



Vigyan Prasar

DREAM 2047

May 2017

Vol. 19

No. 8

Rs. 5.00

Otto Hahn

Discoverer of Nuclear Fission



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

Consolidating science communication activities in our country



Dr. R. Gopichandran

It is well known that the National Council of Science Museums of the Ministry of Culture, Government of India, the National Institute of Science Communication and Information Resources (NISCAIR) of CSIR, the National Council for Science and Technology Communication (NCSTC) of the Department of Science and Technology (DST), Government of India and Vigyan Prasar, also of DST, have been carrying out excellent science communication activities over the years. It cannot be denied that the reach has been quite significant collectively. Generations of students have benefited from Science Reporter, the popular science monthly of NISCAIR, for instance, and the science museums across the country have reached out to citizens in nooks and corners of the country. These are two typical examples of the successes in science popularisation. Several grassroots initiatives directly connecting with citizens have been supported by NCSTC. Vigyan Prasar's publications and software including the magazine that carries this editorial have also reached out to thousands of citizens and institutions consistently. Vigyan Prasar's materials are also embedded in the National Repository of Open Educational Resources and recently over the past seven years or so its radio and television programmes have also formally established the value of focussed science communication through mass media.

Interestingly Vigyan Prasar is also launching into two other massive large-scale citizen engagement initiatives. These are the Indian Science News Feature Service and the India Science Technology and Innovation Portal. While I will present greater details about these two sometime soon, I wish to highlight the fact that these initiatives will be truly inclusive in nature. Activities and successes across the landscape of science technology and innovation across our country will be duly highlighted, creating the scope for significantly higher visibility and interactions that could follow. It is equally important to recognise that India's landscape on these three fronts in particular is quite humongous and therefore there is scope for any number of interested players to deliver and in fact optimally showcase through mutually acceptable synergies. Vigyan Prasar is lucky to secure the involvement of some well-known news media specialists to deliver on this front. The portal too will be inclusive and highlight milestones and successes in research and development, knowledge networks including leading experts in various fields, finding opportunities and

India's leadership in science technology and innovation (STI) across the bilateral and multilateral framework also. The news feature service and the portal activity have well defined action plans to reach out to fellow institutions and citizens with suitably embellished platform and opportunities for all to deliver together.

While these are interesting and extremely important, especially because they respond to the call to upscale and value add science and technology communication, it is equally important to document the insights and success of initiatives that are actually responsible for the robustness of STI-based citizens' engagement across the country. I propose the idea that it is essential and timely to create a compendium on science technology innovation communication activities being carried out at the grassroots level. This compendium will give the necessary and much needed visibility for the activities at the local level and help connect with local level leadership for targeted communication outcomes in the longer run. It will also be possible to interpret the linkages between processes that help deliver appropriate information in a timely manner and the impacts expected to be generated on account of such strategies. Most importantly, it will be possible to document and understand motivators of success, and limitations and scope of STI communication for further improvement. Above all these considerations, it will be possible to demonstrate the value of a bottom-up approach much needed to strengthen communication processes in our country. Arguably it will then be possible to validate theories in science communication; only to create the necessary knowledge framework and pathways of information flow to fulfill the larger agenda of science communication of our country.

The principal objective of this call is to establish the fact that a lot has really happened in our country in so far as science communication is concerned. As part of the way ahead it is really important to understand the dynamics of science communication based on the principles and practice of science of science communication. This is a very important step to prevent trivialization of science communication and ensure seamless transitions into large scale STI communication.

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Published and Printed by Manish Mohan Gore on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Aravali Printers & Publishers Pvt. Ltd., W-30, Okhla Industrial Area, Phase-II, New Delhi-110 020 Phone: 011-26388830-32.

Otto Hahn: Discoverer of Nuclear Fission



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“Like Kekule before him, Hahn originally was intended for a career in architecture, but this was overruled by his interest in chemistry, which he studied at Marburg. In 1904 he spent 6 months in London and which introduced him, under (William) Ramsay’s guidance, to then the novel field of radiochemistry.”

The Cambridge Dictionary of Scientists (2nd edition), 2002

“Professor Meitner stated that nuclear fission could be attributed to chemistry. I have to make a slight correction; chemistry merely isolated the individual substances, but did not precisely identify them. It took Professor Hahn’s method to do this. This was his achievement.”

Fritz Strassmann in an interview with the German Television, ARD on 8 March 1958 (Lise Meitner also took part in the same interview.)

“In post-war Germany, Otto Hahn became the most revered elder statesman of what had once been Europe’s proudest scientific establishment. He collected many awards, including a Nobel Prize in chemistry for his discovery of fission. But he always accepted such honours with characteristic humility. Visiting an atomic reactor or nuclear power station, he would shrug modestly: ‘It has all been the work of others’. In a soon-to-be published 300-page memoir, he brushed off his historic work in fewer than five pages. Last week, at the age of 89, the father of fission died peacefully in his beloved Göttingen.”

The Time Magazine, New York, 9 August 1968

Otto Hahn was a pioneer of radiochemistry and nuclear science. He was involved in the discovery of several radioisotopes. He defined nuclear isomerism, which arises when nuclei with different radioactive properties turn out to be identical in atomic number and mass. Hahn is best known for his discovery of nuclear fission jointly with the Austrian-Swedish physicist Lise Meitner (1878-1968) and the German chemist Fritz Strassmann (1902-1980). The discovery, which was announced in 1939, is regarded as one of the most important discoveries of the 20th century. Hahn was awarded the Nobel Prize in Chemistry in 1944 for ‘his discovery of the fission of heavy nuclei.’ Hahn’s discovery was the beginning of long scientific journey. On the occasion of the 75th anniversary of the discovery of nuclear fission, Yukiya Amano, Director General of IAEA (International Atomic Energy Agency) said: “The pioneering work of Otto Hahn, Lise Meitner and Fritz Strassmann was a crucial step in the long scientific journey that led to the development of nuclear technology as we understand it today.”

Otto Hahn was born on 8 March



Otto Hahn

1879 at Frankfurt-am-Main, Germany. He admitted later that he was not an outstanding student at school. He wrote: “At school I was adequate but never an outstanding pupil. I remember that in the sixth grade I

jumped from eighteen (which was my rank in primary school) to third place, mainly because I learned my first foreign language, French, quickly and pronounced it well. But I remained in third, fourth, or fifth place and never made first place...”

Hahn was drawn to chemistry at an early stage. He wrote: “I became interested in chemistry when I was fifteen; a friend and I dabbled in chemical ‘experiments’ in our ‘wash kitchen’ as the laundry was normally called in Germany. My interest grew more serious a year or two later, and when I was in the highest grade of school I attended an evening course on ‘organic stuffs’ given at the Physical Society (the forerunner of Frankfurt University) by Professor Martin Freund.” Thus it was natural that Hahn wanted to pursue a career in chemistry. However, Hahn’s father, who was a successful merchant, wanted his son to train as an architect. So it was against lot of family opposition that he was finally allowed to study chemistry at Marburg University, which he joined in 1897. He spent his third and fourth seminar under Adolf von Baeyer at the University of Munich.

He obtained his PhD degree in 1901 from the Marburg University. His research supervisor was the German organic chemist Theodor Zincke. After his PhD, Hahn was contemplating to pursue an industrial career. During this time the Head of the Kalle and Company mentioned to Hahn’s research supervisor Zincke that they would be interested in hiring a young organic chemist, but the prospective candidate should be familiar with a foreign country and well conversant in a second language. Knowing Hahn’s interest, Zincke advised him to visit England and to learn English. Zincke also made arrangement for Hahn during his stay in England to work in the laboratory of William Ramsay at the University College of London. As advised by his research supervisor, Hahn went to England and started working at the University College of London. At the instance of Ramsay, Hahn took up the work of separating radium from some radioactive

material that Ramsay had acquired from Sri Lanka (then Ceylon). While working at the Ramsay's laboratory Hahn found a new material, a highly active form of thorium and he named it 'radiothorium', which was later found to be a new isotope of thorium, with mass number 228.

It was Ramsay who played a decisive role in shaping the career of Hahn. Ramsay persuaded Hahn to pursue a career in the field of radioactivity. Hahn wrote: "Near the end of my stay, Ramsay asked me about my future plans. I told him about the prospective job with Kalle & Co. in Bierbrich. Ramsay said that I should not go into industry—after all, I had discovered a new radioactive element (radiothorium), and I should stay with radioactivity, which was certain to be a field with a great future. I should go to Berlin, where the greatest of the universities was located. There, he said, such a new field would have chance to develop."

Ramsay did not stop at simply giving advice. He wrote to the German organic chemist and biochemist Emil Hermann Fischer (1852-1919), then the Director of the Chemistry Institute at Berlin University requesting him to accommodate Hahn in his laboratory. Ramsay in his letter of recommendation to Fischer wrote: "I am quite astounded by the boldness, skill, and stamina of Dr. Hahn...He should qualify as a lecturer, and I believe it would be good if did so with you. Would it be possible for him to work in your laboratory for a couple of years? He is a nice fellow, informed, trustworthy and talented...He is, and wishes to remain German, and may be trusted with all methods of investigating radioactivity. I know that you want to make your laboratory as versatile as possible...do you have a corner for him?" Emil Fischer, who was a good friend of Ramsay, agreed to help.

