionally, the specific models of quintessence are able to solve a very well-known problem of theoretical cosmology called cosmic coincidence problem which asks why cosmic acceleration started when it actually did. But till now there is no experimental evidence to support the quintessence model and currently this theory is in realm of theoretical physicists only.

In addition to these theories many other theories have been proposed to shed light on the nature of dark energy in which



Distribution of dark energy

time-varying dark energy theories and topological defects are prominent. But none of these has yet proved as compelling as the two leading ones.

Experiments to observe dark energy

There are four main experimental techniques that can allow us to shed light on the mystery of dark energy. The first one is baryon-acoustic-oscillation method which has been designed to look for ripples in the distributions of galaxies, which originated in acoustic oscillations of normal matter when it was bound up with the cosmic background radiation (which is a relic of the Big Bang) before matter and radiation decoupled and became separate entities. Since wavelength of the ripples can be measured from the pattern of temperature fluctuations in the cosmic microwave background, they can be compared them to observations of the galaxy pattern across the sky to determine the distances at which those galaxies lie. The baryon-acoustic-oscillation method is

mostly sensitive to the matter density of the universe. This is because such measurements require a comparison between the observed sizes of acoustic ripples to the size expected from the cosmic microwave background, which originated in an era when the gravitational attraction from matter should have dominated over gravitational repulsion from dark energy. When combined with supernova observations, however, it plays an important role in separating out the matter density from dark-energy properties.

The second method is to study the cosmic microwave background itself. The temperatures and spatial extents of the hot and cold spots in this sea of electromagnetic radiation provide a superb probe of the primordial universe some 360,000 years after the Big Bang. Since the early universe should be dominated by matter, with little dark energy, the microwave background says relatively little directly about the properties of dark energy. But, like the baryonic acoustic oscillations, it plays an important role in separating out the role of the matter density. There are many projects already in progress for studying the cosmic background radiation, which include the Clover, EBEX, POLARBEAR, QUIET and Spider projects.

The cosmic microwave background also provides a "backlight" to detect clusters of galaxies through their "shadows" as microwave photons scatter off the hot electrons in the cluster core. Known as the Sunyaev-Zel'dovich Effect, it could be used to measure the size of clusters and hence their distances in order to investigate dark energy. Experiments such as ACT and APEX-SZ in Chile and at the South Pole Telescope are based on this approach.

In the third experimental technique, supernovae and galaxies are studied to know the rate of cosmic expansion. Cosmologists use the fact that Type Ia supernovae are nearly "standard candles" and all have nearly the same absolute brightness or luminosity when they reach their brightest phase. By comparing the apparent brightness of two supernovae, their relative distances can be determined. Since 1998, when dozen supernovae had been studied to discover dark energy and accelerating expansion of the universe, till date several hundreds have been measured helping the astronomers to create a wide view of last 10 billion years of cosmic expansion. The proposed space probe



Possible effect of dark energy on the Universe

Euclid of Dark Universe project of European Space Agency (ESA) in collaboration with NASA is aimed at drawing up a map of 3D distribution of up to two billion galaxies and dark matter associated to them, in order to understand the nature of dark energy and matter by accurately measuring the acceleration of the universe.

The fourth approach to defining dark energy involves a method called gravitational lensing. According to Albert Einstein's theory of general relativity, a beam of light travelling through space appears to bend because of the distortion in space-time caused by mass of matter. If two clusters of galaxies lie along a single line of sight, the foreground cluster will act as a lens that distorts light coming from the background cluster. This distortion can tell astronomers about the mass of the foreground cluster. By sampling millions of galaxies in different parts of the universe, astronomers should be able to estimate the rate at which galaxies have clumped into clusters over time, and that rate in turn will tell them how fast the universe expanded at different points in its history. Weak lensing therefore probes dark energy both directly via the stretching of distances and indirectly via the mass of galaxy clusters, since the faster the expansion the harder it is for gravity to pull mass together.

