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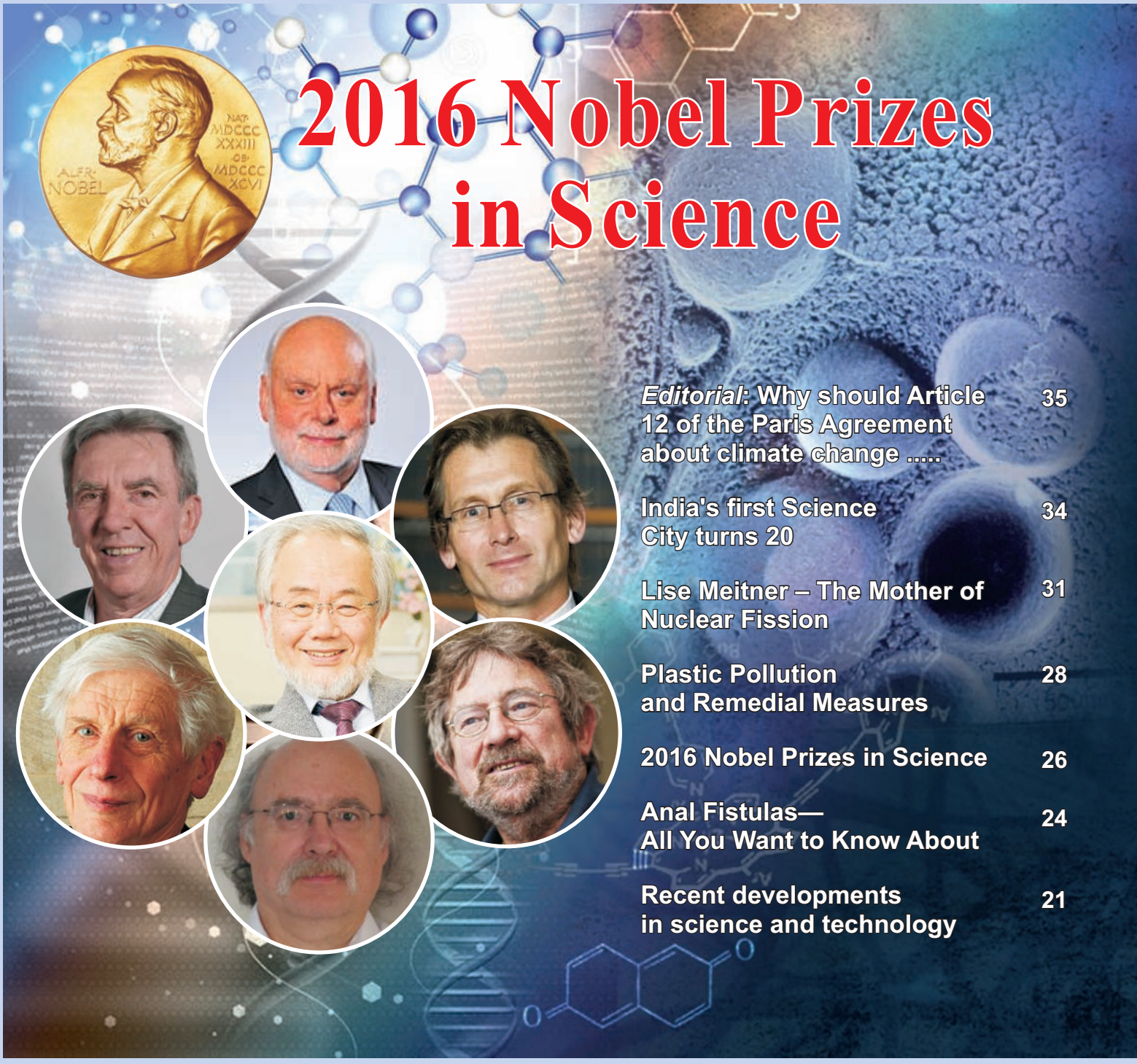

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Why should Article 12 of the Paris Agreement about climate change not be considered science popularisation?

Dr. R. Gopichandran

India communicated with the United Nations on the 2nd this month that she has ratified the Paris Agreement. This is seen as a major step forward to help account for the number of countries needed to set related activities on the move. India recognises the pervasive nature of challenges posed by climate change and expressed her preparedness to join worldwide efforts.

Article 12 of the Agreement states, "Parties shall cooperate in taking measures, as appropriate, to enhance climate change education, training, public awareness, public participation and public access to information, recognising the importance of these steps with respect to enhancing actions under this Agreement". The agenda for science and technology communication has been accordingly set. A major thrust on science popularisation can also be construed looking at the need for public awareness and access to information.

I wish to argue that radio and television-based modules on the science of the phenomenon of climate change, India-specific aspects regarding nature and scale of impacts, signals, their manifestation and persistence and the roles individuals can play in mitigation and adaptation functions are well within the framework of science popularisation.

- Communicators should not shy away from this opportunity to connect with citizens about these topics simply saying that there are many other agencies designated to carry out these tasks and that there are turf-related institutional challenges. Why should I not take it as an excuse for not wanting to rise up to communicate about high-rigour science?
- Genuine concerns about turfs and designated agencies can be overcome by defining the unfinished agenda. Some of the important elements of such an unfinished agenda will be i) Reaching the unreached; ii) Reality checks on information and capacity building needs of specific stakeholder groups so that appropriate information can be delivered in a timely manner. Awareness can be a robust forerunner to capacity building. (iii) Will it not be useful to create a community of practitioners based on their abilities to assess mitigation and adaption opportunities and actually help deliver sustainable solutions? iv) Information clearing houses with teach and learn modules on mitigation and adaption practices are essential elements of enabling access to state of art information on a continual basis.
- It is equally important to let people know about efforts undertaken by the Government of India including funding mechanisms that help access alternatives and foster locally relevant and feasible action.

This logical framework will only help synergize with the efforts of the designated agencies and smother turf boundaries through a common agenda. Technology communication also assumes comparable pathways.

The Paris Agreement centres on an overarching framework of quality of life, thereby linking the imperatives of sustainable development and disaster risk reduction. These are unique integrated windows of opportunity to highlight pervasiveness of science and the proximity of its applications in daily life. Additionally, economic and livelihood sustainability considerations are intertwined. Insights about open-endedness and methods of science can best be embedded in modules that communicate these aspects. I will be happy to understand an alternative perspective.

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India's first Science City turns 20

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Science City, Kolkata in 1998

Science City, a landmark of Kolkata in post-independence era for science communication, is the first and largest of its kind in India. Situated on a 20-hectare plot of land of sprawling greenery, at the crossing of Eastern Metropolitan Bypass and J.B.S. Halden Avenue (or Park Circus connector), it is a constituent unit of the National Council of Science Museums (NCSM), an autonomous body under the Ministry of Culture, Government of India. Science City was a unique gift to the city of Kolkata in the Golden Jubilee Year of Indian Independence, dedicated to the people by Shri Inder Kumar Gujral, Prime Minister of India on 1 July 1997.

A Science City is conceptually similar to a Science Centre, but is much larger in dimension. It portrays the growth of science and technology and their application in society, for general visitors including students, families, and tourists, with the help of educative and entertaining exhibits. A Science City is expected to be financially self-sustainable.

It was Dr Saroj Ghose, Diector General of NCSM, who in 1992 had conceptualised this gigantic science and technology enclave. In 1993, the Calcutta Municipal Corporation (CMC) gifted more than 12 hectares of land to NCSM for the Science City project. CMC further transferred about 8 hectares of land to NCSM on long-term lease.

The Kolkata Science City primarily consists of two major facilities – the 'Convention Centre Complex' and the 'Science Centre Complex'.

A. Convention Centre Complex

This facility of Science City was completed in the first phase of the project. It was inaugurated on 21 December 1996 by Prof Paul J. Crutzen, the 1995 Nobel Laureate in Chemistry, in presence of Shri Jyoti Basu, Chief Minister of West Bengal. Facilities available in this complex are (i) Main Auditorium with 2,232 seating capacity, (ii) Mini Auditorium with 393 seating capacity, (iii) Seminar Hall complex comprising 11 halls and a lobby, (iv) 2.5 hectares of uncovered exhibition ground, and (v) parking space for around 500 vehicles.