Ramsay further suggested to Hahn that before going to Berlin he should go to Montreal, Canada to work with the New Zealand physicist Ernest Rutherford (1871-1937). Ramsay believed that there was no other place where one could



William Ramsay



Emil Hermann Fischer

learn more about radioactivity than at McGill University in Montreal where Rutherford worked. Ramsay recommended Hahn to Rutherford: "Hahn is a splendid colleague and has done admirable work. I am sure you will enjoy working together with him."

Rutherford provided Hahn an opportunity to work in his laboratory. Hahn worked in Montreal from September 1905 until mid-1906. While working in Montreal he discovered thorium C (later identified as polonium-212), radium D (later identified as lead-210) and radioactinium (later identified as thorium -227). He also investigated the alpha rays emitted by radiothorium, the new material that he had earlier discovered at Ramsay's laboratory in London.

After returning from Montreal, Hahn started working at the Chemical Institute of Berlin University, where Emil Fischer was the Director and to whom Hahn was recommended by Ramsay. Fischer made Hahn available a former woodworking shop to use as his laboratory. Hahn was supposed to convert this unused space into a working laboratory. However, within a short span of time working with extremely primitive apparatus Hahn discovered mesothorium - an isotope of radium. Hahn was qualified as a University lecturer in the spring 1907. By the end of 1907, he was joined by Lise Meitner who came from Vienna and their collaboration lasted over thirty years. Five years after they started working

at Berlin University they both moved to the newly established Kaiser Wilhelm Institute for Chemistry at Berlin-Dahlen, where Hahn became head of a small but independent division of radiochemistry.

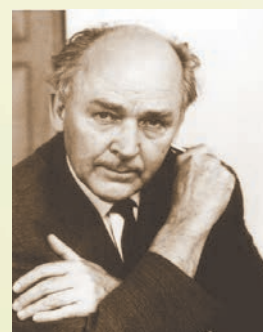
Hahn's research from 1904 onwards was devoted entirely to the chemistry of the radioactive elements and their decay products. During the First World War (1914-1918) both



Ernest Rutherford



Lise Meitner



Fritz Strassmann

Hahn and Meitner had to take up military duties. Hahn became an expert in chemical warfare and served on all European fronts. Meitner served as a nurse. After the end of the War they resumed their collaborative research. His best-known research was on the irradiation of

uranium and thorium with neutrons. It was in 1934 when Hahn became interested in the work of the Italian-American physicist Enrico Fermi (1901-1954), who had demonstrated that when uranium, the heaviest element, was bombarded by slow neutrons, several radioactive products were formed. Fermi was of the view that these products were artificial elements similar to uranium. Hahn was fascinated with the behaviour of uranium when bombarded with slow neutrons. He jointly with Meitner pursued this work. They were later joined by Hahn's student, Fritz Strassmann.

Bombarding uranium with slow neutrons they expected to find some isotopes of radium. However, to their surprise instead of radium they found barium. In 1938, Meitner had to leave Germany as, because of her Jewish ancestry, she found it unsafe to remain in Germany. She left for Holland but finally settled in Stockholm, Sweden. Hahn found it very difficult to explain the findings because compared to uranium barium was far too low in the Periodic Table. So if this was the case then large amounts of alpha particles would have emerged and which Hahn should not have missed to detect. But Hahn did not find any such thing. It was too much for him to think that the heavy uranium nucleus could split into two lighter ones by neutron bombardment

(or nuclear ‘bursting’ as it was called then). It was something too outrageous to contemplate at that time as it was “in contradiction to all previous experience in nuclear physics”.

At the same time it was also true that Hahn was sure that he was dealing with barium and not some isotopes of radium. He realised that something very strange must have happened; the only mechanism that could explain his findings was a process by which nuclei of uranium atoms actually broke up to form nuclei of much lighter atoms. Hahn was unsure about his interpretation and he feared ridicule in publishing such a revolutionary theory. In any case he quickly sent off a joint paper with Strassmann for publication. This was irrespective of the fact Hahn was not sure whether it would be prudent to believe in what he actually found. Thus Hahn later wrote: “After the manuscript had been mailed the whole thing once seemed so improbable to me that I wished I could get the documents back out the mail.” It was his former collaborator Meitner, who was then in Sweden and her nephew, the Austrian-British physicist Otto Robert Frisch (1904-1979) who made the necessary calculation to provide a theoretical basis to explain the observation made by Strassmann. They called the process ‘nuclear fission’ and it was announced in early 1939.

The discovery of nuclear fission was possible by combined effort of chemists and nuclear physicists. As Peter J. Westwick observed: “Physicists and chemists alike recognised the importance of nuclear fission after its announcement in January 1939, and both disciplines would play central roles in the military and industrial application of nuclear energy in World War II and afterwards. The discovery required the sort of interdisciplinary collaboration possible in Hahn’s institute, which helps explain why physicists alone failed to notice the effect earlier. Nuclear fission exemplifies the interplay of chemistry and physics within



Enrico Fermi

a common field of nuclear science; Rutherford’s early Nobel Prize symbolised the difficulties Nobel committees experienced in distinguishing physics from chemistry in the nuclear sciences of the 1930s.”

Hahn shared the prestigious Enrico Fermi award in 1966 with Strassmann and Meitner. He was honoured by many learned societies and universities. Hahn served as the last President of the Kaiser Wilhelm Society in 1946. He was the founding President of the Max Planck Society (1948-1960). He assisted in post-war rehabilitation of German science. Many people regarded Hahn as a model for scholarly excellence and personal integrity.

In 1960 Hahn’s only son Hanno and daughter-in-law died in a car accident and he spent his last years caring for his invalid wife and grandson. Hahn died on 28 July 1968 at Gottingen, Germany.

Hahn’s name is commemorated in the Hahn-Meitner Institut for Nuclear Physics in Berlin, and Otto Hahn Institute for Chemistry at Mainz. The first nuclear vessel developed by the erstwhile

West Germany was named *Otto Hahn*. The element with atomic number 108 was named ‘hahnium’ after Hahn by the International Union of Pure and Applied Chemistry in 1994.

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(This article is a popular presentation of the important points on the life and work of Otto Hahn available in the existing literature. The idea is to inspire the younger generation to know more about Hahn. The author has given the sources consulted for writing this article. However, the sources on the Internet are numerous and so they have not been individually listed. The author is grateful to all those authors whose works have contributed to this article.)

Dr. Subodh Mahanti worked in Vigyan Prasar (1994-2014) and co-ordinated several science popularisation projects. He has written extensively. He writes both in Hindi and English. ■

VP website

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Keep Your Eyes Healthy



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Eyes are the organs of vision, which detect and collect light from the surrounding environment. The collected light is detected by the retina which is made up of two types of visual cells: rods (which work well in dim light and are not sensitive to colour) and cones (requires brighter light and are sensitive to colour).

This vital organ of vision plays a very important role in the human body providing

kale, and collards besides salmon, tuna, and other oily fish, eggs, nuts, beans, and other non-meat protein sources, oranges and other citrus fruits or juices, etc., are also beneficial for eye health.

Diet for healthy eyes

The diet recommended healthy for hearts is also considered good for eyes because such diets containing low amounts of trans- and

fried foods like French fries, fried chicken, doughnuts, cookies, pastries, and crackers should be avoided.

Smoking and eye health

It has been well accepted that smoking can cause cataract, damage to the optic nerve, and macular degeneration. For healthy eyes it is better to give up smoking. To protect our eyes from effects of sunlight it is necessary to use proper sunglasses, which protect eyes from effects of UV rays.

Cosmetics and eye health

Improper use of eye cosmetics may promote the growth of harmful bacteria, which can cause allergies, dryness, and infections. To reduce the risk of eye infection, cosmetics should be changed every three to six months interval and it should not be shared with anybody to reduce cross-contamination. Cosmetic tools or application brushes should be washed using warm water or soap because cosmetic tools act as breeding ground for bacteria and germs. Eye cosmetics should be properly stored to avoid humidity and moisture.

Electronic gadgets and eye health

Most of us use electronic gadgets such as laptops, mobile phones, hand-held computer games, TV, etc., which directly affect vision. The excessive use of these gadgets may make life easier, but it harms the body, especially the eyes. Use of electronic gadgets may be a boon if used in the right manner, but if used excessively they may affect vision. Many studies have concluded that excessive use of mobile phones

may lead to a condition known as strabismus or "squint". The condition of strabismus is



Fig. 1. Healthy diet keeps eyes healthy

the sense of sight. The human eye is able to see in dim light or bright light, but it cannot see objects in total absence of light.

Our eyes assist us in almost every activity we perform like walking, reading, watching TV, working on a computer, etc., and play a crucial role in learning, communicating, working, and improving the quality of life. This important organ works almost non-stop in our waking hours. Several forms of non-verbal communication come from eyes and these can reflect the mood of a person and also reflect our health and wellbeing.