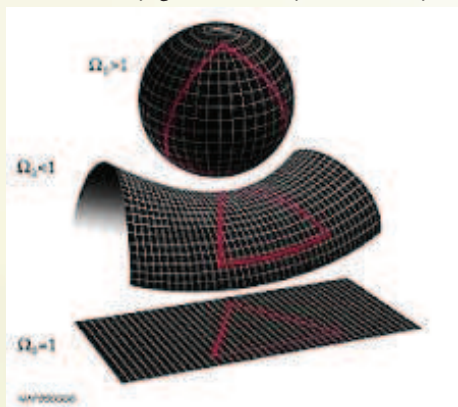
Alternatives to dark energy

Although the case for dark energy has been strengthened over the past fifteen years, many people feel unhappy with the current cosmological model. It may be consistent with all the current data, but there is no satisfactory explanation in terms of fundamental physics. As a result, a number of alternatives to dark energy have been

proposed as viable alternatives to solve the problems posed by dark energy theories. According to the cosmologist Christos Tsagas, dark energy does not exist at all. As per his argument it is very likely that all the accelerated expansion of universe witnessed by us is an illusion only caused by our motion relative to the rest of universe.

Some other theories treat dark energy and cosmic acceleration as a failure of the general theory of relativity at larger than super cluster scales and

try to explain the observations using very complex concepts of time reversed solutions of general relativity or gravitational effects of density inhomogeneity. But these theories fail to modify general theory of relativity in



Possible shapes of the Universe
(Courtesy: wikipedia)

such form which could satisfactorily explain cosmic acceleration phenomena. While some other theories treat dark energy and dark matter as two faces of a single coin and propose a theory of dark fluid to explain all the observed phenomena.

Implication of dark energy to destiny of universe

Our understanding of destiny of universe depends on how better we understand dark energy. Since the discovery of dark matter in 1998 our comprehension about its nature is increasing day by day. Based on the theories of dark energy till date we can visualise a number of fates of the universe that are theoretically possible. If the repulsion caused by dark energy is or in future becomes stronger than Einstein's prediction for cosmological constant's value, the universe in future may

be torn apart by a "Big Rip" during which the universe would expand so violently that all the galaxies, stars, planets and even the atoms come unglued in a catastrophic end. In an extremely opposite scenario, the dark energy might fade away with time or become attractive as indicated by some theories, and then the universe will ultimately implode to a "Big Crunch". In a third scenario it is also possible the universe may never have an end and continue in its present state forever due to rise of exact balance between gravity and dark energy at a particular instant of time in future. Currently there is no evidence to support any of these scenarios but we are in need of better determination of properties of dark energy and more precise observations before we are in a position to describe the ultimate fate of universe with confidence.

Future of dark energy

Inferred from observations of Type 1a supernovae, dark energy is one of the most profound discoveries of cosmology. It has thrown open an excellent vast new frontier both in observational and theoretical cosmology. In the next ten years with the advent of sophisticated next generation experiments using a range of technologies for greatly improved accuracy in the measurement of dark energy, our understanding should be vastly advanced. In the coming decade, on the observational front, scientists will either verify to a high precision the existence of a truly constant vacuum energy representing a new fundamental constant of nature and potentially a crucial clue to the reconciliation of gravity to the standard model, or they will detect varying dark energy densities indicating a new dynamical component or an alteration to the celebrated general theory of relativity itself. Similarly on theoretical front, it is hoped that understanding of dark energy shall provide the invaluable insight into one of the most perplexing issues of theoretical physics (cosmological constant problem) as well as to the brand new issue of coincidence problem which in turn could further open exciting new theoretical developments. It is also quite possible the ongoing research on dark energy may lead to the discovery of something which is currently even beyond imagination.

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Biofertilisers: The Need of the Hour



Dr. Arvind Singh

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Bring about nutrient enrichment of the soil. There are large numbers of bacteria and blue-green algae (cyanobacteria) which fix atmospheric nitrogen (convert elemental nitrogen to ammonia) either in association with some other organism or in free-state. Similarly there are several fungi and bacteria in nature which have the capability to solubilise bound phosphate in the soil. There are several fungi that are capable of decomposing organic matter faster, consequently releasing the nutrients in the soil. Thus biofertilisers enrich the soil with nutrients by nitrogen fixation, by phosphate solubilisation and by quick release of nutrients (due to enhanced decomposition of organic matter).



Azolla pinnata is a nitrogenous bio-fertilizer used to supplement nitrogen in paddy fields (Source: www.flickr.com)

Why are biofertilisers the need of the hour?

