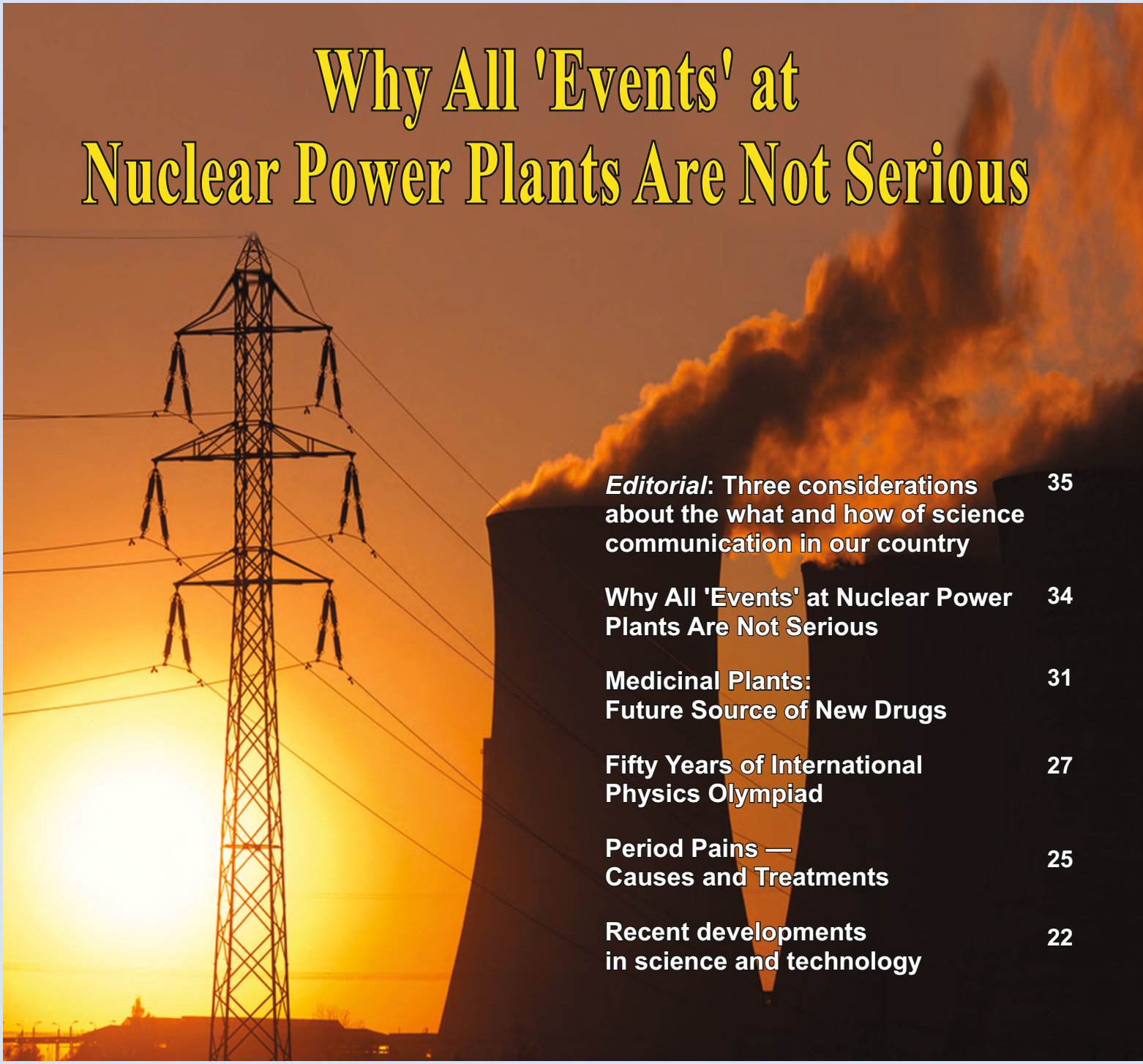
R.N. 70269/98
ISSN : 0972-169X

Postal Registration No.: DL-SW-1/4082/15-17
Date of posting: 26-27 of advance month
Date of publication: 24 of advance month