Care of the eye is not limited to any age; it is compulsory throughout lifetime. An important factor in protection of our eyes is our food habits. The different nutrients in diet such as carotene, lutein, zinc, and vitamin C, etc., are considered good for eye health and are also beneficial to resolve many age-related vision problems. Regular use of diet containing green vegetables such as spinach,

saturated fat and keep the blood vessels of the eyes healthy. Diet containing vitamin C, antioxidants, zinc, beta-carotene, and vitamin E is considered helpful in prevention of age-related macular degeneration (a degenerative disease of the eye that results in blurred vision and can cause blindness). Besides carotene, several other vitamins



Fig. 2. Playing with mobile phone (left) and laptop (right) can have adverse effect on eyes of children.

and minerals are essential for healthy eyes. Intake of diet rich in trans-fat may lead to high blood pressure, which in turn can cause damage to the blood vessels of the retina. For healthy eyes, diets rich in trans-fat such as

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Phenol: A Serious Environmental Threat



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Environmental pollution is a growing threat to the survival of mankind on Earth. Among the various types of pollutions, water pollution is a serious threat because water sustains life. Less than 0.36% of freshwater on Earth is available for human consumption and use. Polluted water is the cause of approximately 21% communicable diseases as reported by World Health Organization (WHO).

Water pollution can be due to natural causes or human activities. Use of chemical fertilisers and pesticides for agriculture purposes and the effluents released from industries like petrochemical refineries, pulp and paper mills are the key sources of water pollution. These industrial effluents contain a wide variety of degradable and non-degradable organic toxic chemicals such as phenols, chlorophenol, cresol, butyl phenol, and toxic metals such as lead, mercury, chromium, manganese, iron, cobalt, nickel, copper, zinc, etc., among which phenol is a major organic pollutant as reported by WHO. Consumption of these toxic effluents loaded with phenol causes malformation in urban children, neurological disorder, and mutagenic changes. So treatment of wastewater containing phenol is essential for the survival of all types of life forms. There are various types of physiochemical methods available for treating these effluents. However, due to high cost, energy and requirement of toxic chemicals for these methods, biological methods including treatment with various microorganisms are most preferred to treat the phenol-containing effluents without affecting environmental sustainability.

Importance of phenol

Phenol is a white-coloured aromatic compound in which a hydroxyl group attached to the six-membered aromatic ring structure. It is designated by various names such as mono hydroxybenzene, monophenol, carbolic acid, benzaphenol, acidum phenylicum, etc. It is a slightly acidic compound and shows limited solubility (8.3 g/100 ml) in water. It can be found naturally

as well as in the form of manufactured chemicals. However, despite being a very toxic compound but nowadays, phenol and its derivatives are widely used in various fields (Table 1).

Sources of phenolic effluents

Wastewater from various industries like plastic, pharmaceuticals, varnish, paints,

Table 1. Applications of phenol in various fields

Application	Description
Industrial use	In the manufacture of dyes, inks, varnishes, anti-rust products, photographic chemicals, etc.
Medical use	As an antiseptic, and as a building block for pharmaceutical synthesis, etc.
Beauty products	Used in the manufacture of several cosmetic products like skin lightening cream, hair dyes, sunscreen, etc.
Laboratory use	Phenol-chloroform mixture used in molecular biology for DNA and RNA purification from proteins.

Harmful effects of phenol

Phenol has toxic effects on every kind of life form. It is reported that 1g of phenol is lethal for humans. Because of its toxic and hazardous effects a limit level of 1 mg/l has been set by the World Health Organization (WHO) to control the phenol concentration in drinking water and it is listed as a priority pollutant by the U.S. Environmental Protection Agency. Phenol and its derivatives are classified as hazardous materials. Long-term ingestion of phenol causes gastrointestinal irritation, enlarged liver, skin inflammation, necrosis (death of body tissue), gastrointestinal disturbance and tumour promoting properties whereas acute exposure results in dysfunction of the heart and muscle weakness.

coking plant, pulp and paper mills, and oil and petroleum refineries are the major sources of phenolic effluents. When this wastewater gets mixed with receiving water bodies, it would be harmful to fish even at low concentration of 5-25mg/l.

Methods available for removal of phenolic compounds

There are several methods reported for removal of phenolic compounds and these can be categorised into three different types: physical, chemical and biological methods. All methods have their own advantages and disadvantages. Physical methods basically include sedimentation, adsorption, and flotation whereas aerated lagoon and microbial degradation comes under the biological methods.

Table 2. Phenol concentration in industrial effluents

Industry	Phenol concentration (mg/l)
Pharmaceuticals	1,000
Coking plant	28-3,900
Oil and petroleum refineries	2.8-1,220
Pulp and paper	0.1-1,600
Gas production	4,000

Adsorption

In the adsorption technique activated carbon is widely used as adsorbents for the removal of inorganic and organic micropollutant from waste water. But high regeneration cost and the formation of carbon fines are the major drawbacks of this method. Other adsorbents like uncharged polymeric resins are also used but they show lower affinity for phenol removal. Anionic resins remove phenol via ion-exchange mechanism. DowexXZ (strong anion-exchange resin) and AuRIX 100 (weak anion-exchange) are two ion-exchange resins show maximum phenol removal under alkaline conditions. Other methods used for the removal of phenol are dialysis, oxidation, extraction with solvents and impregnated resins, etc.

Chemical methods

Chemical methods include distillation, coagulation, liquid-liquid extraction with the use of different solvents, membrane solvent extraction, filtration, and precipitation, etc.

Limitations of physicochemical methods for the treatment of phenol

- Highly expensive, economically not viable
- Formation of undesirable by-products
- Complete removal of phenol is not possible
- Higher requirement of chemicals and electricity
- Considering these limitations the biological method is the most preferred method for treatment of phenol-containing wastewater

Biological methods

Biological method involves removal of phenol with the help of microorganisms. Several microorganisms such bacteria, yeast, fungi and microalgae have the capability to utilise phenol as a carbon source for their growth. These microorganisms degrade phenol either by microbial metabolism or through biological oxidation with the help of phenol oxidising enzyme. The biological method involves the complete mineralisation of complex compound to simpler ones.

Advantages of biodegradation

Biodegradation is a cost-effective method in which harmful by-products are not formed

Table 3. Microorganisms and their phenol degrading capabilities

S.No.	Microorganisms	Source of phenolic compound	Phenol removal (mg/l)
1	<i>Bacillus cereus</i> (bacteria)	Waste water of coking industry	800
2	<i>Acinetobacter</i> (bacteria)	Waste water of coal industry	1,200
3	<i>Rhodococcus opacus</i> (bacteria)	Contaminated soil with chlorobenzene	1,200
4	<i>Acinetobacter</i> (bacteria)	Aerobic granules	1,000
5	<i>Sphaerobacter</i> (bacteria)	Activated sludge in coking plant	2,000
6	<i>Enterobacter</i> (bacteria)	Wastewater of cork manufacturing	941
7	<i>Thermoanaerobacterium</i> <i>Thermosaccharolyticum</i> (bacteria)	Palm oil mill effluent	1,000
8	<i>Pseudomonas</i> sp.(bacteria)	Phenol-contaminated soil from hospital waste	1,000
9	<i>Alcaligenes</i> (bacteria)	Waste water of coke company	1,200
10	<i>Paecilomyces variotii</i> (fungi)	Activated sludge	1,800
11	<i>Aspergillus niger</i> (fungi)	Waste of paper manufacture	250
12	<i>Aspergillus flavus</i> (fungi)	Polluted soil of workshop	1,000
13	<i>Trichosporon multisporum</i> (yeast)	Agriculture field	200
14	<i>Saccharomyces cerevisiae</i> (yeast)	Soil of landfill site	800
15	<i>Candida tropicalis</i> (yeast)	Chemical contaminated soil	1,000

and this method completely removes phenol below the toxic limit.

Phenol-degrading microorganisms

Although phenol is toxic to microbial life, bacteria such as *Acinetobacter* sp, *Bacillus* sp, *Achromobacter* sp, *Pseudomonas putida*, *Pseudomonas aeruginosa* (up to 1,200 mg/l), and fungi such as *Coriarius versicolor*, *Ralstonia* spp., and *Phanerocheate chrysosporium* have the ability to degrade phenol. Some species of oil-rich yeast such as *Trichosporon* sp. also have the ability to degrade phenol (more than 1,000mg/l).

Conclusion

The worldwide increase in industrialisation has been recognised as serious threat related to environmental deterioration due to the discharge of various waste products and

effluents in the surrounding environments. According to World Health Organization (WHO), phenol comes under the most common toxic environmental pollutant released by these industries. Phenol removal from industrial effluents is essential for the safety of the environment. Physicochemical methods are usually considered for the same, but cost-effectiveness and production of hazardous metabolites during processing are the main problem with these methods. To combat this challenge, various microorganisms such as oil-rich yeasts are a better alternative for degrading phenol and also for the production of high-quality biodiesel.

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Accidental Discoveries in Medical Science



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Introduction

“Eureka!” shouted the ancient Greek scientist Archimedes when he discovered buoyancy – the principle that explains why objects float in water. The word eureka means “I have found it”, and the purpose of science is to find explanations for the things that happen in the world around us. Science is a quest for veracious justification of how the world works. From the tiniest subatomic particle, through all living things, to the Universe itself, the scope of science is infinite and immeasurable.

Science is a way of life. It is the process that takes us from the field of confusion to understanding which is predictive and reliable. All the scientific knowledge we have today is the result of centuries of careful questioning, research, and observation together with the inspiration of many brilliant minds. Before the precise scientific method was fully developed, people made discoveries about the world and developed technologies mainly through guesswork. And sometimes, with Nature’s will, discoveries were made through accidents! Surprising! Here are a few examples.