Chemical fertilisers used to raise the fertility status of the soil are costly and are manufactured from non-renewable petroleum feedstock, which is gradually diminishing. The continuous use of chemical fertilisers is also detrimental to soil health. For instance, excessive use of nitrogenous fertilisers destroys the soil structure thus making the soil prone to erosive forces like wind and water. Chemical fertilisers are also responsible for the surface and ground water pollution. Furthermore, use of nitrogenous fertilisers makes the crop vulnerable to diseases and pests infestation. Fertiliser-enriched soil has less humus and less nutrients and hence does not support microbial life. Indian soils are generally poor in organic matter and nitrogen because of excessive use of chemical fertilisers. Application of excessive superphosphate leads to copper and zinc deficiency in plants.

Fertilisers also alter the nutritional value of food crops. Excessive use of nitrogenous fertiliser urea causes a decrease in the potassium content of food grains. Similarly, excessive potash treatment reduces

the vitamin C (ascorbic acid) and carotene contents in plants. Nitrate fertilisers increases the total crop yield, but at the cost of protein. Moreover, the balance of amino acids is disturbed within the protein

molecule thus lowering the protein quality. Fertiliser use produces over-sized fruits and vegetables which are more prone to insects and other pests.

Benefits of biofertilisers

Biofertilisers provide the following benefits:

- Biofertilisers are cost-effective relative to chemical fertilisers. They have lower manufacturing costs.
- Biofertilisers add nutrients to soil through natural processes of nitrogen fixation, phosphorus solubilisation and organic matter decomposition.
- Biofertilisers provide protection to plants against root pathogens.
- Biofertilisers restore the nutrient cycling of the soil and build organic matter.
- Biofertilisers stimulate plant growth through the synthesis of growth-promoting substances.



Types of biofertilisers

Biofertilisers can be categorised into three types:

1. Nitrogenous biofertilisers:

The biofertilisers which brings about the nitrogen enrichment of the soil are called as nitrogenous biofertilisers. Nitrogenous biofertilisers are important as they supply nitrogen to soil. There are large number of bacteria and blue-green algae in nature that fix atmospheric nitrogen. The important nitrogen-fixing bacteria are represented by *Rhizobium*, *Azotobacter*, *Beijerinckia*, *Clostridium*, *Rhodospirillum*, *Herbaspirillum* and *Azospirillum*. The *Rhizobium* forms symbiotic association (association in which both the organisms live together for mutual benefit) with the roots of leguminous plants and fix atmospheric nitrogen.

Azotobacter, *Beijerinckia*, *Clostridium* and *Rhodospirillum* are nonsymbiotic nitrogen fixing bacteria, as they fix atmospheric nitrogen in free-state in the soil. *Herbaspirillum* and *Azospirillum* are associative nitrogen fixers, as they form a loose association with roots of plants and fix atmospheric nitrogen. These two bacteria inhabit the root zone (Rhizosphere) of tropical grasses and crops like maize and sorghum.

The important blue-green algae which fix atmospheric nitrogen are represented by *Nostoc*, *Anabaena*, *Aulosira*, *Cylindrospermum*, *Gloeotrichia*, *Gloeocapsa*, *Calothrix*, *Tolypothrix*, and

Scytonema. The amount of nitrogen fixed by blue-green algae ranges between 15 and 45 kg nitrogen per hectare. Standing water of 2 to 10 cm in the field is necessary for the growth of blue-green algae. They grow well



Azotobacter is a nitrogenous bio-fertilizer used to supplement nitrogen in the soil other than paddy fields (Source: www.indiamart.com)

in a pH range of 7 to 8.

The *Anabaena* also forms symbiotic association with a water fern *Azolla* and fix nitrogen. Hence *Azolla* is used as potent biofertiliser for rice crop. A thick mat of *Azolla* supplies 30 to 40 kg nitrogen per hectare. Normal growth of *Azolla* occurs in temperature range between 20 and 30°C. It grows better during the rainy season.

Azolla-Anabaena symbiosis – *Azolla* is a tiny aquatic fern with tiny leaves. The leaves are bilobed. The lower lobe is white in colour and is submerged in water while the upper lobe, which floats on the surface of water, is green in colour (due to presence of chloroplast) hence, performs the function of photosynthesis. The upper green lobe has an algal cavity in which the nitrogen fixing blue-green alga *Anabaena azollae* resides and fixes atmospheric nitrogen.

2. Phosphatic biofertilisers: These are biofertilisers which solubilise bound phosphate in the soil thus ensuring its availability to the plants. Several phosphate-solubilising fungi like *Acaulospora*, *Gigaspora*, *Endogone*, *Glomus*, *Sclerocystis*, *Amanita*, *Boletus* form symbiotic association with roots of plants and supply phosphate to the plants. This association of fungi with roots of plants is known as mycorrhizal association. *Endomycorrhiza* and *ectomycorrhiza* are two different categories of mycorrhizal association.