Convention Centre

B. Science Centre Complex

1. Space Odyssey

Space Odyssey is an enclave where visitors experience a thrilling voyage to the universe through exhibits called Space Theatre, Space Science, Time Machine, 3D Theatre, Spinning platform, Van-de-Graaff generator, Mirror Magic, and interactive multimedia kiosk on Solar System.

(i) Space Theatre

In this 23-metre dome theatre with seating capacity of 360 is suitable for both large-format movies and planetarium shows.

Space Odyssey and Dynamotion Hall in 1997

It is equipped with GSS-Helios Star Ball planetarium projector manufactured by Goto Optical Mfg. Ltd., Japan and is supported by 150 special effect projectors and Astrovision-70 large-format movie projection system. The system was imported by Science City Kolkata in 1996 and installed in early 1997.

(ii) 3D Vision Theatre

Since human eyes are located side by side, each eye captures a slightly different view of

Inner view of Space Theatre

yourself, Erase the figure, Floating mirror, Fun mirror, Ghost wall, Giant hall, Half you and half me, Head on a platter, Hole in the chest, Honey comb, Horizontal image, Icosahedron, Infinite well, Interactive zone, Kaleidoscope, Mirror in kitchen, Mirror maze, Mirror wall, Octahedron, Periscope, See your back, Side image, True image, Upside down, Vanishing image, and You and me.

the same object. These two signals are then processed in the brain to form 3D image of the object, with the perception of depth. For shooting an image in 3D, two cameras are used to capture images of an object from slightly different angles. The captured images when projected on screen in a theatre and viewed through special polaroid spectacles gives the feeling of watching the movie in 3D. In 3D theatre of Science City Kolkata, 3D movies are screened regularly for the visitors to experience the immersive effect of this technique.

(iii) Time Machine

The Time Machine at Science City is a motion simulator which has been in operation since 1997. There is a carriage or capsule which accommodates 30 persons and its doors can be closed. It is made to move in three rotational degrees of freedom (roll, pitch, and yaw) and three translational or linear degrees of freedom (surge, heave and sway). The movement of the capsule is synchronised with a movie projected on a screen kept in front of the occupants. Thus when the capsule is in motion and the movie is on, a virtual environment of motion or ride is created for the occupants.

(iv) Mirror Magic

We use mirrors in several ways in our daily life. We are also familiar with the images that we see in mirrors. But we get excited when we see some unusual reflections in mirrors. These can be done by using mirrors aligned in special ways. In Mirror Magic hall of Science City such experience is gained through 29 mirror exhibits called: Changing image, Cube, Curving tunnel, Dine with

Duck into Kaleidoscope

2. Dynamotion Hall

This specially designed building houses enclaves, galleries and facilities such as an aquarium, a large butterfly enclave, many interactive exhibits on physics and bioscience, exhibits on illusions, a laboratory on nano science, a mini theatre for regular science shows, etc.

(i) Aquarium

The aquarium located on ramp level one of Dynamotion Hall harbours 16 species of live fishes, such as Albino shark, Angel fish, Argus, Asiatica, Bristol Shubunkin, Chitala, Discus, Feather-back fish, Fire-mouth, Mono angel, Oranda, Oscar, Plecostomus, Silver dollar, Veil-tail gold fish, and Tiger shark.

(ii) Biodiversity

The exhibition was set up in 2010 to commemorate the International Year of Biodiversity. The process of photosynthesis is explained here with the help of a series of exhibits dealing with plant, leaf, internal structure of leaf, organs responsible for absorption of carbon dioxide and release of oxygen, role of chloroplasts in making chlorophyll, chemical reactions that takes place in the process of photosynthesis, etc. Light and dark reactions that occur during photosynthesis are also explained in these exhibits with interesting illustrations. Further there are 3D models of a cell, nucleus, nucleolus, lysosomes and mitochondria on display.

(iii) Butterfly Enclave

Several butterflies can be seen in this enclave located on the ground floor of Dynamotion Hall. Here the visitors can see the whole life cycle of a butterfly. One can also know interesting facts about laying of eggs by butterflies on a particular plant. The eleven life species of butterflies exhibited in the enclave are: Angled Custer (*Ariadne ariadne*); Blue Tiger (*Tirumala limniace*); Common crow (*Euploea cora*); Common jay (*Atrophaneura aristolochiae*); Common Mormon (*Papilio polytes*); Common tiger (*Danaus genutia*); Tailed jay (*Graphium agamemnon*); Lemon emigrant (*Calopsilia pomona pomona*); Lime Butterfly (*Papilio demoleous*); Plain Tiger (*Danaus chrysippus*); and Tawny Coster (*Acraea terpsicore*).

Butterfly in Science City

(iv) Physical Science

The ground floor of the Dynamotion Hall of Science City displays more than 50 physics based exhibits including a large Energy Ball. It is expected that the exhibits would stimulate the intrinsic and extrinsic faculty of visitors and keep them engrossed in

Vertigo Tunnel

the scientific process of discovery. It is, however, to be noted that some of these exhibits can be seen in 'Fun Science Gallery' of some of the Science Centres developed by National Council of Science Museum in India.

(v) Nano Lab

Science City offers guidance and facilities to students to carry on investigative projects on nano science and technology in this laboratory on weekends, holidays and vacations.

(vi) Illusion

With the help of 50 visuals and exhibits this section creates an atmosphere where visitors often cannot believe their own eyes. Here colour, brightness and patterns are used to create literal optical illusions, physiological illusions, and cognitive illusions. Titles of some of the exhibits are: Ghost line, Phantom dots, Bent pencil, Rotating screw, Vanishing doll, Are the shades different? Traffic motion, Moving butterflies, Rotating square, Glowing flowers, Phantom lines, Dimples or pimples? Pink or white? Breathing squares, Moving ring, and Holograms.

(vii) Power of Ten

This panel based exhibition draws visitor's attention to the relative size of objects in the Universe. Its illustrations and text are based on a book by Philip Morrison and Phylis Morrison published in 1990. While one set of 26 photographs depict macro objects of size 10^0 to 10^{25} cm, the other set of 17 photographs depict micro objects of size 10^0 to 10^{-16}.

(viii) Science Shows

This interactive and entertaining show is presented regularly on topics like liquid nitrogen, frozen carbon dioxide, and unexpected science. Curriculum-based demonstrations are arranged for organised school groups on great experiments in electricity, surprising chemical reactions, luminescence, etc.

3. Maritime Centre

This permanent museum is housed in a two-storied building that looks like a ship. It was developed by Science City, Kolkata in collaboration with Kolkata Port Trust. With the help of 92 exhibits, spread over a floor area of 700 sq. metres, the museum depicts segments of maritime history, maritime activity and related subjects.

Maritime Centre in Science City

An exhibit in Maritime Centre

4. Earth Exploration Hall

Earth Exploration Hall is a museum that displays exhibits on physical geography, geology, land, flora, fauna and people of our Planet Earth. The hemispherical building of 25-metre diameter has galleries on two floors which are divided into 12 equal longitudinal segments. There is a huge Earth globe exhibit at the centre on ground floor. There are also large number of panels, multimedia presentations and interactive exhibits in the museum. An additional attraction of the exposition is a built-in 3D theatre where visitors can witness the dynamic phenomena on Earth.

Earth Exploration Hall

5. Science Exploration Hall

The latest addition to the Science City is the 'Science Exploration Hall' for facilitating visitors' entertainment, exploration and science learning. Spread over an area of 5,400 square metres the building houses the following four galleries: Evolution of Life – A Dark Ride; Panorama on Human Evolution; Science and Technology Heritage of India; and Emerging Technologies.