Anaesthesia

A pregnant woman incapable of delivering her baby normally asked her gynaecologist for a better alternative. Her physician smiled and assured her that she will deliver a healthy baby through Caesarean section (a surgical procedure in which one or more incisions are made through a mother’s abdomen and uterus to deliver the baby). The woman again expressed her anxiety by saying that she cannot bear the pain of cutting her body. The doctor pacified her and said that she won’t feel any pain.

What made the doctor say like this? How can there be no pain during a Caesarean section? Medical procedures like surgeries would be a big pain literally if they are done with patients in senses. But anaesthesia enables the painless performance of medical procedures that would cause

relentless or intolerable pain to a patient without anaesthesia.

The true discoverer of anaesthesia is contested. Several names are associated with the accidental discovery of this astonishing medical technique. Crawford Long, William Morton, Charles Jackson, and Horace Wells are accredited for the unexpected discovery of anaesthesia. These men discerned that in some cases, ether and nitrous oxide (laughing gas) inhibited pain in people under their influence.

In the 1800s, inhaling either of these compounds was somewhat trendy for both recreation and amusement. By witnessing and even partaking in these social events, often named as ‘laughing parties’ and ‘ether frolics’, anaesthesia’s founding fathers learned more about how these experiences affected people’s perceptions of pain. In 1844, Horace Wells attended an exhibit and witnessed a man injure his leg while under the influence of laughing gas. The man, whose leg was profusely bleeding, told Wells that he didn’t sense any pain. After this accidental observation, Wells used the compound as an anaesthetic while he removed his own tooth and found that the process was painless. The process of anaesthesia and its use during medical procedures and surgeries was slowly becoming clear to these physicians. Wells, Morton and Jackson collaboratively began to use nitrous oxide as anaesthesia in dental practices, while Crawford Long used ether for minor surgeries.

Before it was recognised as an anaesthetic, nitrous oxide was used as an effective tranquilliser (drug used to reduce anxiety, fear, tension, agitation, and related states of mental disturbance) and “mood enhancer” in upscale parties and cross-

country sideshows. Joseph Priestley was the bright mind who discovered the use of nitrous oxide as an anti-panic agent.

The unintended discovery of anaesthesia has been a boon for people around the globe. In modern times every patient can experience a painless surgery irrespective of the critical nature of the operation. Anaesthesia can be categorised into two major classes: local anaesthesia numbs a small part of the body for minor procedures while regional anaesthesia blocks pain to a larger part of the body. General anaesthesia involves the patient being put into a medication-induced state which, when deep enough, means that the patient will not respond to pain and includes changes in breathing and circulation. Under general anaesthesia, a patient is in a state of carefully controlled unconsciousness.

Radiography

On 8 November 1895, German physicist Wilhelm Conrad Roentgen (1845-1923) became the first individual to observe X-rays, a significant scientific advancement that would ultimately revolutionise the entire arena of medical science, by making the invisible visible. But Roentgen preferred

to credit his discovery to an accidental observation that happened while working on radiation-producing cathode rays in his laboratory in Würzburg, Germany. When he was testing if cathode rays could pass through glass, he suddenly noticed a glow coming from a nearby chemically coated screen. Actually it was a fluorescent screen coated with the chemical called barium platinocyanide in his lab that glowed whenever the cathode ray was switched on. This wouldn’t have been unusual, except for

the fact that the fluorescent screen was surrounded by cardboard from all sides.

Roentgen had anticipated that the thick cardboard would have blocked most of



Wilhelm Conrad Roentgen

the incoming radiation, but it still glowed. Roentgen tried to place a few objects between the tube and the screen to check if the screen still glows. To his surprise, in every case the screen glowed. Eventually, he put his hand in front of the tube and saw the silhouette of his palm bones projected onto the screen. Roentgen had discovered X-rays and at the same time proposed its innumerable uses in medical science. He named these radiations as X-rays as he was not sure about its properties and nature. Shortly after his discovery of X-rays, Roentgen took a radiograph of his wife Bertha's left hand on 22 December 1895.

Following its discovery, it was confirmed that X-rays are actually electromagnetic waves that behave similarly to light rays, but at wavelengths approximately 1,000 times shorter than those of light. Most X-rays have a wavelength ranging from 0.01 to 10 nanometres, corresponding to frequencies in the range 3×10^{16} Hz to 3×10^{19} Hz and energies in the range 100 eV to 100 keV.

Roentgen conducted a series of experiments to better understand his phenomenal discovery. He perceived that X-rays penetrate through human flesh but not high-density substances such as bone or lead and that they can be photographed. Roentgen's discovery was designated a medical miracle and X-rays soon became an important diagnostic tool in medicine, allowing doctors to see inside the human body for the first time without any incision. In 1897, X-rays were first used on a military battlefield, during the Balkan War, to find bullets and broken bones inside injured soldiers. An X-ray machine projects X-rays through the body. The images are recorded on a computer or film. Structures that are dense (such as bones) block most of the X-ray waves, and appear white on screen. Metal and contrast media (special dye used to highlight areas of the body) also appear white in the X-ray image. Internal structures containing air usually appear black, and muscle, fat, and fluid appear as shades of grey.

The type of X-ray diagnosis to be done depends on position of the body. Slightest motion in body organs or presence of any metal object on body causes blurred images. Scientists were rapid to realise the benefits of X-rays, but slower to comprehend the harmful effects of radiation. Initially, it was presumed X-rays passed through flesh

as harmlessly as light. However, within a short period of time, researchers began to report cases of burns and skin damage after exposure to X-rays. Thomas Edison's assistant, Clarence Dally, who had worked extensively with X-rays, died of skin cancer in 1904. Dally's poignant death caused some scientists to begin taking the risks of radiation more seriously, but they still were not fully understood. During the 1930s, 40s and 50s, many American shoe stores featured shoe-fitting fluoroscopes that used X-rays to enable customers to see the bones in their feet; it was not until the 1950s that this practice was determined to be risky business.

Rontgen received numerous accolades for his work, including the first Nobel Prize in Physics in 1901. A Roentgen unit of measurement for radiation exposure was named in his honour which became a measure of the ionisation produced in air by X-rays or gamma radiation. Today, X-ray technology is widely used in medicine, material analysis and devices such as airport security scanners.

Insulin

A dog's urine proved worthwhile for the accidental discovery of an elusive substance which regulates blood-sugar levels in the body. Frederick G. Banting, a young Canadian doctor, and Professor John J.R. MacLeod of the University of Toronto shared the Nobel Prize in 1923 for Physiology or Medicine for their isolation and clinical application of insulin in treatment of diabetes. Their work with insulin followed the chance discovery of the link between the pancreas and blood-sugar levels by two other doctors on the other side of the Atlantic decades earlier.

In 1889, German physicians Joseph von Mering and Oscar Minkowski detached the pancreas from a healthy dog in order to learn about the role of the pancreas in digestion. Several days after the dog's pancreas was removed, the doctors happened to detect a swarm of flies feeding on a puddle of the dog's urine. On testing the urine to determine the cause of the flies' attraction,

the doctors realised that the dog was secreting sugar in its urine, a basic sign of diabetes. Because the dog had been healthy prior to the surgery, the doctors knew that they had created its diabetic condition by removing its pancreas and thus understood for the first time the relationship between the pancreas and diabetes through this accidental observation. With subsequent tests, von Mering and Minkowski concluded that a healthy pancreas must secrete a substance that controls the metabolism of sugar in the body.

Though many scientists tried in vain to isolate the particular substance released by the pancreas after the Germans' accidental discovery, it was Banting and MacLeod who established that the baffling substance was insulin and began to put it to use as the first truly valuable means of controlling diabetes. On 30 July 1921, Banting injected the hormone insulin into a diabetic dog and found that it successfully lowered the dog's elevated blood glucose levels to normal, thus proving the experiment successful.

Diabetes, often referred to by physicians as diabetes mellitus, describes a group of metabolic diseases in which the person has soaring blood glucose (blood sugar) level, either because insulin production is inadequate, or because the body's cells do not respond properly to insulin, or both. Patients with high blood sugar will typically experience problems like polyuria (frequent urination), and excessive thirst (polydipsia) and hunger (polyphagia). Insulin is a hormone released by the pancreas that allows our body

to use sugar (glucose) from carbohydrates in the food or to store glucose for future use. Insulin helps keep the blood sugar level from getting too high (hyperglycemia) or too low (hypoglycemia). Patients affected with diabetes needs to take synthetic insulin to keep the blood glucose level in normal range.

Pap smear

In the year 1923, George Nicholas Papanicolaou, nicknamed 'Dr. Pap', initiated a series of medical studies with the hope of witnessing cellular changes over the itinerary of female menstrual cycle. He began observing and examining the vaginal smears



F. Banting

of animals during their sex cycle.

After successful inspection in female guinea pigs, Papanicolaou noticed cell transformation and wanted to substantiate the phenomenon in human females. So, he undertook a study of vaginal fluid in women, in hopes of observing related cellular alterations. But his fate had some other plans. It happened that one of Papanicolaou's human subjects was suffering from uterine cancer, one of the widespread ailments affecting women at that period of time. Much to his revelation, upon examining the slide made from the smudge of the cancer patient's vaginal fluid, Papanicolaou was dumbfounded to discover that abnormal cancer cells and their proliferation could be plainly observed under a simple microscope. He reported his discovery by saying, "The first observation of cancer cells in the smear of the uterine cervix gave me one of the greatest thrills I ever experienced during my scientific career." Papanicolaou swiftly realised that doctors could administer a simple test on a sample of vaginal fluid and analyse it for early signs of uterine and other cancers.