In endomycorrhizal association the fungal partner penetrates deep in the roots of plants. It is also known as 'vesicular arbuscular type of mycorrhiza' (VAM), which is generally found in crop plants. VAM fungi

enhance the frequency of nodulation in leguminous crop plants thereby increasing their yield. *Acaulospora*, *Endogone*, *Glomus*, *Gigaspora* and *Sclerocystis* are the examples of VAM fungi.

In ectomycorrhizal association the fungal partner remain confined to the surface of plant roots. It is generally found in forest trees like pine, oak, beech, etc. *Amanita* and *Boletus* are the examples of ectomycorrhizal fungi.

Besides fungi there are certain free-living bacteria like *Bacillus subtilis*, *Pseudomonas fluorescens*, and *Pseudomonas putida* which solubilise phosphate in the soil thus making it available to the plants.

3. Cellulolytic biofertilisers: The biofertilisers which enhance the rate of decomposition of organic matter thus facilitating the quick release of nutrients to the soil are known as cellulolytic biofertilisers. Cellulolytic biofertilisers are represented

by fungi like *Aspergillus*, *Trichoderma* and *Penicillium*.

Conclusion

Chemical fertilisers are not only expensive but their use also degrades the environmental quality and soil health. Moreover, chemical fertilisers also alter the nutritional quality of food grains. Therefore use of biofertilisers is the need of the hour to sustain soil health, environmental quality and production of nutritious food grains.

Dr. Arvind Singh is M.Sc. and Ph.D. in Botany with area of specialization in Ecology. He is an dedicated Researcher having more than four dozen of published Research Papers in the Journals of National and International repute. His main area of Research is Restoration of Mined Lands. However, he has also conducted Research on the Vascular Flora of the Banaras Hindu University Main Campus, Varanasi (India). ■

Requirement of Language Editors (Hindi and English) for 'Dream 2047'

Vigyan Prasar is a national institution under the Department of Science & Technology, Government of India. Among other activities, VP brings out a monthly bilingual popular science magazine "Dream 2047". Number of subscription of the magazine is over 50,000. The magazine is sent free to scientific institutions, science clubs, schools, colleges and individuals interested in science and technology communication.

VP invites applications from interested and experienced individuals to do language editing of the magazine "Dream 2047" (Hindi and English separately). Only individual with proven track record of editing popular science magazine will be considered. There is no upper age limit.

Essential qualification (English editing):

- ii) M.Sc. or B. Tech/MBBS from a recognised university.
- ii) Experience in editing English popular science magazine.
- iii) Proven track record of writing popular science articles, books etc. in English

Essential qualification (Hindi editing):

- i) M.Sc. or B. Tech/MBBS from a recognised university.
- ii) Experience in editing Hindi popular science magazine.
- iii) Proven track record of writing popular science articles, books etc. in Hindi

Note:

The job is purely on a contractual basis for a period of one year extendable to three years. Consolidated remuneration of ₹12,000/- per month will be paid. No other benefits will be provided. Interested individuals may send their bio-data along with copies of articles, books written by them to:



Registrar, Vigyan Prasar
A-50, Institutional Area,
Sector-62, NOIDA-201 309, (U.P.)

Last date of submission of application is 15 May 2015. Envelope should be superscribed with "Application for language editor (Hindi/English) – Dream 2047".

Allergic rhinitis – Culpable factors, Symptoms and Medical Help



Dr. Yatish Agarwal
E-mail: dryatish@yahoo.com

You may wear this allergy all year long, or you may feel worse during certain times of the year, but a runny nose, itchy eyes, congestion, sneezing and bad sinuses are the hallmark symptoms of allergic rhinitis. A common condition, found at all ages, and, particularly, among school children, it produces cold-like signs and symptoms, but unlike a cold, is caused by an allergic response to outdoor or indoor allergens, such as pollen, dust mites or pet dander. Since it has no tie up with the cold virus, you do not run the risk of being a villain in spreading the malady within the community.



Factors at play

The following factors may increase your risk of developing allergic rhinitis:

Vulnerability to allergy

If you have other allergies or asthma, you are much more likely to suffer from allergic rhinitis.

Family history

Having a blood relative (such as a parent or sibling) with allergies or asthma makes you more susceptible to develop allergic rhinitis.