(i) Evolution of Life – A Dark Ride

This immersive exposition commences with a dynamic presentation on the formation of the Earth and evolution of various life forms. The exposition comprises 56 robotic

Waiting for a dark ride in Evolution of Life gallery

Continued on page 22

Lise Meitner – The Mother of Nuclear Fission

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Most of us may not have heard of her. Not surprising! Even the Nobel committee ignored her and awarded the prize to another scientist who collaborated with her. But then the Nobel Prize pales into insignificance when she has a permanent abode on the periodic table with a chemical element (109) named after her. The element Meitnerium is named after Lise Meitner, who can be called the mother of nuclear fission and who cleared the path for nuclear fission when it baffled even a great scientist like Niels Bohr. While Meitner collaborated with Otto Hahn and Otto Frisch in the discovery of nuclear fission of uranium, it was Meitner who gave the first theoretical explanation of the fission process.

Born in Vienna on 7 November 1878, Meitner was one of eight children of her parents. Her father practised law in Austria. When women were not encouraged to study, her parents educated her. Her grandmother warned this young girl not to sew on the Sabbath, for the heavens would come tumbling down. Lise wanted to test. She stuck the tip of the needle in the embroidery and glanced anxiously at the sky. Nothing happened, took a stitch, waited again. When satisfied that heavens were where they were, she continued with her work. That rational scepticism was her constant companion which transformed a shy, introverted girl into an aggressive researcher.

Meitner was the second woman to receive a doctorate in physics at the University of Vienna in 1905. Unsure of which subject to select, she attended lectures in both mathematics and physics; "taking more notes than the registered students". Her university teacher was Ludwig Boltzmann who "gave her the vision of physics as a battle for the ultimate truth, a vision she never lost." Later she recalled Boltzmann's lectures as "the most beautiful and stimulating that I have ever heard. . . . He himself was so enthusiastic about everything he taught us that we left every lecture with the feeling that a completely new and wonderful world had been revealed."

Lise Meitner

Otto Hahn

She served as a nurse in World War 1, handling X-ray equipment, but left in 1916 to continue her research. Max Planck did not allow any women to his lectures but Meitner was an exception. She later became his assistant. Together with chemist Otto Hahn she discovered many new isotopes, working in a remodelled carpenter's shop because the university did not yet accept women on an official basis. She became the first woman in Germany to take up professorship in physics at the University of Berlin.

Diamond ring for bribe

When Adolf Hitler came to power in 1933, Jewish scientists like her nephew Otto Frisch, Fritz Haber, Leo Szilard were persecuted and had fled. Meitner was protected by her Austrian citizenship and the head of the physics department of the Kaiser Wilhelm Institute for Chemistry. After the annexation of Austria, she also had to flee Germany for Sweden.

Unknown to Lise Meitner, Danish physicist Niels Bohr made a careful arrangement for her escape from Berlin. Even her close partner Otto Hahn was not aware of this until days before her departure in July 1938. Dirk Coster, a Dutch physicist, secretly escorted her in that nerve-wracking train journey across Nazi borders into the Netherlands. Otto Hahn had given her his mother's diamond ring: in case it was required to bribe the frontier guards. Fortunately it was not given away and her nephew's wife later wore it. From there she left for Copenhagen and then Sweden, courtesy Bohr. "Meitner left Germany forever with 10 marks in her purse."

She continued her work at Manne Siegbahn's institute in Stockholm, but Manne Siegbahn, himself a Nobel Prize committee member ignored her, partially due to his prejudice against women in science. She would sign her scientific articles as "L. Meitner." When the publisher came to know "L. Meitner" was a woman, he stopped publishing her articles.

Niels Bohr

Breaking up nuclei

On 13 November 1938, Hahn met secretly with Meitner in Copenhagen. On her suggestion, Hahn and Strassmann performed further tests on a uranium product they thought was radium, which in fact was barium. Hahn could not understand uranium nuclei splitting to form barium and krypton. On 24 December she received a letter from Hahn asking her to interpret this process: "What would physics say about such break-up? …….. Perhaps you can come up with some sort of fantastic explanation. We knew ourselves

that [uranium] can't actually break up into [barium]." For the holiday season, she left for Sweden by train to visit her 29-year-old nephew Otto Robert Frisch. While trekking on the snowy Swedish woods Meitner and Frisch vigorously discussed the puzzling "break-up" process.

Frisch recalled later, "We [Frisch and Lise Meitner] walked up and down in the snow, I on skis and she on foot (she said and proved that she could get along just as fast that way), and gradually the idea took shape that this was no chipping or cracking of the nucleus but rather a process to be explained by Bohr's idea that the nucleus was like a liquid drop; such a drop might elongate and divide itself."

While sitting on a tree trunk, Meitner excitedly scribbled out the formulae on a piece of scrap paper. Meitner was the first to realise Einstein's famous equation $E=mc^2$ was at play here, converting mass into energy. "No one really thought of fission before its discovery." Such a "break-up" would release tremendous amounts of energy! Replicating the experiments, Frisch confirmed this on 13 January 1939. He coined the term, "fission." In the early 1939, Meitner wrote with Frisch a series of articles to be published in *Nature* on the nuclear fission of uranium. Electrified, soon every lab all over the world with reasonable facilities started working on this.

The consequences of nuclear fission were devastating. Leo Szilard, Edward Teller, and Eugene Wigner persuaded Albert Einstein to write to President Franklin D. Roosevelt a warning letter. Apprehending German advancement in nuclear fission, the Manhattan Project was established.

Meitner's collaborator Hahn received the 1944 Nobel Prize in Chemistry for "his discovery of the fission of heavy atomic nuclei. She did not get it, because of "a mixture of disciplinary bias, political obtuseness, ignorance, and haste." Meitner wrote in a letter, "Surely Hahn fully deserved the Nobel Prize for chemistry. There is really no doubt about it. But I believe that Otto Robert Frisch and I contributed something not insignificant to the clarification of the process of uranium fission—how it originates and that it produces so much energy and that was something very remote to Hahn."

Woman with a bomb in her purse

Many other honours that Meitner received in her lifetime overshadowed this Nobel. In 1966, Hahn, Fritz Strassmann, and Meitner together were awarded the Enrico Fermi Award. She was unable to travel to the US to receive it due to her frail physical condition. She received the Max Planck Medal of the German Physics Society in 1949. In 1997, element 109 was named "meitnerium" in her honour. She is the first and so far the only the non-mythological woman thus honoured. Additional naming honours are craters on the Moon and on Venus, and the main-belt asteroid 6999 Meitner.

Lise Meitner in 1946

On a visit to the United States in 1946, she was treated as a celebrity, "who left Germany with a bomb in her purse." Hollywood offered to make a movie with this theme, but Lise was annoyed when she read the script. She was offered a lot more money, but she never gave in.

Nothing to do with bomb

She received the honour of "Woman of the Year" by the National Press Club. During a dinner at the Women's National Press Club, President Harry Truman, remarked, "So you're the little lady who got us into all of this!" Despite distorted press reports in Sweden and President Truman's mix-ups, Meitner never worked on the atomic bomb research itself. When she was invited to work on the Manhattan project at Los Alamos, Lise refused, "I will have nothing to do with a bomb." She said that Hiroshima had come as a surprise to her, and that she was "sorry that the bomb had to be invented." She later said, "You must not blame us scientists for the use which war technicians have put our discoveries."

She also said, "I have no intention to suggest how atomic energy should be controlled, beyond expressing my sincere hope that no occasion will again arise where it will be utilised in war. A lasting peace is more desirable than the creation of weapons which might lead to the extermination of mankind."

Meitner spent most of her 70s and 80s travelling, encouraging women students to "remember that science can bring both joy and satisfaction to your life." She says, "Science makes people reach selflessly for truth and objectivity; it teaches people to accept reality, with wonder and admiration, not to mention the deep awe and joy that the natural order of things brings to the true scientist."

During her next visit to the United States in 1964, Meitner suffered a heart attack. She eventually moved into a Cambridge nursing home. She died in her sleep on 27 October 1968 at the age of 89.

Einstein had described her as the "German Marie Curie!"

Krishna Murty Kommajosyula is Author of several popular science books published by Pustak Mahal, engineering book by Industrial Press, New York. Contributes to Science Reporter and Electronics For You. Radio talker. Leading RCFA specialist.