Pap smear is an investigative technique of cervical screening used to detect potentially pre-cancerous and cancerous processes in the cervix (lower part of the uterus). Abnormal reports are often followed up by more perceptive diagnostic procedures to intervene progression of cervical cancer. Cells scraped from the aperture of the cervix are thoroughly observed under a microscope. Papanicolaou's chance observation of cancer cells while doing a genetic study spawned the custom use of the so-called "Pap smear," a simple test that has saved billions of women from the ravages of uterine cancer. In the contemporary world, it is a standard cancer screening test for all women and has greatly reduced the death rate from cervical cancer throughout the world.

Pacemaker (implantable pulse generator)

One of the most notable creations in the field of medicine, the implantable cardiac pacemaker, was discovered accidentally by a lifelong inventor, Wilson Greatbatch. In the 1950s, Greatbatch resigned from the Navy and was working as a medical researcher. He was shaping an oscillator to record heart sounds when he pulled the wrong resistor out of a box. When he re-assembled

his device with a wrongly sized resistor, it started to give off a rhythmic electrical pulse which resembled human heart beats. In a way that only great minds can work, he quickly made the correlation that this pulse-producing device could help regulate the electrical activity of the human heart and guarantee a steady rhythm for patients. The heart has its own internal electrical system that controls and coordinates the rate and rhythm of heartbeat. With each heartbeat, an electrical signal spreads from the top of the heart to the bottom. As the signal travels, it directs the heart to contract and pump blood. Each electrical signal usually originates in a group of cells called the sinus node or sinoatrial (SA) node. While spreading from the top to the bottom, the signal directs the timing of cardiac cell activity. Patients with bradycardia (abnormally slow heart action) require pacemaker to fortify proper working of heart. A pacemaker resets the heart rate to an appropriate pace, thus ensuring adequate blood and oxygen being delivered to the brain and other parts of the body.

But in designing a usable pacemaker, Greatbatch faced a problem – the size of the pacemaker. The pacemaker he was working on was too large to be implantable. He spent two years reducing the size of the equipment as well as making it safe from body fluids. On 7 May 1958, surgeons at the Veterans Administration Hospital in Buffalo, USA, demonstrated that a smaller version Greatbatch had created, of just two cubic inches (32 cc), could take control of a dog's heartbeat. In the same year, 43-year-old Arne Larsson became the first human patient to receive an implantable pacemaker in Sweden. Arne died at the age of 86 years due to pre-diagnosed skin cancer, but was able to demonstrate the value of the pacemaker as a life-saving asset. A few sources also say Greatbatch's first pacemaker was implanted in a 77-year-old patient who lived 18 months with the device.

The accidentally invented small implantable pacemaker changed the course of people's lives. Greatbatch used to say, "Nine things out of 10 won't work. The

10th one will pay for the other nine." In 1985, the National Society of Professional Engineers recognised his pacemaker as one of the ten greatest engineering achievements of the last 50 years. Never ceasing to seek improvement in his device, Greatbatch acquired rights to a lithium iodine battery invented in 1968 by researchers in Baltimore. It addressed a huge limitation in



Wilson Greatbatch

his original pacemaker design, the zinc-mercury batteries that had a life span of as little as two years or even less. The lithium battery ensured an implant that would keep on working for more than a decade. As pacemakers improved, his company, Greatbatch Inc., eventually supplied 90% of the world's pacemaker batteries. The pacemaker eventually increased the average life expectancy of people reducing the frequency of death due to

heart malfunctioning or failure. Despite his fame, fortune and extensive contribution to science and medicine, Greatbatch remained a humble man who believed that God had guided him through his greatest works. With a possession of more than 350 patents, Greatbatch left for his heavenly abode at the age of 92 gifting the world another reason to live.

Viagra

Drugs undergo careful and rigorous trials before they are released to the market, but in real senses the factual trial only begins when large populations of people start consuming them. Patrick Vallance, Head of Drug Discovery of a renowned pharmaceutical company aptly suggests, "In many ways you learn as much about your medicine after it's launched as you knew before". When Simon Campbell and David Roberts, two researchers employed at the pharmaceutical company Pfizer, initiated studying the effectiveness of a new drug, they had no clue what their product would turn into. New drug, Viagra started life as plain old UK-92480, a new treatment for high blood pressure and angina. Angina is a heart ailment where the vessels that supply the heart with blood get constricted. The drug company Pfizer was searching for some remedy that would relax these blood vessels and created UK-92480, later named

as Viagra. By the late 1980s, it was ready to be examined on human patients in clinical trials. The team administered the drug to patients in a trial and found that it wasn't as effective as researchers had predicted.

Pfizer were about to abandon further trials when the male trial volunteers started coming back with an unusual side effect – lots of penile erections. With an open mind, the Company charged their scientist Chris Wayman with exploring this unintended side effect. Wayman created a model 'man' in the lab. He took a set of test-tubes filled with an inert solution, and in each one dropped a piece of penile tissue, taken from an impotent man (impotency is a male sexual disorder where the person suffers from less or almost no penile erection even after courtship with his partner). Each piece of tissue was then connected up to a box. The box was meant for sending a pulse of electricity through the tissue at the flick of a switch. Applying this electricity of very low intensity mimics what happens when a man is sexually aroused. Nothing happened to the vessels in the first attempt. However, when he added Viagra to the tissue bath and allowed electricity

to pass, the penile blood vessels abruptly relaxed – as they would do for a man to give him an erection. Restoration of the erectile response with a medicine meant for angina treatment was a real surprise for the entire crew of Pfizer as well as the whole medical world.

Before the launch of Viagra in 1998 there was no oral treatment for erectile dysfunction, the only options were an injection or a fairly gruesome prosthetic implant. The newly named Viagra, chemically known as sildenafil citrate, was approved by the U.S. Food and Drug Administration in 1998. Viagra does not cause a man to be sexually aroused or to have erection; it is only effective when the man is sexually aroused. When a man is sexually stimulated, the nervous system in the erectile tissue of the penis releases nitric oxide (NO). The nitric oxide further stimulates an enzyme that produces a messenger called cyclic guanosine monophosphate (cGMP). The cGMP helps the penile smooth muscle cells to relax. As a result of which the arteries in the penis dilate and the blood rushes into the penis to procure an erection.

Though Viagra's side effects are generally mild and brief, men with severe heart or liver problems, recent stroke or heart attack, extremely low blood pressure are advised to avoid this drug.

Conclusion

As seen in the preceding paras, seemingly insignificant result by one researcher often leads to a breakthrough discovery by another; a physician methodically pursuing the answer to a medical conundrum over several years suddenly has a "Eureka" moment; a scientist who chooses to study a contaminant in his culture rather than tossing it out stumbles upon something entirely novel and new. The one trait that tied all these lucky strikers together: open-mindedness. As the renowned physicist Joseph Henry once noted, "The seeds of great discoveries are constantly floating around us, but they only take root in minds well prepared to receive them".

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Keep Your Eyes Healthy (continued from page 31)

mostly seen during infancy, but sometimes kids develop it suddenly.

The use of computer is also harmful to physical health during a child's growing age and may lead to a critical condition called as computer vision syndrome (a condition resulting from focusing the eyes on a computer for protracted, uninterrupted periods of time).

Measures to reduce adverse effects

Several suggestions have been considered to reduce the risk of harmful effects of electronic display gadgets, computers, mobiles, TV, etc.:

To avoid the harmful effects of computers on eye we have to reduce the screen brightness and also of the room to reduce eye strain.

Duration of time children spend on computer should be reduced to minimise the adverse effects of computer. Parents should encourage kids to take a break at

regular interval of 20 minutes or so to avoid the risk of eye focussing problem.

It has been suggested that watching TV for long hours may have many health-related problems and may cause dry or tired eye condition. TV should be watched from a proper distance and the time spent in TV watching should be cut down as much as possible.

To protect accidental injuries to the eyes it should be mandatory to wear safety glasses or protective goggles when working with harmful materials. Many games like cricket, hockey, ice hockey, racquet ball, etc., may also cause the eye injury; to avoid such injury use of sports goggles, helmets and face masks to guard the eyes should be a must.

Exercise and eye health

Eye health depends upon, what we eat or do. It has been reported by several researchers that myopia (nearsightedness) is seen more often if one is overweight or suffering from adult-onset diabetes. It has been

accepted that high insulin levels may cause disturbance in focussing power and capacity of sharp image formation by the eye.

Daily exercise is good for general health as well as the eyes. In most of cases exercise is found beneficial for eyes as it reduces the vein occlusion in central retina. Many studies have shown that physical exercise protects from cardiovascular as well as eyes-related problems such as macular degeneration and cataract. Exercise may protect eyes in indirect ways such as reducing the risk of diabetic retinopathy, obesity and metabolic disorders. Regular physical exercise such as walking is helpful to maintain healthy eyes. Symptoms like itching, burning, unusual redness, blurred vision, pain, excessive discharge, or unusual sensitivity to light should not be ignored and should be considered as a sign of an infection and an eye specialist should be consulted.