Age

Although allergic rhinitis can begin at any age, you are most likely to develop it during childhood or early adulthood. It is common for the severity of allergic rhinitis reactions to change over the years. For most people, allergic rhinitis symptoms tend to diminish slowly, often over decades.

The condition is fairly common and its occurrence appears to be on the rise. A multi-centre study conducted by the Asthma Epidemiology Study Group of the Indian Council of Medical Research has found the prevalence of allergic rhinitis to be 3.5% in the general population. The prevalence of allergic rhinitis in school children has been found much higher, between 21 and 26 per cent.

Where you live

The city-village divide also closely impacts the prevalence. When seen along with socio-economic status, the prevalence was 27.1 per cent in lower class, 33.3 per cent in middle class, 28.6 per cent in upper class in urban area and 11.1 per cent in village area of Delhi.

Tobacco use

The association of the incidence of allergic rhinitis has been found to be most severe with tobacco use. The prevalence is much higher

(55 per cent) in tobacco users compared to 12.8 per cent in no-tobacco users.

What sets off the trigger?

If you are constitutionally wired to suffer the ills of allergic rhinitis, the process is activated through a complex process called sensitisation. Your immune system mistakenly identifies a harmless airborne substance as something harmful, and starts producing antibodies against this harmless substance. The next time you come in contact with the substance, these antibodies recognise it and signal your immune system to release chemicals, such as histamine, into your bloodstream. This “chemical *locha*” (disturbance) in the body system causes a reaction that leads to the irritating signs and symptoms of allergic rhinitis.

Seasonal triggers

A number of factors can rig up allergic rhinitis at a specific time of the year. These seasonal triggers include:

- Tree pollen, common in the spring
- Grass pollen, common in the late spring and summer
- Ragweed pollen, common in the fall
- Spores from fungi and moulds, which can be worse during warm-weather and rainy months



Year-round triggers

Some triggers are present year-round. These include:

- Dust mites
- Cockroaches
- Spores from indoor and outdoor fungi and moulds
- Dander (dried skin flakes and saliva) from pets, such as dogs, cats, or birds



Classic symptoms

The signs and symptoms of allergic rhinitis usually start immediately after you are exposed to a specific allergy-causing substance (allergen) and can include:

- Runny nose and nasal congestion
- Watery or itchy eyes
- Sneezing
- Cough
- Itchy nose, roof of mouth or throat

- Bad sinuses and facial pain
- Swollen, blue-coloured skin under the eyes (allergic shiners)
- Decreased sense of smell or taste

These symptoms may occur year-round or start or worsen at a particular time of year. This frequency relates to the presence of allergy-causing substance in the environment. If you're sensitive to indoor allergens, such as dust mites, cockroaches, mould or pet dander, you may have year-round symptoms. However, if your allergy is triggered by tree pollen, grasses or weeds, which all bloom at different times, you may have seasonal symptoms. Your symptoms get worse during certain times of the year.

How to differentiate allergic rhinitis from a viral cold?

Differentiating between allergic rhinitis and a viral cold isn't always easy. However, the signs and symptoms between them can make it easy to differentiate the two. Here's how to tell which one's causing your symptoms:

	Allergic rhinitis	Viral colds
Onset	Immediate; on exposure to the allergen(s)	1-3 days after exposure to a cold virus
Signs and symptoms	Runny nose with thin, watery discharge; no fever	Runny nose with watery or thick yellow discharge; body aches; low-grade fever
Duration	As long as you're exposed to allergens	3-7 days

How allergic rhinitis might affect life?

If you have allergic rhinitis, you may feel quite miserable. It may affect your performance at work or school and interfere with leisure activities. You may experience the following difficulties:

Poor sleep

Allergic rhinitis symptoms can keep you awake or make it hard to stay asleep. You may also develop severe snoring.

Worsening asthma

If you have asthma, allergic rhinitis can worsen signs and symptoms, such as coughing and wheezing.

Sinusitis

Prolonged sinus congestion due to allergic rhinitis may increase your susceptibility to sinusitis — an infection or inflammation of the membrane that lines the sinuses.

Ear infection

In children, allergic rhinitis often is a factor in middle ear infection (otitis media).

Reduced quality of life

Allergic rhinitis can interfere with your enjoyment of activities and cause you to be less productive. For many people, allergic rhinitis symptoms lead to absences from school or work. However, the good bit is you don't have to necessarily put up with these annoying

symptoms. Learning how to avoid triggers and finding the right treatment can make a big difference.