Vigyan Prasar

DREAM 2047

June 2017 | Vol. 19 | No. 9 | Rs. 5.00



Why All 'Events' at Nuclear Power Plants Are Not Serious

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

EDITORIAL

Three considerations about the what and how of science communication in our country

Dr. R. Gopichandran

The present editorial is quite theoretical. This comes against the backdrop of the inspiration I experience when I look at the spread and depth of science communication activities in our country. This includes the wide variety and numbers of audio, video and print materials produced by national and grass root level institutions and attempts to create a groundswell of interest through formal curricula and non-formal support for such learning. The first of three is the fact that cannot be denied is the large volume of such materials. Several of them are also adapted for ease of use at the local level including languages. The opportunity is the need to develop and deliver a significantly larger quantity and reach the unreached.

The second is about the changing demands of scale and speed of delivery and access. Social media are a typical case in point. Will it be useful to also highlight successes, knowledge networks and funding available, especially for the benefit of students? The third is overarching. It is about the esteem of the communicators and the process of communication by itself. It is absolutely essential to acknowledge the efforts of programmes and the enthusiasm science communicators have demonstrated to enrich the content and delivery processes in our country over the years. They cannot be trivialized. On the other hand, it is absolutely important to deliberate on the ways and means of significantly upscaling science communication activities in our country. It is quite logical of course to ask for a specific focus on stakeholder engagement and related bottom-up impacts. This is especially so when we wish to see a direct connect between the intent of inclusive development and aspirations for better quality of life. We should however not mistake the zeal of a top=down delivery with the impact of learning it is expected to create. Quantity and quality of intent and expected impacts of communication are obviously apples and oranges and cannot be mistaken for one another.

Based on the above, I am inspired to revisit the research agenda about the science of science communication I had highlighted a few weeks ago. One of the much-needed focal points will be to document successes of science communication through grass root initiatives. I assume this will establish a rich diversity of approaches and outputs. They have to be acknowledged and enriched to maintain their uniqueness. We should not err about homogenising them while attesting to harmonise. A repository of knowledge products will assist this enrichment. A good starting point will be to produce a compendium of best practices developed by teachers at the grass roots to inspire children. They should be conferred the much-needed visibility.

I wish to draw your attention to yet another point I have written about in the past. It is about a fantastic publication titled "TIME: 85 years of great writing" edited by Christopher Porterfield. You too will enjoy the precision and punch articles therein provide.

Email: r.gopichandran@vigyanprasar.gov.in ■

Editor : R Gopichandran
Associate editor : Rintu Nath
Production : Manish Mohan Gore and Pradeep Kumar
Expert member : Biman Basu
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
Tel : 011-26967532; Fax : 0120-2404437
e-mail : info@vigyanprasar.gov.in
website : http://www.vigyanprasar.gov.in

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.

Why All 'Events' at Nuclear Power Plants Are Not Serious

Dr. M.S.S.Murthy

Nuclear events can range in severity from being trivial with no public impact, to devastating. However, it is a very emotive issue and generates a sense of horror – a hovering mushroom cloud taking a toll of thousands of people.

On 11 March 2016, there was small leak in the primary heat transport system of Unit 1at the Kakrapar Nuclear Power Station in Gujarat, which was operating at its rated power, which led to the shutdown of the unit. "The reactor was shut down as per design provisions and all safety systems are working as intended", said a statement issued by the Station Director. A Station emergency was declared.

Subsequent announcements stated that the radioactivity levels inside and outside the station were normal and no one had been exposed to excess radiation. However, the news generated a lot of debate in the media and confusion and fears in the minds of the public. The fact that the incident occurred on the fifth anniversary of the disastrous accident at the Fukushima Nuclear Power Plant in Japan added an additional dimension to the episode.

Potential for a nuclear accident

In a nuclear reactor, the fuel is uranium, which undergoes fission, liberating enormous amount of heat. A coolant, generally water or heavy water, circulates through the fuel to pick up the heat and transfer it to a steam generator through a heat exchanger, which in turn turns a turbine to produce electricity. An important aspect of a nuclear reactor from the point of view of safety is the build-up of radioactivity in the fuel. Uranium is only mildly radioactive. However, the products of fission reaction are highly radioactive. Hence, during the operation of the reactor, the radioactivity in the fuel builds up to extremely high levels. In normal circumstances the fission products are contained within the fuel casing and handled safely. For any reason, if the rate of fission reaction exceeds the designed level or if there is an interruption in coolant flow, the fuel may become so hot that it may vaporise, with a potential to release large amounts of radioactivity to the environment.