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Cures for haemorrhoids— Simple treatments and Surgeries



Dr. Yatish Agarwal

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A common malady, which affects nearly 50 per cent of people at one time or the other in the course of their lives, **haemorrhoids or piles**, are nothing but enlarged and swollen veins in or around the anus and rectum. They make life intolerable in many ways, and may cause rectal bleeding. Managing them, however, is not too difficult, provided one has the will.

Various treatment options are on hand to deal with **haemorrhoids**. Of them, the simplest are creams, ointments and suppositories, which a person with **haemorrhoids** must insert into his bottom. Such over-the-counter treatments are easy to get to from chemists, do not require a prescription, and can be used to relieve any **itching**, discomfort and swelling. **Once you have found relief with these easy measures, it is quite possible that the haemorrhoids may clear up by themselves within a few days.**

Subsequently, you can prevent their recurrence and keep **haemorrhoids at bay** by just making dietary changes to ease constipation and not straining on the toilet. Your doctor might also prescribe a few medicines to ease your symptoms and make it easier for you to pass stools.

These basic treatments may not however work for the more severe haemorrhoids. They may need more robust treatments such as banding, a non-surgical procedure where a very tight elastic band is put around the base of the haemorrhoid to cut off its blood supply; or sclerotherapy, wherein a chemical solution is injected into the blood vessels in the anus and rectum. Approximately 1 in every 10 people needs surgery. A number of surgical approaches are in vogue, which help remove or shrink haemorrhoids.

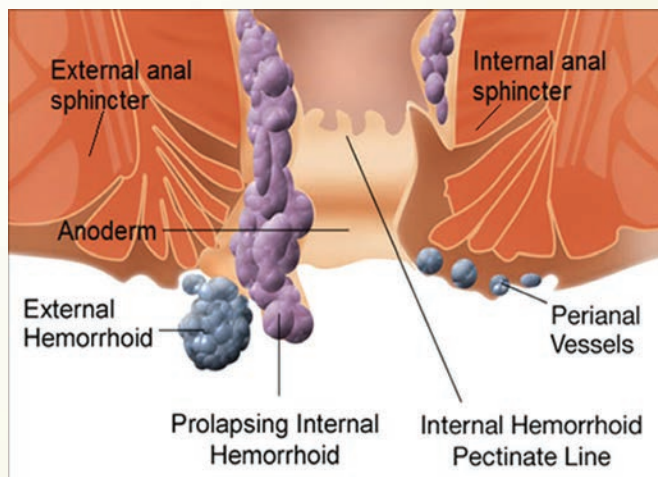
Medication

Topical treatments

A number of creams, ointments and suppositories are available from pharmacies to ease your symptoms. They can be used to relieve any swelling and discomfort. These medicines should only be used for five to seven days at a time. They may irritate the sensitive skin around the anus if you use them longer than this.

The choice of these treatments is best guided by your personal preference. Whichever product you find most suitable is good for you,

since there is no evidence to suggest that one method is more effective than another.



you empty your bowels.

Painkillers and numbing agents

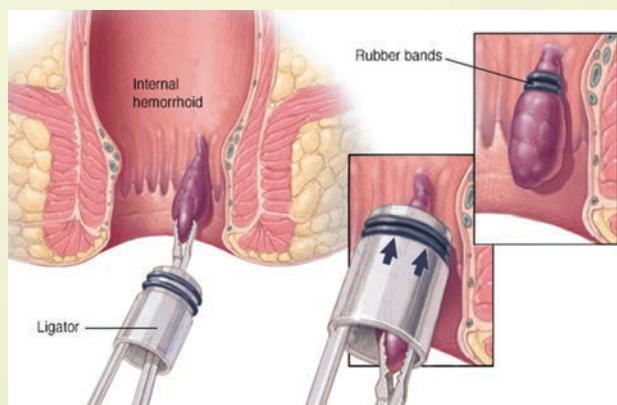
Common painkilling medication, such as paracetamol, can help relieve the pain of haemorrhoids. It is also the safest.

Avoid the use of such non-steroid anti-inflammatory drugs as ibuprofen, because they can make rectal bleeding worse. You must also avoid using codeine painkillers as they can cause constipation.

Your doctor may prescribe products that contain local anaesthetic to treat painful haemorrhoids. Like over-the-counter topical treatments, these should only be used for a few days because they can make the skin around the back passage more sensitive.

Non-surgical treatments

If dietary changes and medication don't improve your symptoms, your doctor may refer you to a surgeon or colorectal specialist. They can confirm whether you have haemorrhoids and recommend appropriate treatment.



Corticosteroid cream

If you have severe inflammation in and around the anus and rectum, your doctor may prescribe corticosteroid cream, which contains steroids. Use the cream for no more than a week at a time. A prolonged use of steroid cream can make the skin around the anus thinner and the irritation worse.

Laxatives

If you are constipated, your doctor may prescribe a laxative. Laxatives are a type of medicine that can help

If you have haemorrhoids in the upper part of anal canal, non-surgical procedures such as banding and sclerotherapy may be recommended.

Banding

Banding involves placing a very tight elastic band around the base of your haemorrhoids to cut off their blood supply. The haemorrhoids should then fall off within about a week of having the treatment.



Banding is usually a day procedure that doesn't need an anaesthetic, and most people can get back to their normal activities the next day.

You may feel some pain or discomfort for a day or so afterwards. Normal painkillers are usually adequate, but your doctor can prescribe something stronger if needed.

You may not realise that your haemorrhoids have fallen off, as they should pass out of your body when you go to the toilet. If you notice some mucus discharge within a week of the procedure, it usually means that the haemorrhoids have fallen off.

Directly after the procedure, you may notice blood in the toilet seat after going to the toilet. This is normal, but there shouldn't be a lot of bleeding.

If you pass a lot of bright red blood or blood clots, you must rush to your doctor's office or the nearest accident and emergency department immediately. Ulcers can occur at the site of the banding, although these usually heal without needing further treatment.



Surgery

Although most haemorrhoids can be treated using the more simple methods, around 1 in every 10 people eventually need surgery. There are many different types of surgery that can be used to treat haemorrhoids, but they all usually involve either removing the haemorrhoids or reducing their blood supply, causing them to shrink.

The following are the main types of different surgical procedures carried out for piles:

Sclerotherapy shots

A treatment called sclerotherapy may be used as an alternative to banding. During sclerotherapy, a chemical solution is injected into the blood vessels in anal canal. This relieves pain by numbing the nerve endings at the site of the injection. It also hardens the tissue of the haemorrhoid so a scar is formed. After about four to six weeks, the haemorrhoid should decrease in size or shrivel up.

You should avoid strenuous exercise for the rest of the day after having the injection.

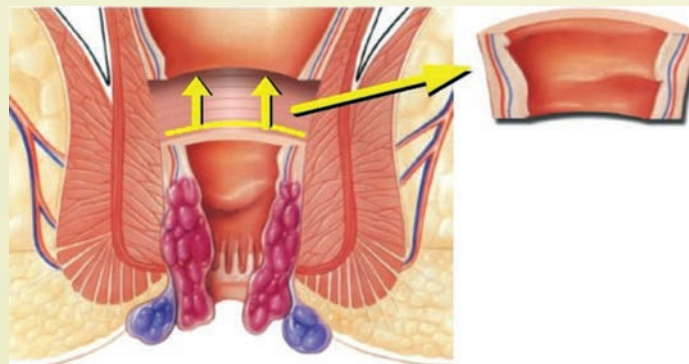
You may experience minor pain for a while and may bleed a little. You should be able to resume normal activities, including work, the day after the procedure.

Electrotherapy

Electrotherapy, also known as electrocoagulation, is another alternative to banding for people with smaller haemorrhoids. During the procedure, a device called a proctoscope is inserted into the anus to locate the haemorrhoid. An electric current is then passed through a small metal probe placed at the base of the haemorrhoid, above the dentate line (a line which divides the upper two-thirds and lower third of the anal canal). The specialist can control the electric current using controls attached to the probe.

The aim of electrotherapy is to cut off the blood supplying the haemorrhoid, which shrinks it. If necessary, more than one haemorrhoid can be treated during each session.

Electrotherapy can either be carried out on an outpatient basis using a low electric current, or a higher dose can be given while the person is under a general anaesthetic or spinal anaesthetic.



You may experience some mild pain during or after electrotherapy, but in most cases this doesn't last long. Rectal bleeding is another possible side effect of the procedure, but this is usually short-lived.

Electrotherapy has been found to be an effective method of treating smaller haemorrhoids. It can also be used as an alternative to surgery for treating larger haemorrhoids, but there's less evidence for its effectiveness.

Haemorrhoidectomy

A haemorrhoidectomy is an operation to remove haemorrhoids. An enema is usually given an hour or so before the operation to clear the lower part of the bowel. The operation is performed under a general anaesthetic. During the operation the haemorrhoids and tags are removed using an electrical cutting device (diathermy). Usually the wounds are left open. The operation takes around 45 minutes to complete.

Convalescing after surgery

A haemorrhoid surgery can be uncomfortable afterwards. You will have some local anaesthetic injected into the area; this will numb the pain for a few hours.