When to see a doctor

See your family doctor if you think you may have allergic rhinitis, particularly, if your symptoms are ongoing and bothersome, or allergy medications aren't working for you, or you think the allergy medications work, but side effects are a problem, or you are having difficulty with asthma or frequent sinus infections.

Getting the right treatment can reduce irritating symptoms. In some cases, treatment may help prevent more-serious allergic conditions, such as asthma or eczema.

You may want to see an allergy specialist (allergist) if your symptoms are severe, allergic rhinitis is a year-round nuisance, allergy medications aren't controlling your symptoms, or you want to find out whether allergy shots (immunotherapy) might be an option for you.

What to expect from your doctor

Your doctor will ask detailed questions about your personal and family medical history, your signs and symptoms, and your usual way of treating them. Your doctor will also perform a physical examination to look for additional clues about the causes of your signs and symptoms. S/he may also recommend one or both of the following tests:



Skin prick test

During skin testing, small amounts of material that can trigger allergies are pricked into the skin of your arm or upper back and you're observed for signs of an allergic reaction. If you're allergic, you develop a raised bump (hive) at the test location on your skin.

Allergy specialists usually are best equipped to perform allergy skin tests. However, these tests have a limited value, because even if the allergen is identified, you may not be able to avoid it; and equally, you may have allergy to many other unidentified substances which would continue to pull the trigger.

Allergy blood test

A blood test, sometimes called the radioallergosorbent test (RAST), can measure your immune system's response to a specific allergen. The test measures the amount of allergy-causing antibodies in your bloodstream, known as immunoglobulin E (IgE) antibodies. A blood sample is sent to a medical laboratory, where it can be tested for evidence of sensitivity to possible allergens.

This test also suffers from the same shortcomings that the skin prick test suffers from. However, many doctors recommend the test. It is best to discuss beforehand with your doctor the benefits and limitations of the test.

(Next month: Allergic Rhinitis—Medications and Prevention) ■

Recent developments in science and technology

Dawn becomes the first spacecraft to orbit a dwarf planet

NASA's *Dawn* has become the first spacecraft to go into orbit around a dwarf planet – Ceres – the largest object in the Solar System between Mars and Jupiter. Since its discovery in 1801, Ceres has been known as a planet,



This artist's concept shows NASA's Dawn spacecraft arriving at the dwarf planet Ceres, the most massive body in the asteroid belt. (Credit: NASA/JPL)

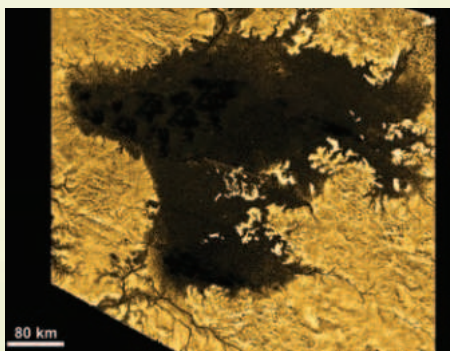
then an asteroid, and later as a dwarf planet. *Dawn* is also the first spacecraft to orbit two worlds after leaving Earth. After its launch in September 2007, it was the first spacecraft to go into orbit around an object in the main asteroid belt when it explored the giant asteroid Vesta from 2011 to 2012. The spacecraft reached Ceres on 6 March 2015 after a journey of 4.9 billion kilometres and 7.5 years. Guiding the small spacecraft over such a long distance and making a perfect orbital insertion was indeed a remarkable feat. Over the next year and a half, mission control scientists plan to progressively lower the orbit until the spacecraft is just a few hundred kilometres above the surface. By that stage, it will be returning very high-resolution pictures of the dwarf planet.

The most remarkable feature of the *Dawn* spacecraft is its means of propulsion. Unlike other spacecraft which use chemical propulsion systems, *Dawn* uses an ion engine that makes use of ions of xenon gas for propulsion. An ion engine is not very powerful, but can sustain a weak yet constant thrust over extremely long periods that no chemical rocket is capable of. According to mission scientists, at peak thrust, *Dawn's* engine produces only as much force as a

single falling sheet of paper. But *Dawn's* ion engines can keep firing for weeks, months and years, accelerating the spacecraft to tremendous speeds. Over the years in the vacuum of space, the initial weak thrust built up, boosting *Dawn's* speed by a record-breaking 39,600 kilometres per hour. *Dawn* is the first spacecraft to use an ion engine for space exploration.