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Plastic Pollution and Remedial Measures

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Plastic is both a boon and a curse in modern times. We have been habituated to depend on it in such a way that this modern time is referred to as the Plastic Age, like Stone Age, Copper Age, Bronze Age, and Iron Age earlier. Plastic is a lightweight, waterproof, corrosion-resistant, handy, and cheap material. But there are also some demerits of this material.

What is a plastic? It is a chemical substance known as a polymer made from organic chemicals. It is a macromolecular substance that is made up of long chains of small molecular units known as monomers. There are many natural polymeric substances such as proteins, RNA, DNA, starch, cellulose, natural rubber, etc. They are all biodegradable; that is, they easily decompose when left in the nature and do not pollute the environment. But there are man-made polymers such as plastics which are non-biodegradable and their presence in nature is a big threat to living species.

During World War II, there was a big surge in scientific research all over the world aimed at developing powerful weapons. Side by side, a number of parallel products were also invented, one of which was plastic. Human beings started to enjoy the advantages of plastic products from that time. And now it has established itself as one of the most essential materials for mankind. For example, Nylon, Terylene, synthetic rubber (Gutta Percha, polyneoprene, Buna-S, etc.), polyethylene (popularly known as Polythene), polyvinyl chloride (PVC), Teflon, Melamine, polypropylene, polystyrene, Bakelite, etc., are all artificial or synthetic polymers and play important roles in our daily life.

The term plastic has come from the word "plasticity", which is a physical property just opposite to another physical property known as elasticity. When a force is applied on an elastic material then its shape and size change. But when the force is removed, it gets back to its previous shape and size. On the other hand, plastic substances can change their shape according to the applied force, but do not get back to their previous shape when the force is removed. There are two types of synthetic plastics, viz., *thermoplastics* (e.g. polyethylene, polypropylene, PVC, etc.) and *thermosetting plastics* (e.g. Melamine, Bakelite, etc.). Thermoplastics can be softened repeatedly on application of heat, can be stored in cold state and can be recycled. While thermosetting plastics are rigid and cannot be softened on application of heat. They cannot be recycled.

The popularity of plastic products can be justified by their varied uses, a few examples of which are given in Table 1. In addition of those listed, the advantages

Table 1: Uses of selected polymers and corresponding name of the monomers

Name of polymer	Name of monomer unit/s	Properties and uses
Polyethylene	Ethylene	Used to make carry bags, bottles, electrical insulators, etc.
Polypropylene	Propylene	It is little harder than polyethylene and lighter and very resistant to bending. It is used to make furniture, TV body, computer spare parts, buckets, etc.
Polystyrene	Styrene	It is transparent and is used to make toys, cups, plates, water glasses, ice cream pots, combs, etc.
Teflon	Tetrafluoroethylene	High melting point. Used to make non-stick cookware, tape, etc.
PVC	Vinyl chloride	It is a very good substitute of rubber. It is used to make pipes, floor tiles, raincoats, gumboots, sandals, etc.
Terylene or Dacron (Polyester)	Ethylene glycol and terephthalic acid	Used to make thread, cloth, seatbelt, magnetic tape, etc.
Nylon 66	Hexamethylene diamine and adipic acid	To make tooth brush, hosiery products, textiles, ropes, cloth, tarpaulin, net, carpet, mattress, etc.
Glyptal or alkyd resin	Ethylene glycol and phthalic acid.	Used in paint industry.
Perspex	Methyl methacrylate	Perspex glass is a very popular name and is widely used in making contact lens, sheet, rod, prism, lens of spectacles and binocular etc.
Buna-S	Butadiene and styrene	Artificial rubber, used to make tyres.
Orlon	Acrylo nitrile	Used as thread and fibre.
Saran	Dichloroethylene	Used to produce seat cover of cars.
Bakelite	Phenol and formaldehyde	Used to make electrical plug, switch, etc.

of plastics over other materials are their light weight, corrosion resistance, heat and electrical insulation, resistance to chemicals, water and air, long life expectancy, abrasion resistance, low production and maintenance cost, etc. These are the reasons that have made them an extraordinary material. It has become a good substitute of traditional materials such as cloth, paper, jute, etc., especially for packaging where the use of plastics lead to phenomenal savings (Table 2).

From the descriptions in Table 1 and Table 2 it is clear why plastics have become so popular. The present-day situation is that more than 150 million tonnes of plastics have accumulated (from a report published in 2006) all over the world, which is quite alarming and poses serious threat to the environment. The hazardous effects due to plastic pollution may be summarised as follows:

1. Plastic articles never degrade in nature causing huge accumulation of solid wastes. As a result, the environment is being polluted as well as the ecological balance is greatly affected.
2. Plastic carry bags clog the water ways and drains resulting in water logging, especially in urban areas.
3. Blocked sewers help in breeding of bacteria and mosquitoes, bringing in secondary effects of plastic pollution. Rain water collected in used plastic bags also helps in breeding of mosquitoes.
4. Workers in the plastic industry suffer from several physiological disorders such as disorders in kidney, lungs and liver.
5. Some types of plastics bags, containers, etc., react with food, causing serious health hazards to the users. Although plastic is a polymeric substance, all the monomers that make it up do not add up and remain in the product. The safety level of such monomer is often 1ppm, else they are toxic and carcinogenic. Cheaper plastics are highly contaminated with toxic monomers.
6. Plastic bags when washed down a drain or blown into a river end up in the sea affecting marine lives as follows:

(a) Marine turtles, fish, etc., get entangled in plastic bags and die.

(b) Plastic bags look like jellyfish and are consumed by many of the marine animals causing choking or severe damage to their digestive system.

(c) When sea birds eat marine animals or directly eat plastic debris floating in the sea, plastics get into their digestive system causing gastrointestinal blockage.

(d) Plastic particles smaller than 1 mm are known as microplastics, which become heavy enough to sink when colonised by microorganisms. These particles obstruct the flow of oxygen when they reach the seabed causing the death of oxygen-dependent marine flora and fauna.

(e) Toxic chemicals leaching out of plastics contaminate the sea food and magnify through food chain.

7. Based upon their similar physicochemical properties, other toxic chemicals such as DDT or DDE are adsorbed by the plastics and are likely to leach out over time.
8. The ground water do not recharge due to blockage of rainwater by plastic bags in the topsoil.
9. Plastic articles cause air pollution on burning.
10. Plastic additive 2,2-bis (4-hydroxyphenyl) propane popularly known as Bisphenol A or BPA that is used in hard plastics (especially in polycarbonate plastics and epoxy resins) is leached out from food containers and mimics oestrogen hormone. It causes reproductive disorders by affecting egg maturation in human, heart disease in adults, liver enzyme abnormalities, type 2 diabetes, increased possibility of breast cancer in woman and asthma.

There are many other harmful effects of plastics and thus it is high time to rethink over our dependence on plastics and to search for alternatives. The Golden Three 'R's for solid waste management are 'Reduce', 'Reuse' and 'Recycle'. Firstly, we have to be less dependent on plastics (Reduce) and secondly, we should not throw away used plastic materials (Reuse). The most important among the Golden Three 'R's is Recycling where we can help this process by collecting used plastics appropriately. But the main drawback of recycling is that the recycled plastics do not contain a pure polymer; that is, they are not homogeneous since different types of polymers are mixed up. Not only that, at the time of their first synthesis, a number of other compounds such as pigments, fillers, additives, etc., are added which also get into the recycling unit. Dirty and contaminated plastics are also responsible for the production of poor-quality recycled plastics. To obviate these difficulties some coded symbols of the monomer units are required to be embossed in thermoplastic products in order to sort them before recycling to improve the homogeneity of the recycled product. Although this technique is followed by most of the countries all over the world, the scenario is a little different in India where neither this type of coding is strictly followed nor is the Government making it mandatory for the manufacturers to do so. Still, the silver lining is that the solid waste management situation in India is a little better than many other countries due to the role played by the rag pickers who help sort plastic wastes in a big way.