Defence-in-depth

To reduce the chances of such an event nuclear reactors are built with a succession of safety layers known as "defence-in-depth". The concept works at two levels. One is to secure the operational safety of the reactor with devises like control rods (which control the fission reaction rate), coolants, heat exchangers, pumps, valves, etc. Redundancy is built-in at every stage so that if one system fails the other takes over. The other is to mitigate the consequences of a mishap. These are in the form of barriers to prevent the escape of radioactivity to the environment. There are five to seven containment levels to achieve this. The last of these is the familiar dome-like structure enclosing the entire reactor system. During operation all subsystems are closely monitored. Whether an event like the interruption of coolant flow would lead to a potential accident would depend upon how promptly any off-normal conditions are detected and steps taken to

The author is former Head, "Radiological Physics Division, Bhabha Atomic Research Centre, Mumbai.
Email: mssmurthyb104@gmail.com

prevent them from developing into a serious situation.

Hence, nuclear events can range in severity from being trivial with no public impact, to devastating. However, it is a very emotive issue and generates a sense of horror – a hovering mushroom cloud taking a toll of thousands of people. This is because there had been no way of properly communicating to the public about an event in a nuclear power plant, as for example in the case of an earthquake. The nuclear accidents at the Three Mile Island in USA in 1979 and at Chernobyl in the erstwhile Soviet Union in 1986, created enormous confusion and despair in the public, though they differed widely in severity as well as the impact on people and environment. Hence, in 1989 the International Atomic Energy Agency in Vienna called a meeting of experts to device a scale "for promptly communicating to the public in consistent terms the safety significance" of nuclear events. The result was the birth of the International Nuclear Events Scale (INES). The criteria used to develop the scale have been revised in 2008 to include not only nuclear reactor accidents, but also all types of radiation accidents.

The structure of INES

The most important criterion in the design of this scale is the radiological impact of the event on workers, general public and the environment. These depend upon to what extent the safety provisions and the containment features have been damaged in the event. Further it ensures that the significance levels of less severe and more localised events are clearly separated from the very severe ones. Accordingly, it classifies nuclear events at seven levels, with increasing order of severity. These are: Level 1- Anomaly, Level 2 - Incident, Level 3 - Serious Incident, Level 4 - Accident with Local Consequences, Level 5 - Accident with Wider Consequences, Level 6 - Serious Accident and Level 7 - Major Accident. Events below Level 1 are deviations without any safety significance and not included.

Level 1, the lowest in the scale is called an anomaly. It is an event beyond the authorised operating limits in which a significant part of the defence-in-depth remains intact and has no impact on the workers or the public. It requires only a local correction. Events of Level 2 and Level 3 are known as 'Incidents' and those Level 4 and above are called 'Accidents'. Only accidents are considered to have potential for public and environmental impact, the severity of which is reflected in the assigned level. The scale is constructed on a logarithmic basis so that each level is ten times more serious than the one previous. Thus an event at level 7 is a million times more severe than an event at Level 1.

Since public safety is of utmost importance in the operation of a nuclear facility the highest level in the scale corresponds to a major accident in which a large amount of radioactive material escapes to the environment. Such a release would result in the possibility of immediate health effects like radiation sickness and possibly death of some exposed persons, long-term effects such as cancer and genetic damage, and environmental consequences over a wide area, possibly involving more than one country. It calls for off-site emergency measures such as evacuating people, instructions to stay indoors, restrictions in consuming local water, vegetables, meat, etc. It requires identifying members of the public exposed to excessive radiation to provide immediate and long-term medical aid. On the economic front, post-accident cleanup operation may take years, costing billions of dollars.