At about 950 kilometres in diameter, Ceres is a dwarf planet, fourth in size after Pluto, which has a diameter of 2,302 km. According to mission scientists, data and images sent back by *Dawn* may help researchers better understand the dwarf planet's history, which may also throw new light on how our planetary system formed and evolved. Those studies could also uncover a new frontier in the search for extra-terrestrial life. From telescopic measurements it appears Ceres has a large mantle of water ice on top of a dense, rocky core. Early in its life Ceres may have had an ocean, too. That ocean would have frozen as Ceres slowly cooled, and its icy surface would have gradually sublimated in the sunlight, leaving behind briny deposits of organic minerals. Astronomers have already used large ground- and space-based telescopes to glimpse what seem to be carbonates, clays, and other water-altered minerals on the dwarf planet.

A big question the mission hopes to answer is whether there is a liquid ocean of water at depth on Ceres. Some models



Ligeia Mare, one of the largest pools of liquid methane/ethane found in the north polar region of Titan. (Credit: NASA/JPL-Caltech/ASI/Cornell)



Biman Basu

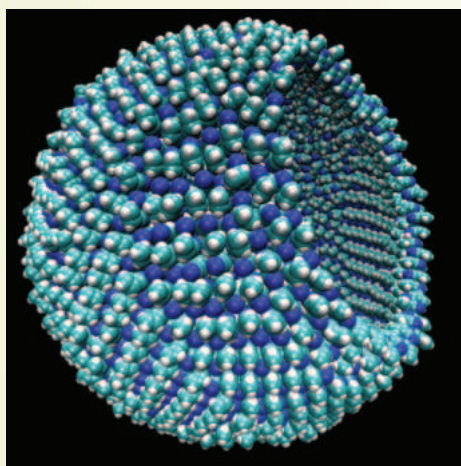
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suggest there could well be. According to the scientists, the evidence will probably be found in Ceres's craters. One interesting feature on the dwarf planet that has dominated the approach to the object is a pair of very bright spots seen inside a 92-km-wide crater in the Northern Hemisphere. The speculation is that Ceres has been struck by something, exposing deeply buried ices, which would have vapourised on the airless world, perhaps leaving behind highly reflective salts.

Methane-based form of life possible

Most forms of life on Earth (except a few anaerobic forms of bacteria) depend on oxygen and water for survival. But scientists have long argued that other forms of life may be also possible, may be on some other planet of the Solar System or outside the Solar System. Now a team of researchers from Cornell University, Ithaca, New York has modelled a new type of methane-based, oxygen-free life form that they say can metabolise and reproduce similar to life on Earth and which they think may exist in the cold and harsh environment of the planet Saturn's giant moon Titan (*Science Advances*, 27 February 2015 | doi: 10.1126/sciadv.1400067). Titan is believed to have vast hydrocarbon oceans and rivers made up of liquid methane at temperatures that would rule out the possibility of existence of Earth-like organisms. However, according to the researchers, the Titan's unique conditions might allow certain methane-based organic matter to exist on it, and even give rise to organisms that do not need oxygen and water for their survival.

Life on Earth is based on the phospholipid bilayer membrane – the strong, permeable, water-based sac-like structure (vesicle) that holds together the organic material in cells. A vesicle made from such a membrane is called a liposome. But what if cells were not based on water, but on liquid methane, which has a much lower freezing point? This idea prompted the researchers led by a professor of chemical and biomolecular engineering Paulette Clancy



A representation of a 9-nanometre azotosome, about the size of a virus, with a piece of the membrane cut away to show the hollow interior. (Credit: James Stevenson)

and first author James Stevenson, a graduate student in chemical engineering, to think of an alternative to the phospholipid-membrane-based cell.