Apart from the Golden Three 'R's, the other way out of solid waste management is their disposal by landfilling and incineration. But there has also been some serious harmful effects arising from it. These are:

1. Landfilling by plastic can cause infertility of soil as they remain without being decomposed.
2. Plastic bags release toxic chemicals into the groundwater from landfill sites.
3. Phthalates (used as a plastic softener) are released by some plastics from

Continued on page 25

Table 2: Phenomenal savings due to the use of plastics

Savings in	Reduction in amount in percentage when plastic is used in place of cloth, paper, jute, etc.
Weight of packaging	Reduced to ~25%
Volume of waste	Reduced to ~40%
Energy requirement	Reduced to ~50%
Cost of packaging	Reduced to ~30%

2016 Nobel Prizes in Science

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Physiology or Medicine

Biologists use the term 'autophagy' for the process which cells use to recycle its various components. The word autophagy originates from the Greek words *auto-*, meaning "self", and *phagein*, meaning "to eat". Thus, autophagy denotes "self-eating".

Yoshinori Ohsumi

For a long time scientists knew little about the mechanism of autophagy till Yoshinori Ohsumi of Tokyo Institute of Technology, Tokyo, Japan used baker's yeast to identify genes essential for autophagy. He then went on to elucidate the underlying mechanisms for autophagy in yeast and showed that similar sophisticated machinery is used in human cells to recycle components. The Nobel Prize for 2016 in Medicine or Physiology has been awarded to Oshumi for his discoveries of mechanisms for autophagy

Ohsumi's discoveries led to a new paradigm in our understanding of how the cell recycles its content and also to understanding the fundamental importance of autophagy in many physiological processes, such as in the adaptation to starvation or response to infection. It was found that mutations in autophagy genes can cause disease, and the autophagic process is involved in several conditions including cancer and neurological disease.

It is mainly because of Ohsumi's work that we now know that autophagy controls important physiological functions where cellular components need to be degraded and recycled. Autophagy can rapidly provide fuel for energy and building blocks for renewal of cellular components, which is essential for the cellular response to starvation and other types of stress. After infection, autophagy can eliminate invading intracellular bacteria and viruses. Autophagy also contributes to embryo development and cell differentiation.

Chemistry

How small can you make machinery? This is the question that Nobel Laureate Richard Feynman, famed for his 1950s' predictions of developments in nanotechnology, posed at the start of a visionary lecture in 1984. He was convinced it was possible to build machines with dimensions on the nanometre scale. These, he said, already existed in nature, giving example of bacterial flagella, which make bacteria move forward. But building machines that can be seen only under a microscope still appeared a distant dream. The 2016 Nobel Prize in Chemistry has been awarded jointly to three scientists – Jean-Pierre Sauvage of the University of Strasbourg, France, Sir J. Fraser Stoddart of Northwestern University, Evanston, USA, and Bernard L. Feringa of the University of Groningen, the Netherlands – "for the design and synthesis of molecular machines". The three scientists have built molecular knots, shuttles, rotors, chains, pumps, axles, switches, memory devices and even a nano-car – all at the scale of molecules. According to the scientists, future applications of nano-scale machines could range from delivering drugs to computer memory.

The success came after many years of struggle. In the mid-20th century, as part of efforts to build increasingly advanced molecules, chemists were attempting to produce molecular chains in which ring-shaped molecules were linked together. Normally, molecules are held together by strong covalent bonds in which atoms share electrons. The dream was to instead create mechanical bonds, where molecules are interlocked without the atoms interacting directly with each other.

The first step towards a molecular machine was taken by Jean-Pierre Sauvage in 1983, when he succeeded in linking two ring-shaped molecules together to form a chain, called a 'catenane' in which the molecules were linked by a mechanical bond. The second step was taken by Fraser Stoddart in 1991, when he developed a 'rotaxane'. He threaded a molecular ring onto a thin molecular axle and demonstrated that the ring was able to move along the axle. The first molecular motor was developed by Bernard Feringa; in 1999 he got a molecular rotor blade to spin continually in the same direction.

(l to r) Jean-Pierre Sauvage, J. Fraser Stoddart, and Bernard L. Feringa

(l to r) David J. Thouless, F. Duncan M. Haldane, and J. Michael Kosterlitz

Physics

Strange things happen to properties of materials when present on surfaces or inside extremely thin layers that can be considered two-dimensional, compared to the three dimensions with which we are familiar. The physics that takes place in two-dimensional matter is very different from that we recognise in the world around us. New collective phenomena are being continually discovered in these flatlands, and condensed matter physics is now one of the most vibrant fields in physics. The Nobel Prize in Physics for 2016 has been awarded jointly to David J. Thouless of the University of Washington, Seattle, USA, F. Duncan M. Haldane of Princeton University, NJ, USA, and J. Michael Kosterlitz of Brown University, Providence, USA, for their theoretical explanations of strange states of matter in two-dimensional materials, known as topological phases.

The work of the three scientists in the 1970s and 1980s laid the foundations for predicting and explaining bizarre behaviours that experimentalists discovered at the surfaces of materials, and inside extremely thin layers. These include superconductivity – the ability to conduct electricity without resistance – and magnetism in very thin materials. The three scientists could explain the behaviour of exotic matter through the mathematical concept of topology, which describes properties that remain unchanged if an object is deformed but not torn. In 1973, Thouless and Kosterlitz, working at the University of Birmingham, UK, used the concept of topology to explain certain kinds of phase transition. They showed that topological phase transitions – in which a material switches between states with different topologies – were possible in thin layers of materials. In 1982, Thouless also explained a phenomenon known as the quantum Hall effect and showed that it was, again, a topological phenomenon.

[Detailed accounts of the work of the laureates will be published in forthcoming issues.]

Plastic Pollution and Remedial Measures (continued from page 27)

landfill sites that are known to cause birth defect, birth of premature babies and infertility in men. Phthalates can mimic the female hormone oestrogen and are suspected to be responsible for early puberty in girls.

4. Incineration of plastics releases carcinogenic chemicals called dioxins into the air. They are also responsible for developmental disorders and other health problems.

Therefore the situation is quite critical and it cannot be changed overnight. At least what we can do to begin with is to play some primary roles such as carry a jute or cotton bag every morning when we go to the market, and to boldly refuse any kind of plastic carry bag offered by the shopkeepers. We can discourage our family members, colleagues, friends, close circles from using plastic carry bags. We can educate our children at home and students in educational institutes on the bad effects of using plastics recklessly. Academic persons should shoulder some responsibility by campaigning for mass awareness and by creating plastic-free (especially plastic-bag-free) zones as much as possible. Getting habituated without using plastic bags and other products would help reduce its use to a great extent.

There are some do's and don'ts as a part of remedial measures. These are:

1. Never use plastic carry bags of thickness below 50 microns as they readily form microplastic particles and can release toxic chemicals.
2. Never use plastic bowls (even branded and microwave-safe) in the microwave oven as they react with food.
3. Plastic bath tubs are not safe, especially during winter when warm water is used.
4. Never pour any just-prepared hot food item in a plastic bowl or container.
5. Try to use biodegradable plastics such as corn starch bags (soluble and digestible to animals) as much as possible.
6. Do not throw plastic articles here and there.
7. Do not allow plastic bags to clog the drains by regularly cleaning them.
8. Don't keep dry food items such as tea leaves, coffee, cashew nuts, raisins, biscuits, etc., in plastic containers for a long time as they catch the smell of the plastics and get contaminated.
9. Avoid PVC bags for school children.
10. Crush bottles of packaged drinking water after single use and dump them appropriately.
11. Thermosetting type of plastics such as Melamine or Teflon is comparatively safer and articles made of them can be used.

Since the present age is referred as the Plastic Age, therefore, we cannot completely avoid the uses of plastics. Apart from all the negative sides, it can be reiterated that the situation is still under control. What we have to do is to be little more conscious and to have the attitude to be environment friendly.