Table 1 lists some of the nuclear events across the world, graded under the INES. In the long history of nuclear reactors, the only Level 7 events were the ones that occurred at the Chernobyl nuclear power plant in the erstwhile USSR in1986 and the 2011 Fukushima Nuclear Power Plant accident in Japan. The accident at Chernobyl occurred due to a combination of technical problems and human errors and completely breached the defense-in-depth as the reactor was not protected by any containment shield. And it was a chemical gas explosion and not any nuclear explosion which damaged

Table 1: Some of the nuclear events around the world graded under the INES scale

Level 7–Major accident

- Major release of radioactive materials with widespread health and environmental effects, requiring implementation of planned and extended countermeasures.
  Examples: Chernobyl in Soviet Union (1986) –Fuel meltdown and explosion;
  Fukushima in Japan (2011) – several fuel meltdowns and explosions.

Level 6–Serious accident

- Significant release of radioactive materials, likely to require implementation of planned countermeasures.
  Examples: Mayak in Russia (1957) – Explosion at a nuclear waste tank;
  Simi Valley in USA (1959) – fuel meltdown.

Level 5–Accident with wider consequences

- Severe damage to reactor fuel with large release of radioactive materials within the site. Limited release of radioactive materials to the wider environment, requiring implementation of some planned counter measures.
  Examples: Chalk River in Canada (1952) - Fuel meltdown; Windscale in UK (1957) - Fire in nuclear power plant; Leningrad in Soviet Union (1974) - Partial fuel meltdown, radiation exposure; Lucens in Switzerland (1969) - Fuel meltdown; Belojarsk in Soviet Union (1977) -Fuel meltdown; Three Mile Island in USA (1979) - Fuel meltdown; Chernobyl in Soviet Union (1982) - Fuel meltdown; Tokaimura in Japan - Explosion in reprocessing plant.

Level 4–Accident with Local Consequences

- Partial fuel meltdown or damage to fuel, release of significant quantities of radioactive materials within an installation. No counter measures likely to be needed other than local food controls.

Examples: Los Alamos in USA (1946)- Criticality accident; Idaho Falls in USA (1955)-Fuel meltdown; Sellafield in UK- 5 events from 1955 to 1979; : Los Alamos in USA (1958)- Criticality accident; Knoxville in USA (1959)- Explosion; Idaho Falls in USA (1961)- Explosion; Monroe in USA (1966)- Fuel meltdown; Saint-Laurent in France (1969/1980)- Fuel meltdown; Jaslovske Bohunice in Czechoslovakia (1977)- Overheating and damage to reactor core.

Level 3–Serious Incident

- Severe radioactive contamination in an area of a facility, with non-lethal injuries such as radiation burns. Low probability of significant public exposure.
  Examples: Buenos Aires RA-2 Facility (1983) - Accidental criticality; Vandellos Nuclear Power Plant in Spain (1989) - Fire destroyed many control systems. The reactor was shut down; Paks Nuclear Power Plant in Hungary (2003) - Fuel rod damaged in cleaning tank.

Level 2–Incident

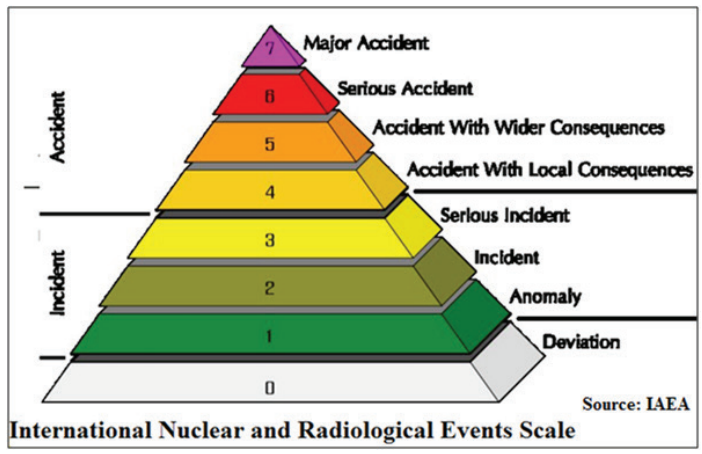
- Radiation levels in an operating area of a nuclear facility of more than 50 millisieverts (mSv) per hour. Exposure of a member of the public to radiation in excess of 10 mSv. Exposure of a worker in excess of statuary annual limits.
  Examples: Blayais Nuclear Power Plant in France (1999) - Flooding; Forsmark Nuclear Power Plant in Sweden (2006) - Backup generator failure. Two were online but fault could have caused all four to fail; Asco Nuclear Power Plant in Spain (2008) - Radioactive contamination.