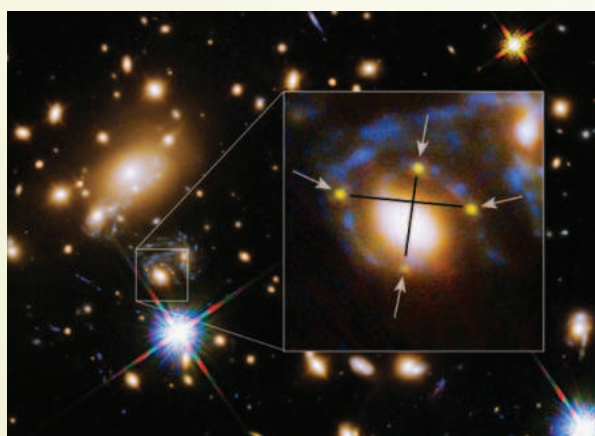
The researchers named their theorised cell membrane an “azotosome” – “azote” being the French word for nitrogen and “soma” meaning body in Greek. So “azotosome” means “nitrogen body.” They found that such a membrane could develop from carbon, nitrogen and hydrogen known to exist on Titan. Furthermore, these structures would be just as strong and flexible as liposome-based cells found on Earth. The researchers used computers to create molecular simulations and demonstrate that these membranes in cryogenic solvent have elasticity equal to that of lipid bilayers in water at room temperature. As a proof of concept, they also demonstrated that stable cryogenic membranes could arise from compounds observed in the seas and atmosphere of Saturn’s moon, Titan. The researchers next plan to attempt to show the azotosome’s behaviour in a methane-rich, oxygen-free environment, and to see what processes would be equivalent to metabolism and reproduction. But the actual proof of the theory may be obtained only by sending robots to explore the methane seas on Titan.

According to Clancy, the research was inspired by a 1962 essay by Isaac Asimov on non-water-based alien life, titled “Not as We Know It.”

“Einstein cross” created by gravitational lensing observed

NASA’s Hubble Space Telescope has captured for the first time a unique case of multiple images of a distant supernova created by gravitational lensing. In 1915, Einstein in his general theory of relativity had predicted the bending of light by strong gravitational field due to warping of space-time. The proof of Einstein’s prediction came quickly during the total solar eclipse of May 1919 when astronomer Arthur Eddington and his collaborators actually found the proof of shift in the apparent position of stars close to the solar limb during totality when the sky became dark and all stars were visible. The amount of the shift was exactly as predicted by Einstein’s theory. It was an absolute vindication of Einstein and made him world-famous overnight.

Gravitational lensing effect is seen only under certain special circumstances. If a



Astronomers have captured the first photo of a single supernova showing up in four different places of a single image due to a phenomenon known as gravitational lensing. The four bright spots make up what is known as an “Einstein cross” (box at right). The “lens” in this case was a massive galaxy that is capable of using its gravity to bend and magnify light. (NASA/ESA)

distant source happens to be located directly behind a hugely massive astronomical object such as a galaxy in direct line of sight of the observer, the massive object can behave like a giant cosmic ‘lens’, bending light from the distant source and create multiple images of it. This is exactly what the Hubble Space Telescope has observed. The distant supernova, dubbed SN Refsdal (after the late pioneering astrophysicist Sjur Refsdal), was captured by Hubble on 10 November 2014, which shows four images of the supernova

arranged in the form of a cross, also known as the “Einstein cross”. The supernova is located about 9.3 billion light-years away, near the edge of the observable universe, while the lensing galaxy is about 5 billion light-years from Earth. The discovery was made by Patrick Kelly, of the University of California, Berkeley while looking through infrared images taken by the HST in November last year (*Science*, 6 March 2015 | doi: 10.1126/science.aaa3350).

Gravitational lensing was predicted by Einstein’s general theory of relativity and the first such lens was discovered in 1979. It was a twin-quasar in the constellation of Ursa Major, lying about 7.8 billion light-years from Earth. It is a quasar that appears as two images – the result of gravitational lensing caused by the galaxy YGKOW G1 located in the line of sight between the Earth and the quasar. More than 20 such cosmic lensing effects have been recorded since then including multiple images of quasars forming Einstein cross, but the present case is the first one showing multiple images of a distant supernova. Sometimes, the distant light source, the lensing galaxy, and the observer line up precisely, producing what is known as an “Einstein ring” – a perfect loop of light from the source, encircling the lensing mass. But if there is any misalignment along the way, we observe partial arcs or spots. Four images can be seen, depending on the relative positions of the bodies, forming an Einstein cross. The lensing effect also serves as a “natural telescope” for astronomers, who can determine the mass of the lensing galaxy and its dark-matter content based on the amount of distortion observed.

Interestingly, as light from the same distant source follows different paths around the massive object it covers different distances to form the images on the other side, which may become visible at different times. In the present case, the Hubble team predicts that a fifth image of the same supernova will appear in the next decade as light from the same supernova following a different path around the intervening galaxy reaches Hubble. According to the scientists, “The longer the path length, or the stronger the gravitational field through which the light moves, the greater the time delay”.