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Anal Fistulas—
All You Want to Know About

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

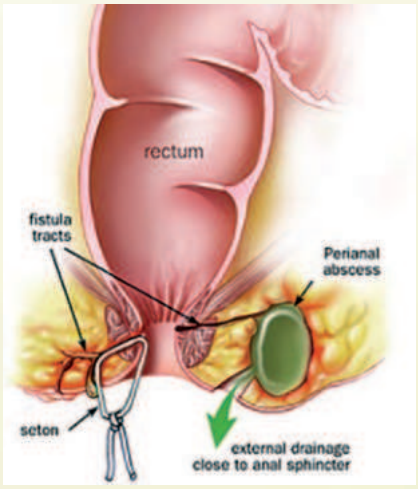
Put simply, an anal fistula is a small tunnel-like track that develops between the lower end of the bowel (rectum) and the skin near the anus. The anus is the external opening through which faeces are expelled from the body. Just inside the anus are a number of small glands. If one of these glands get blocked, an abscess—an infected cavity—may form. An anal abscess is usually treated by surgical drainage, although some drain spontaneously. About 50 per cent of these abscesses may develop into a fistula, in which a small tunnel connects the infected gland inside the anus to an opening on the skin of the buttocks around the anal opening.

Often given the name of 'fistula-in-ano' in medical parlance, it is a troublesome condition, causes bleeding and discharge when passing stools, and can be quite painful. While many of the patients with anal fistula experience a persistent discharge through the skin opening around the anus, others may suffer at the hands of recurrent anal abscesses, particularly, if the outer opening of the tract on the skin gets closed.

Managing an anal fistula is a bit of tricky affair; the only cure being surgery. However, unless it is removed in entirety, it can recur. The surgery of complicated fistulas is also not free of possible complications.

Causes

Most anal fistulas result from previous or existing anal abscesses. Ninety per cent of these abscesses are the result of an acute infection in the internal glands of the anus. Occasionally, bacteria, faecal material or foreign matter clog an anal gland and tunnel into the tissue around the anus or rectum, where it may then collect in a cavity called an abscess. When these abscesses break down, a track may form between the anus on one end, and the perianal skin on the other. These tracks may have multiple side branches, extend as a horseshoe to the other side, and be associated with one or more cavities.



A small number of fistulas may be associated with other disease processes. These include the following:

- Tuberculosis
- Sexually transmitted diseases
- Diverticulitis: infection of the small pouches that can stick out of the side of the large intestine (colon)
- Rectal injury or following a complication of surgery near the anus
- Rectal cancer
- Hidradenitis suppurativa: a long-term skin condition that causes abscesses and scarring
- Crohn's disease: a long-term inflammatory condition of the bowel

Symptoms

A patient of fistula-in-ano may present with a number of signs and symptoms:

Anorectal pain

Most patients complain of pain and swelling around the anus. They may also experience pain on bowel movement.

Discharge from the opening around the anus

A large majority of patients complain of a bloody or foul-smelling pus discharge from the outer perianal skin opening. The pain may diminish once the pus gets drained and the fistulous track cleans up. A persistent perianal discharge may produce irritation of the skin.

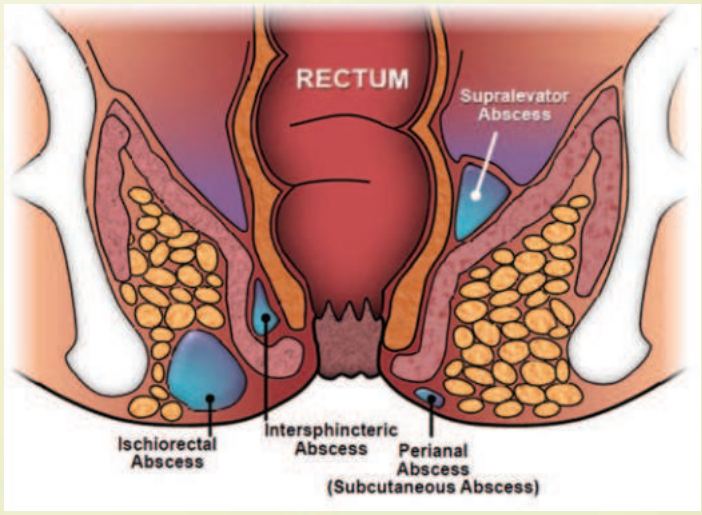
Rectal bleeding

Some patients may suffer rectal bleeding.

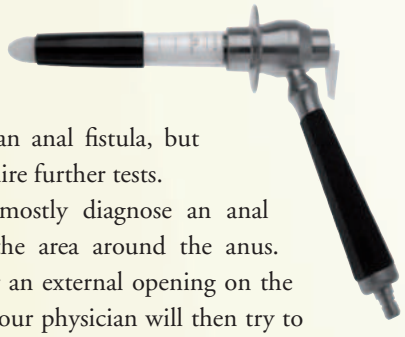
Anal abscess

Recurrent anal abscesses can worsen the misery of a patient. The victim experiences repeated attacks of anorectal pain, swelling, redness of the perianal skin (due to cellulitis) and fever.

If you notice any of these symptoms, you should see your family physician, or better still, a colorectal or general surgeon.



Tests and diagnosis



Usually, a clinical evaluation – including a digital rectal examination – is sufficient to diagnose an anal fistula, but some patients may require further tests.

A surgeon can mostly diagnose an anal fistula by examining the area around the anus. He or she will look for an external opening on the skin. If this is visible, your physician will then try to determine the depth and direction of the fistula tract. Often a discharge can be produced from the external opening.

Some fistulas may not be visible on the skin's surface. In this case, the surgeon may carry out or ask for some additional tests. The simplest is proctoscopy. This technique uses a special instrument to peep inside the anus and rectum.

The surgeon may also seek an anorectal ultrasound or MRI of the anal area to better define the fistula tract.

If a fistula is found, the surgeon may also want to do further tests to see if the condition is related to tuberculosis of the intestine. Among these studies are blood tests, X-rays, and colonoscopy. A colonoscopy, in which a flexible, lighted instrument is inserted into the colon via the anus, is performed under conscious sedation.

Treatment options

Since anal fistula rarely heals if left untreated, surgery is usually necessary. It is best performed by a colon and rectal specialist, although most general surgeons are fairly adept at performing the operation.

During surgery, the physician will assess the depth and extent of the fistula tract. Most fistulas are treated with a fistulotomy, in which the skin and muscle over the tunnel are cut open, converting it into an open groove. This allows the fistula tract to heal from the inside out into a flat scar.

A more complex fistula may require placement of surgical thread called a seton for at least six weeks, after which a definitive surgical repair is done.

Other techniques include filling the fistula with special glue, blocking it with a special plug, or covering it with a flap of tissue. They may also sometimes be used.

All these procedures have different benefits and risks. You can discuss this with your surgeon. The best option for you will depend on the position of your fistula and whether it is a single channel or branches off in different directions. Sometimes you may need to have an initial examination of the area under general anaesthetic to help determine the best treatment.

Your surgeon will talk to you about the options available and which one they feel is the most suitable for you. Surgery for an anal fistula is usually carried out under general anaesthetic. The aim of surgery is to heal the fistula while avoiding damage to the sphincter muscles, the ring of muscles that open and close the anus, which could potentially result in loss of bowel control (bowel incontinence).

Fistula surgery generally requires only a short hospital stay. Very large or deep fistula tunnels may, however, require a more complicated surgery.

Fistulotomy

The most effective and most common type of surgery for anal fistulas is a fistulotomy. This involves cutting along the whole length of the fistula to open it up so it heals as a flat scar.

This surgery, however, only works for fistulas that don't pass through much of the anal sphincter muscles. In patients where the fistula cuts across a large part of the anal sphincter, the so-called trans-sphincteric fistula, this is not the ideal method since it would carry a high risk of bowel incontinence.

Seton technique

If the fistula passes through a significant portion of anal sphincter muscle, the surgeon may initially recommend inserting a seton. A seton is a piece of surgical thread that is left in the fistula for several weeks to keep it open. This allows it to drain and helps it heal, while avoiding the need to cut the sphincter muscles.