If the surgeon has placed a dressing pack in the anus this will be removed before discharge. Patients are allowed to eat and drink as soon as they feel able. Patients will normally be able to go home on the same day as the operation.

You will be given painkillers to take by mouth; you should take these regularly to prevent pain coming on. You will also receive an antibiotic, Metronidazole (Flagyl) to take for 7 days after the operation; this has been shown to help with the discomfort.

It will be uncomfortable when you first open your bowels after the operation, it is important that you do not avoid going to the lavatory. The discomfort will get better. Patients are given a regular stool softener to take for 4-6 weeks and are advised to avoid straining.

Patients are encouraged to move about after the procedure, but they should avoid heavy lifting or increased physical activities for about 6 weeks. Patients can normally resume driving after

about 2 to 4 weeks, but this may vary. Patients are normally reviewed in the surgery OPD around 6 weeks after the operation but they can be seen sooner if there are problems.

Chance of recurrence

After having a haemorrhoidectomy, there is around a 1 in 20 chance of the haemorrhoids returning, which is lower than it's happening after non-surgical treatments. Adopting or continuing a high-fibre diet after surgery is recommended to reduce this risk.

Stapling

Stapling, also known as stapled haemorrhoidopexy, is an alternative to a conventional haemorrhoidectomy. It is sometimes used to treat prolapsed haemorrhoids and is carried out under general anaesthetic. During the operation, part of the anorectum – the last section of the large intestine – is stapled. This means the haemorrhoids are less likely to prolapse. It also reduces the supply of blood to the haemorrhoids, which causes them to gradually shrink.

Benefits

Stapling has a shorter recovery time than a traditional haemorrhoidectomy, and a person can probably return to work about a week afterwards. It also tends to be a less painful procedure.

Risks

Following stapling, more people experience another prolapsed haemorrhoid compared with having a haemorrhoidectomy.

This procedure also carries a slightly higher risk of more serious complications than with other treatments. These include the springing of an ano-vaginal fistula in women, where a small channel develops between the anal canal and the vagina, or rectal perforation, where a hole develops in the rectum.

Haemorrhoidal artery ligation operation

To reduce the blood flow to the haemorrhoids, some surgeons prefer to perform the operation of haemorrhoidal artery ligation. A safe and effective alternative to a haemorrhoidectomy or stapled haemorrhoidopexy, the surgery is usually carried out under general anaesthetic and involves inserting a small ultrasound probe into the anus. The probe produces high-frequency sound waves that allow the surgeon to locate the vessels supplying blood to the haemorrhoid.

Each blood vessel is stitched closed to block the blood supply to the haemorrhoid, which causes it to shrink over the following days and weeks. The stitches can also be used to reduce haemorrhoids that hang down from the anus (prolapsing).

Benefits

The recovery time after having haemorrhoidal artery ligation is quicker compared with other surgical procedures. It causes less pain and, in terms of results, a high level of satisfaction has been reported.

Risks

There is a small risk of bleeding, pain when passing stools, or the haemorrhoid becoming prolapsed after this procedure, but these inconveniences usually fade away within a few weeks.

Risks associated with haemorrhoid surgery

Although the risk of serious problems is small, complications can occasionally occur after haemorrhoid surgery. You must discuss

with your surgeon the risks in more detail before deciding to have surgery.

The complications can include:

Rectal bleeding

A person may experience bleeding or passing blood clots, which may happen a week or so after the operation.

Formation of rectal abscess

Following surgery a person may develop infection, which may lead to a build-up of pus or development of a rectal abscess. To reduce this risk, a short course of antibiotics is given after surgery.

Acute urinary retention

A person may have difficulty emptying his bladder.

Faecal incontinence

A person may suffer with involuntary passing of stools.

Development of anal fistula

A person may develop an anal fistula, wherein a small channel may develop between the anal canal and surface of the skin, near the anus.

Anal canal stenosis

A person may develop narrowing of the anal canal. This risk is highest if treatment is taken on haemorrhoids that have developed in a ring around the lining of the anal canal.

The Red Flags: When to seek medical advice

Seek medical advice from the hospital unit where the surgery was carried out or your doctor if you experience:

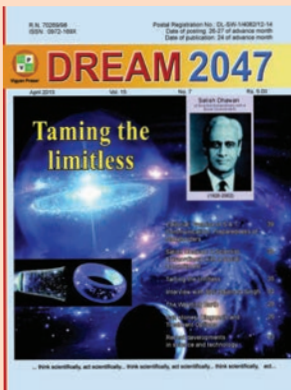
- excessive bleeding,
- a high temperature (fever),
- problems urinating, or
- worsening pain or swelling around your anus.

Prof Yatish Agarwal is a physician and teacher at New Delhi's Safdarjung Hospital. He has authored 47 popular health-books. ■

Articles
Invited

Dream 2047

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Recent Developments in Science and Technology



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'SMASH' theory may solve five major physics problems

The Standard Model of particle physics is a theory that fairly explains the electromagnetic, weak, and strong interactions, as well as classifies all the known elementary particles. It was developed during the latter half of the 20th century, as a collaborative effort of scientists around the world. The Standard Model includes quarks (the building blocks of protons and neutrons), electrons and neutrinos, and a number of more exotic particles like the Higgs boson. Altogether, there are seventeen different types of particles in the Standard Model.

But the Standard Model is not perfect because the current version is only able to explain about 5 percent of the matter found in the universe – the type of matter we are familiar with that is visible. However, astrophysical observations suggest that the mysterious dark matter is more than five times as common and the Standard Model cannot explain it. An international team of theoretical physicists has now come up with an extension to the Standard Model which could not only explain dark matter but at the same time also solve five major problems faced by particle physics at one stroke. Earlier efforts have attempted to explain these phenomena by much more complicated means, even adding hundreds of particles. But in the new model, the researchers say, the problems can be “intertwined in a remarkably simple way, with a solution pointing to a unique new physics scale around 10^{11} GeV.” (*Physical Review Letters*, 15 February 2017 | DOI: 10.1103/PhysRevLett.118.071802).

Dubbed SMASH, for “Standard Model Axion Seesaw Higgs” portal inflation model, the theory was developed by a group of French physicists at the

University of Paris-Saclay in an attempt to unify multiple different theories to solve five of the biggest problems in physics: dark matter, cosmic inflation, the strong CP problem, neutrino oscillations, and baryogenesis (the hypothetical physical



SMASH, the extended Standard Model. The six new particles are shown in the three columns on the right.

processes that took place during the early universe that produced the imbalance of matter (baryons) and antimatter (antibaryons). All of these problems in the current physics model are in some way related to the mysteries of quantum mechanics. The new theory explains the neutrino mass using the “see-saw” theory – giving each of our three known (very light) neutrinos a much heavier counterpart to balance it out. According to the researchers, the imbalanced decay of these heavy neutrinos into matter, rather than antimatter, explains why matter dominates the universe.

The SMASH theory adds a total of six new particles to the Standard Model: three heavy, right-handed neutrinos and an additional quark, as well as a so-called ‘axion’ and the heavy rho (ρ) particle. According to the researchers, the axion (first predicted in 1977) is a candidate for dark matter; the heavy neutrinos explain the mass of the already known, very light neutrinos. The rho particle is a bit like the

Higgs boson; it gives mass to neutrinos and also teams up with the Higgs to drive the cosmic inflation in the first split second after the Big Bang. In addition, the new model provides explanations as to why our universe contains so much more matter than antimatter, even though equal amounts must have been created during the Big Bang; and it reveals why no violation of so-called CP symmetry is observed in the strong force, one of the fundamental interactions.

According to the researchers, “The good thing about SMASH is that the theory is falsifiable. For example, it contains very precise predictions of certain features of the so-called cosmic microwave background.

Future experiments that measure this radiation with even greater

precision could therefore soon rule out SMASH – or else confirm its predictions”. They hope that the SMASH theory could potentially be tested experimentally within the next ten years.

Vitamin B may mitigate ill-effects of air pollution

In the past few years air pollution has become a major health issue with evidence building up of its link with increasing mortality. Nearly 2.4 million deaths every year are attributable to air pollution. The main culprit is particulate matter known as PM2.5, signifying particles with a diameter of 2.5 micrometres or less, about 30 times smaller than a human hair. PM2.5 comes primarily from combustion. Diesel car engines and coal- or natural gas-fired power plants are all major PM2.5 sources. According to the World Health Organisation, 92% of the world’s population lives in places where the PM2.5 level exceeds the recommended threshold of 10 mg per cubic metre. The Indian capital Delhi recorded an average PM2.5 reading

of 153 micrograms per cubic metre, which is nearly triple the level in Beijing and more than ten times the average in New York City.

Ambient PM_{2.5} pollution is one of the most dangerous air pollutants because they deposit in the respiratory tract resulting in both lung and systemic inflammation and stress. PM_{2.5} particles are small enough to bypass our respiratory system's defences and can easily get into our lungs, where they can even

penetrate the bloodstream and cause the real damage. Scientists suspect that exposure to PM_{2.5} can cause "epigenetic" changes to our cells – disturbances or mutations that can damage our health. It has been found that people who live in cities with high levels of PM_{2.5} have more heart attacks, depressed lung function, worse asthma, and overall die younger than people who breathe clean air.