Level 1–Anomaly

- Minor problems with safety components with significant defence-in-depth remaining intact.
  Examples: Gravelines in Nord, France (2009) - Fuel bundle snagged on to the internal structure of the reactor. Operation stopped, reactor building was evacuated and isolated in accordance with operating procedures; Penly in Seine-Maritime, France (2012) - an abnormal leak in the primary circuit of one of the reactors after fire was extinguished; Kakrapar Nuclear Power Plant Unit 1 in India (2016) - leakage of heavy water in the primary heat transfer system.

the reactor. In the fire-fighting operation, 31 workers died of thermal and radiation injuries. Huge quantities of radioactive materials escaped to the environment resulting in contamination of thousands of square kilometres of land, not only in the Soviet Union but also in the neighbouring countries. About 3,50,000 persons had to be moved to safer areas.

Even though no member of the public received fatal radiation dose, higher incidence of thyroid cancer have been reported in some areas. The Fukushima accident is reported to have occurred due to unexpectedly severe earthquake and Tsunami which swamped all the auxiliary power supply to the plant resulting in core melt down and explosions although the magnitude-9 earthquake that shook north-eastern Japan on 11 March 2011 did not cause any damage to the reactors. Though no deaths due to radiation occurred, large quantities of radioactive materials were released to the environment necessitating the evacuation of about 80,000 people.



International Nuclear and Radiological Events Scale

The Kakrapar Event

The Kakrapar Atomic Power Station (KAPS), located near Surat in the state of Gujarat, currently operates two reactors of 220 megawatts each. The first of unit began commercial operations on 6 May 1993. Unit-2 followed two years later in September 1995. The reactors use natural uranium as the fuel and heavy water as moderator and coolant. The core in each reactor comprises of 306 coolant channels, each of which carries 12 fuel bundles. The coolant flows through these channels transferring heat from the fuel to the steam generator.

This is not the first time that operation of the reactor was interrupted. In 1998 KAPS-1 was switched off for 66 days because of a leakage in the cooling loop. In March 2004 the control rods were damaged during a maintenance work and the reactor had to be shut down by adding neutron absorbing materials. However, notwithstanding some temporary shut downs for short periods, both the reactors have been working very satisfactorily with a record gross capacity factor of more than 90 percent. Even a major earthquake near Bhuj in 2001 did not interrupt the reactors.

On 11 March 2016, one of the coolant channels in Unit 1 was found leaking heavy water. Following the leak the reactor tripped and shut down automatically. The emergency cooling system kicked in to cool the reactor core as designed, preventing the event from developing further. A team of experts from the Atomic Energy Regulatory Board, Mumbai, the apex nuclear regulator in the country, visited the site. After a detailed inspection of the plant and environmental monitoring, it announced that there has been no increase in the background radiation level or radioactive contamination in and around the site up to 20 km and rated the event at "Level 1" on the INES, which corresponds to an anomaly in the plant. Subsequently the plant personnel have entered the building to determine the cause of the leak and normalise the system.

Medicinal Plants: Future Source of New Drugs

Arvind Kumar Shakya

The growth of knowledge to cure diseases continued at an accelerating pace and the number of new plant-derived drugs increased likewise. Nature has bestowed our country with an enormous wealth of medicinal plants.

From the very beginning of human existence, mankind has familiarised itself with plants and used them in a variety of ways throughout. Primitive man in search of food and to cope with various illnesses began to distinguish between plants suitable for nutrition from others with definitive pharmacological action. This relationship between plants and man has grown and many plants came to be used as drugs. The growth of knowledge to cure diseases continued at an accelerating pace and the number of new plant-derived drugs increased likewise. Nature has bestowed our country with an enormous wealth of medicinal plants. The earliest recorded evidence of use of medicinal plants are found in Indian, Chinese, Egyptian, Greek, Roman and Syrian texts dating back to about 5,000 years. At this stage, India has a unique position in the world where a number of recognised indigenous systems of medicine, viz., Ayurveda, Siddha, Unani, Yoga and Naturopathy are being utilised for the health care of people.

What is herbal medicine?