Loose setons allow fistulas to drain, but don't cure them. To cure a fistula, tighter setons may be used to cut through the fistula slowly. This may require several procedures that your surgeon can discuss with you. The seton technique is as ancient as Ayurveda and has been practiced for thousands of years in India.

Advancement flap procedure

An advancement flap procedure may be considered if a fistula passes through the anal sphincter muscles and having a fistulotomy carries a high risk of causing incontinence.

This involves cutting or scraping out the fistula and covering the hole where it entered the bowel with a flap of tissue taken from inside the rectum, which is the final part of the bowel.

This has a lower success rate than a fistulotomy, but avoids the need to cut the anal sphincter muscles.

LIFT procedure

The ligation of the intersphincteric fistula tract (LIFT) procedure is a relatively new treatment for anal fistulas. It is designed as a treatment for fistulas that pass through the anal sphincter muscles, where a fistulotomy would be too risky. During the treatment, a cut (incision) is made in the skin above the fistula and the sphincter muscles are moved apart. The fistula is then sealed at both ends and cut open so it lies flat.

Fibrin glue

Treatment with fibrin glue is currently the only non-surgical option for anal fistulas. The surgeon injects special glue into the fistula while the patient is under a general anaesthetic. The glue helps seal

the fistula and encourages it to heal.

It is generally less effective than fistulotomy for simple fistulas and the results may not be long-lasting, but it may be a useful option for fistulas that pass through the anal sphincter muscles because they do not need to be cut.

Follow-up treatment

Following a fistula surgery, the treating surgeon may recommend soaking the affected area in a warm bath and taking stool softeners or laxatives for a week. Since you may also experience some pain or discomfort in the area after surgery, you may require pain pills. Most fistulas respond well to surgical treatment.

Potential risks of anal fistula surgery

Like any type of treatment, treatment for anal fistulas carries a number of risks. The main risks are:

Infection

This may require a course of antibiotics; severe cases may need to be treated in hospital.

Recurrence of the fistula

The fistula can sometimes recur despite surgery

Bowel incontinence

This is a potential risk with most types of anal fistula treatment, although severe incontinence is rare and every care is taken to prevent it. The level of risk will depend upon a number of factors like how the fistula is located and the specific procedure that's being done.

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India's first Science City turns 20 (continued from page 32)

animal models divided into seven sections to showcase the milestone events of evolution and representative life forms of respective eras. Visitors are taken in a slow-moving electric car for this immersive experience, supplemented by computer-controlled special light and sound effects. Each section is introduced to the visitors through a special audio-video presentation.

(ii) Panorama on Human Evolution

This digital panoramic presentation is a unique immersive experience depicting the important milestones during the last 6 million years of human evolution. It starts with a static panoramic image of size 10 m × 122 m showcasing important events of human evolution. This is followed by a 12-minute film with voice over in three languages on human evolution, projected on the giant cylindrical screen with the help of eight powerful digital projectors, contains actual shoot across South Africa and India.

Indus Valley market scene

(iii) Science & Technology Heritage of India

It portrays 5,000 years of Science and Technology heritage of India through varied period setting dioramas, models and interactive exhibits with computer kiosks. It brings forth India's contribution in ancient science and how it pioneered in the philosophical developments in scientific principles. India brimmed with tremendous knowledge on various metallurgical practices, textile weaving, wood crafts, coin making, ship building, architecture and various traditional technologies. Here, the Indus Valley Civilisation has been depicted as a large diorama in a period setting during the times of Harappa and Mohenjo-daro.

(iv) Emerging Technologies

This gallery gives us an over view of the emerging technologies in various fields like robotics, energy, ICT, medical sciences, human genomics, alternative fuels, encoding of information etc. and the role of quantum mechanics, information and communication technologies and molecular biology in these technologies.

6. Outdoor Science Park

The Science Park is an outdoor exposition comprising Rope Way, Musical Fountain, Road Train, Monorail Cycle, and a set of 36 participatory exhibits on physics, such as A simple camera, A swing is a pendulum, Action and reaction, Ellipsoidal speaking

A section of Emerging Technologies gallery

tube, Lift yourself, Revolve faster, Tensegrity structure, etc.

Dr. Tapan Kumar Ganguly, a Chemical Technologist, was the first Director of Science City. Shri Arijit Dutta Choudhury, a Mechanical Engineer, heads the Kolkata Science City since 2009. The entire activities of Science City are managed by seventy-odd staff members.

Kolkata Science City has been visited so far by more than 2 crore 35 lakh visitors till March 2016, including 14,91,730 visitors during the year 2015-16.

Dr Jayanta Sthanapati, former Deputy Director General of National Council of Science Museums, has recently completed his study on 'History of Science Museums and Planetarium in India', as a research project sponsored by the Indian National Science Academy. He holds PhD (Physics) and PhD (History) degrees.

Recent Developments in Science and Technology

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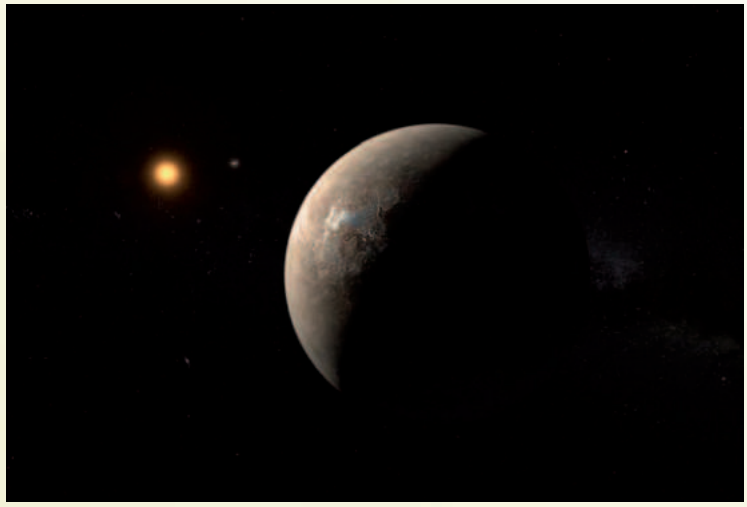
Earth-sized, life-friendly planet discovered

An almost Earth-sized planet with conditions suitable for life has been discovered around a star very close to our solar system. The star is Proxima Centauri, a red dwarf lying at a distance of just 4.2 light years – the nearest star to Earth (leaving out the Sun). Proxima Centaury is much cooler than our Sun; it has an effective temperature of only around 3,050 kelvin, a luminosity of 0.15 per cent of that of the Sun. It has a radius 14 per cent of the radius of the Sun and a mass of about 12 per cent of the mass of the Sun. The planet, named Proxima b, has a mass about 1.3 times that of Earth and orbits Proxima Centauri at a distance of roughly 7,500,000 km with an orbital period of approximately 11.2 Earth days. Although astronomers still don't have any knowledge about the planet's radius and density, they say it lies within the 'habitable' zone of its host star – the range of distances at which liquid water could be stable on its surface.

The discovery was made by astronomers who have been carrying out intense search for planets around Proxima Centauri for more than 15 years, using instruments such as the Ultraviolet and Visual Echelle Spectrograph (UVES) and the High Accuracy Radial velocity Planet Searcher (HARPS), at the European Southern Observatory in Chile. They used the instruments to detect the slight wobbles in the star's movement caused by the gravitational tugs of orbiting planets.

The first sign of a wobble was detected in 2013, but the signal was not convincing. So the astronomers carried out a systematic study and focussed HARPS on Proxima Centauri every night from 19 January 2016 up to 31 March of this year. After they combined this new data with UVES observations from 2000 to 2008 and HARPS observations from 2005 to early 2014, the signal of a possible planet came through loud and clear, following which the discovery of Proxima b was announced (*Nature*, 25 August 2016 | doi:10.1038/nature19106).

Many physical parameters of Proxima b are still uncertain, but it is known that although it orbits its parent star quite close (only 7.5 million km) the radiation it receives from the red dwarf star is only about 70 percent of the solar radiation received on Earth, making its surface temperature somewhat lower than on our planet. Moreover, the slightly larger mass may make Proxima b's atmosphere slightly denser than Earth's enabling a stronger greenhouse effect and making it amenable to life.