At present emission control and regulation is the backbone of controlling air pollution. However, despite regulations, high levels of pollution are unfortunately the rule still in many megacities throughout the world. As individuals, we have limited options to protect ourselves against air pollution. But there is hope. Recent research has shown that the harmful effects of PM_{2.5} on health can be minimised by administration of vitamin B supplements. It was the first study of its kind, in which a team of international researchers looked at the damage caused by PM_{2.5}, which is known to have the most severe impact on health. The team found that something as simple as a daily vitamin B supplement could potentially reduce the impact of the tiny particles on the human body (*Proceedings of the National Academy of Sciences*, 13 March 2017 | doi: 10.1073/pnas.1618545114).

The study was done on a very limited scale. To take part in the study, 10 volunteers were selected who were healthy non-smokers, 18 to 60 years old, and who were not taking any medicines or vitamin supplements. The volunteers were initially exposed to clean air and given a placebo to check their baseline responses. The volunteers were then given another placebo for four weeks before being exposed to heavily polluted air



Air pollution in Delhi.

from downtown Toronto, Canada, where an estimated 1,000 cars pass every hour. The polluted air was delivered to the volunteers through an "oxygen type" face mask. The experiment was then repeated, with each volunteer taking a vitamin B supplement daily – made up of 2.5 mg of folic acid, 50 mg of vitamin B₆, and 1 mg of vitamin B₁₂. The researchers found that four weeks of B vitamin supplements reduced the damage of PM_{2.5} exposure by 28-76%.

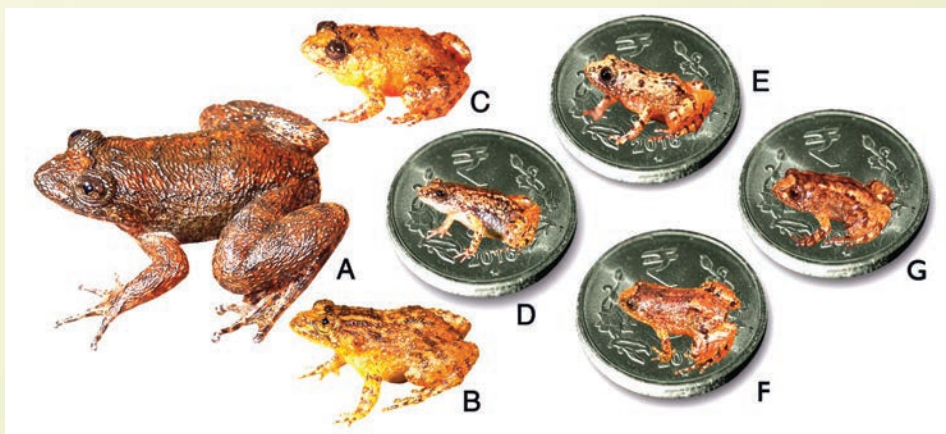
According to the researchers, although done on a limited scale, the study shows how individual-level prevention may be used to control the potential pathways underlying adverse effects of particles with a diameter of less than 2.5 micrometres. These findings could have a significant public health benefit in regions of the world with frequent PM_{2.5} peaks.

Andrea Baccarelli, professor and chair of Environmental Health Sciences at the Mailman School of Public Health, Columbia University, New York, and a member of the research team, expressed the hope that future studies, especially in heavily polluted areas, would be taken up to validate the findings and ultimately develop preventive interventions using B vitamins to contain the health effects of air pollution.

Seven new species of frogs discovered in India

A team of Indian researchers led by Prof. S.D. Biju of Delhi University has discovered seven new species of Night frogs of the genus *Nyctibatrachus*. Four out of the seven species are tiny, measuring 12.2 to 15.4 mm in size, which can comfortably sit on a 5-rupee coin. These are among the smallest frogs in the world. The new species were discovered in the Western Ghats of India after five years of extensive exploration (*PeerJ*, 21 February 2017 | DOI: 10.7717/peerj.3007).

According to the researchers, unlike other frogs in the genus that are predominantly stream dwelling, the new miniature frogs were found under damp forest leaf litter or marsh vegetation. The surprising thing about these previously unknown frogs is that they are not rare. "Rather, the miniature species are locally abundant and fairly common, but they have



*Seven new species discovered from the Western Ghats. A. Radcliffe's Night Frog (*Nyctibatrachus radcliffei*), B. Athirappilly Night Frog (*N. athirappillyensis*), C. Kadar Night Frog (*N. webilla*), D. Sabarimala Night Frog (*N. sabarimalai*), E. Vijayan's Night Frog (*N. pulivijayani*), F. Manalar Night Frog (*N. manalari*), G. Robin Moore's Night Frog. D-G. Size of the miniature species in comparison to the Indian five-rupee coin (Credit: SD Biju)*

probably been overlooked because of their extremely small size, secretive habitats and insect-like calls”, says Sonali Garg of Delhi University who was a member of the team.

The researchers say the newly sampled frogs were confirmed as new species in the lab by using an integrated taxonomic approach that included DNA studies, detailed morphological comparisons and bioacoustics. “Evidence from these multiple sources confirmed that the diversity of Night Frogs is higher than previously known and particularly remarkably for the miniaturised forms. Previously, the Night Frog genus composed of 28 recognised species of which only three were miniature-sized (less than 18 mm). Now the total number of known *Nyctibatrachus* species has increased to 35, of which 20 percent are small in size.” According to the researchers, this frog genus is endemic to the Western Ghats of India and represents an ancient group of frogs that diversified on the Indian landmass approximately 70-80 million years ago.

According to figures available, the past decade has witnessed an exponential increase in the number of new amphibian species described from this region. Of the total new species of amphibians (1,581) described globally between the years 2006-2015, the highest number were from the Brazilian Atlantic Forest (approximately 182) followed by the Western Ghats-Sri Lanka biodiversity hotspot (approximately 159), with 103 species described alone from the Western Ghats region. Prof. Biju, who is a veteran amphibian biologist, is credited with the discovery and identification of more than 80 new species of amphibians from India.

However, according to the researchers, the future of many of the new species may be bleak. All the newly described species are currently known only from single localities in the southern Western Ghats, part of which lies outside protected areas. Some of the species are facing threats such as habitat disturbance, modification and fragmentation and also human activities. “Over 32 percent, that is, one-third of the Western Ghats frogs are already threatened with extinction. Out of the seven new species, five are facing considerable anthropogenic

threats and require immediate conservation prioritization,” Says Prof. Biju.

Spiders are the biggest destroyers of insect pests

Spiders are probably the most feared creatures found in our homes and neighbourhood. Some individuals even go hysterical out of fear on sighting a spider. Contrary to popular belief spiders are not insects; they belong to a class of joint-legged invertebrate air-breathing animals called arachnids. At the present time, more than 45,000 species of spiders are described and those exhibit a very diverse range of lifestyles and foraging behaviours. There is hardly any terrestrial area on this globe where one cannot find



Jumping spider feeding on a fruit fly (Credit: Jeff Burcher).

spiders. “Spiders exist in the most northern islands of the Arctic, the hottest and most arid of deserts, at the highest altitudes, in the depths of caves, in the intertidal zone of ocean shores, in bogs and ponds, on high, arid moorlands, sand dunes, and flood plains.” Scientists estimate that there are on average around 131 spiders per every square metre of land on the globe, and in some places up to 1,000 individuals in that area.

Although spiders never attack humans spontaneously, they will bite if they feel threatened or endangered. Spider venom causes reactions that differ from spider to spider and person to person. Symptoms of a spider bite may include “a stinging sensation, red mark, localised swelling or an injury requiring hospitalisation”. So, it is always best to avoid touching a spider.

Although they appear repulsive, spiders are actually our friends. Because of their high abundance and predominantly insectivorous feeding habits, spiders are believed to be the main predators of insects,

many of them considered as pests. Spiders destroy enormous numbers of insects, which they consume as food. According to a recent study by an international team of researchers, every year, spiders consume up to 500 million metric tons of insects, which is much more than the 400 million metric tons of meat and fish all the humans in world consume each year (*The Science of Nature*, 14 March 2017 | DOI: 10.1007/s00114-017-1440-1).

To arrive at the stunning figures, the researchers first estimated the total mass of all spiders found on Earth. To do this they used published data on spider biomass from different environments such as tropical forests, temperate forests, tropical grasslands, temperate grasslands and shrub lands, agricultural land, deserts and Arctic tundra. They then used global land cover for each type of environment to estimate the total weight of spiders on the globe, and arrived at a figure of 25 million metric tons.

The researchers then worked out the total mass of food (mainly insects) that the creatures would consume in a year using two different methods. In the first, they estimated the food needs of a spider per the spider’s mass, which came to around 0.04 to 0.1 mg per gram of body weight depending on the environment. This method led to a range of between 460 million and 700 million metric tons of prey a year. In the second method, the researchers extrapolated data taken from the field in which they actually counted the number of insects the spiders ate. The figure they arrived at ranged from 395 million to 805 million metric tons.

The researchers wrote, “These estimates emphasise the important role that spider predation plays in our environment. We hope that these estimates and their significant magnitude raise public awareness and increase the level of appreciation for the important global role of spiders in terrestrial food webs.”

Biman Basu is a former editor of the popular science monthly *Science Reporter*, published by CSIR, He is a winner of the 1994 ‘NCSTC National Award for Science Popularisation’. He is the author of more than 45 popular science books. ■