Artist's view of the exoplanet Proxima b with red dwarf star Proxima Centauri in the background.

According to the astronomers, there are three important ingredients necessary for life. "First, we need rock, and Proxima b indeed is a planet that certainly has a rocky surface. Second, the most common molecule in the Universe, water, has to be present. We have no evidence of this, but water can be found everywhere in space and there are no reasons why it would not exist on the surface of Proxima b – and the temperatures on its surface likely allow the water to be liquid and for oceans as well. Third, there needs to be carbon dioxide, but that is simply a common primitive atmospheric molecule on all the Earth-sized planets in the solar system." In other words, all the ingredients for life are most likely available there. If that is the case, the astronomers believe, the formation biochemical processes we can call life on Proxima b is inevitable rather than a rare event.

Proxima b is more than 40 trillion kilometres away, a distance that would take around 30,000 years to reach with current technology. However, the planet is close enough to give scientists confidence that they can develop a spacecraft that would be able to reach it within the scale of a human life time and they believe robotic probes could be sent to Proxima b in years to come.

Sunflowers move by the internal clock

The sunflower plant is known to follow the Sun. Young sunflower plants track the Sun from east to west during the day and then reorient during the night to face east at dawn. Each night the plants reverse their movement, swinging from west to east in order to be the first to face the Sun when it rises over the horizon at daybreak. But mature plants lose this capacity of movement. Plant biologists of the University of California, Davis, have now discovered how sunflowers use their internal circadian clock, acting on growth hormones to follow the Sun during the day as they grow (*Science*, 5 August 2016 | doi: 10.1126/science.aaf9793). Scientists have known about the sunflower plants' sun-seeking behaviour since 1898, when botanist John Schaffner described it in the journal *Botanical Gazette*. But no one had previously thought to associate it with circadian rhythms.

Circadian rhythms are physical and behavioural changes in organisms that follow a roughly 24-hour cycle, responding primarily to light and darkness in an

The sunflower's movement to follow the Sun is driven by the plant's internal clock.

organism's environment. They are found in most living things, including animals, plants and many tiny microbes. Sunflowers, like animals, have a circadian rhythm. During the day, this system sends messages to the eastern sides of their stems, telling those cells to grow slightly longer, thus making the sunflowers lean westward. At night, the message reverses, and the sunflowers tilt back toward the east.

The researchers carried out a series of experiments with sunflowers in the field, in pots outdoors, and in indoor growth chambers to study their daily movement. By tying the plants to stakes so that they could not move, or turning potted plants around daily so that they were facing the wrong way, it was found that the plants' ability to track the Sun could be disrupted. The researchers found that following the Sun provides a growth boost to the plants, while restricting their movement caused reduced production of biomass. When the plants were moved into an indoor growth chamber with fixed overhead light, they continued to swing back and forth for a few days, which provided the clue that the movements were driven by an internal clock.

Exploring further, the researchers identified a number of genes that were expressed at higher levels on the sunward side of the plant during the day or on the other side at night. According to them, there appear to be two growth mechanisms at work in the sunflower stem. The first sets a basic rate of growth for the plant, based on available light. The second – controlled by the circadian clock and influenced by the direction of light – causes the stem to grow more on one side than another, and therefore sway east to west during the day, making the plant follow the motion of the Sun in the sky.

The study found that as the sunflower matures and the flower opens up, overall growth slows down and the plants stop moving during the day and settle down facing east. According to the researchers, mature sunflowers prefer to face east because east-facing sunflowers heated up more quickly in the morning – and attract more pollinating insects because "bees like warm flowers".

India develops world's first leprosy vaccine

Leprosy, caused by the bacteria, *Mycobacterium leprae*, affects around 1.25 lakh people every year in India. About 60% of the world's leprosy patients live in India. However, experts believe that these figures represent just a fraction of the true picture of people affected by leprosy. Lack of awareness, insufficient access to medical treatment and severe stigma surrounding leprosy mean that hundreds of thousands more could be living with the effects of the disease, going untreated.

Leprosy is a crippling disease that often results in a lack of ability to feel pain and thus loss of parts of extremities due to repeated injuries or infection due to unnoticed wounds, often causing gross disfiguring of the fingers and limbs. Leprosy can no longer be treated by the conventional multi-drug therapy (MDT). To control the spread of the disease, the first exclusive vaccine for leprosy has been developed by the National Institute of Immunology (NII), New Delhi, which has been already approved by the Drug Controller General of India (DCGI) and the Food & Drug Administration (FDA) of the US.

The vaccine, made from killed bacterium called *Mycobacterium indicus pranii* (MIP), is an 'immunotherapeutic' vaccine for leprosy, which means it harnesses the ability of body's immune system to combat infection or disease. It enhances the immune system's resistance to the disease. The vaccine is being launched on a pilot basis in five districts in Bihar and Gujarat where the vaccine will be administered as a preventive measure to people living in close contact with those infected.

According to Dr. Soumya Swaminathan, Director General, Indian Council of Medical Research (ICMR), trials

Gross disfigurement caused by leprosy.

had shown that the vaccine, if administered to people in close contact with affected persons, could bring down cases by 60 per cent in three years. It expedited cure rates if given to people with skin lesions. Testing of the MIP vaccine that took place in 2005 showed that the vaccine remains effective for seven to eight years, after which a booster dose would need to be given. If the new project proves to be successful, it is hoped that the vaccine will be used across the country for mass immunisation of contacts of those affected by leprosy.

If the pilot phase shows satisfactory results, the programme will be implemented in other high-prevalence districts across the country. The government have already begun screening in 50 high-prevalence districts across the country. A total of 7.5 crore people were screened out of which 5,000 had leprosy. The next phase will cover 163 districts.

At present, one of the greatest barriers to ending leprosy is the stigma that persists in India, with numerous laws discriminating against people affected by the disease. This discourages many from seeking treatment because they fear being ostracised once people know they have leprosy. It is hoped the new vaccine will change the situation and help bring those threatened with the disease into the mainstream.

Safer food packaging made from milk protein

Plastics are found everywhere in the modern world amidst growing opposition to the widespread use of these synthetic materials. Being non-biodegradable, plastic waste remains in the environment almost forever, affecting vegetation, wildlife and also waterways.

One of the most widespread uses of plastic is in the form of films for packaging, including food packaging. At the grocery store, most food items such as meat, bread, cheese, snacks, etc., come wrapped in plastic packaging. The plastic films used for food packaging is mainly petroleum-based, which is not sustainable. Moreover, not only does this create a lot of non-recyclable, non-biodegradable waste, but some plastic films are suspected of leaching potentially harmful chemicals into food. To address these issues, scientists have been trying t develop a packaging film that is biodegradable and safe for food packaging. They have now come up with one made of the milk protein casein, which is not only biodegradable but is also edible. This was announced at a meeting of the American Chemical Society at Philadelphia, USA, on 22 August.

Food packaging made of milk protein is safer than synthetic plastic films.

The milk protein-based plastic film was developed by a team of researchers led by Peggy Tomasula at the U.S. Department of Agriculture. These casein-based films are up to 500 times better than plastics at keeping oxygen away from food and, because they are derived from milk, are biodegradable, sustainable and edible. According to the researchers, the protein-based films are powerful oxygen blockers that help prevent food spoilage. When used in packaging, they could prevent food waste during distribution along the food chain.

The researchers arrived at the final formulation after several trials and errors. Their first attempt using pure casein resulted in a strong and effective oxygen blocker, but the product was relatively hard to handle and would dissolve in water too quickly. They made some improvements by incorporating citrus pectin into the blend to make the packaging even stronger, as well as more resistant to humidity and high temperatures. After a few additional improvements, the casein-based packaging was found to be almost identical with plastic wraps used in groceries and stores, but less stretchy and better at blocking oxygen. The material is made almost entirely of proteins and is edible. According to the researchers nutritious additives such as vitamins, probiotics and nutraceuticals could be included in the future for food packaging. The group plans to keep making improvements, and hopes to bring this casein film packaging on store shelves within 3 years.

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