Herbal medicine is the use of plants for for either to treat disease or as health-promoting agents. Plants have biologically active substances known as phytochemicals (secondary metabolites). Phytochemicals possess drug-like properties that are considered medicinal or therapeutic. The science of application of these indigenous or local medicinal remedies including plants for treatment of diseases is called ethnopharmacology.

Why plants as herbal medicines?

Herbal medicines usually contain a range of pharmacologically active compounds are known to have therapeutic effects. Herbal medicine provides low-cost but effective and reasonable health care for people and has less side-effect. It has been observed that numerous plants have pharmacological effects due to presence of metabolites. Plant metabolites are organic compounds including primary metabolites and secondary metabolites. Primary metabolites are organic compounds including glucose, starch, polysaccharide, protein, lipids and nucleic acid, which are beneficial for growth and development. Plants also synthesise secondary metabolites like alkaloids, polyphenols (flavonoids, phenolics tannin, glycosides), saponins, terpenes (carotenoids and steroids, anthraquinones and volatile oils, which are bioactive phytochemicals. These phytochemicals are natural compounds which often play important roles in plant-defence against herbivores, pests and pathogens. They also use as medicines, flavourings, and recreational drugs.

People of India have been using plants as medicines without scientific knowledge and proper guidance for thousands of years. Using plants as medicines it is considered as a natural healing system. It has been

The author is Assistant Professor of Biochemistry, School of Sciences, Indira Gandhi National Open University, New Delhi-110068. Email: arvind.kumar@ignou.ac.in

Table 1. Classification of phytochemicals		
Phytochemicals	**Structure**	**Example**
Alkaloids	Nitrogen atom in the heterocyclic ring	Morphine, caffiene, Berberin, codeine
Glycosides	Derived from carbohydrates and noncarbohydrates molecules	Amygdalin, gentiopicrin, andrographolide, polygalin
Polyphenoles (Flavonoids, Phenolics Tannins)	Aromatic aliphatic ring contain phenols	Quercetin, kaempferol and quercitrin, caffeic acid, flavones, rutin, naringin , hesperidin and chlorogenic, tannic acid, gallic acid and ellagic acid
Saponins	Sugar attached to triterpene or steroid aglycone	Diosgenin and hecogenin
Terpenes (Carotenoids, steroids)	long unsaturated aliphatic chains (isoprene units)	Artemesinin, α-carotene, β-carotene, and lycopene, lutein and zeaxanthin
Anthraquinones	derivatives of phenolic and glycosidic compounds	Rhein, salinos poramide and Luteolin

scientifically established that every part of a plant - flower, root, and stem, leafs, fruits, seed and even the whole plant - has medicinal properties. However, some studies have shown that some plants are not safe for health, so it is necessary to conduct proper clinical research on herbal plants to investigate therapeutic efficacy on experimental models because they possess some molecules which can show adverse effects in the body.

Importance of herbal plants

Herbal medicine is widely practised in worldwide. For centuries, people have turned to natural remedies to cure common ailments such as colds, allergy, upset stomachs and toothaches. In recent years, there has been a shift from synthetic to herbal medicines for the prevention of diseases and ailments. The World Health Organization (WHO) estimates that 4 billion people (80% of the world's population) use herbal medicines for some aspect of primary healthcare. Herbal medicine has been recognised by WHO as an essential components for primary health care.

Since time immemorial, human civilisation has been using several plants as food, medicine, clothing and shelter. Vegetarian foods contain high amounts of various "super-nutrients," such as protective antioxidants, phytochemicals, and micronutrients, which promote health and protect from diseases. Plants have several pharmacological roles such as antioxidant, antiviral, anticancer, antimicrobial, antifungal and antiparasitic. Plants have free–radical-scavenging molecules including flavonoids, phenolics, anthocyanins and vitamins which have rich antioxidant activity. Scientific studies have validated that antioxidant property in phytochemicals is effective in reducing free radicals in the human body. Phytochemicals may also reduce the risk of several major diseases including cardiovascular disease, hepato-renal diseases, diabetes, cancers and neurodegenerative disorders. There are several herbal drugs derived directly or indirectly from plants that are considered as important medicine currently in use for treatment of various ailments of humankind.

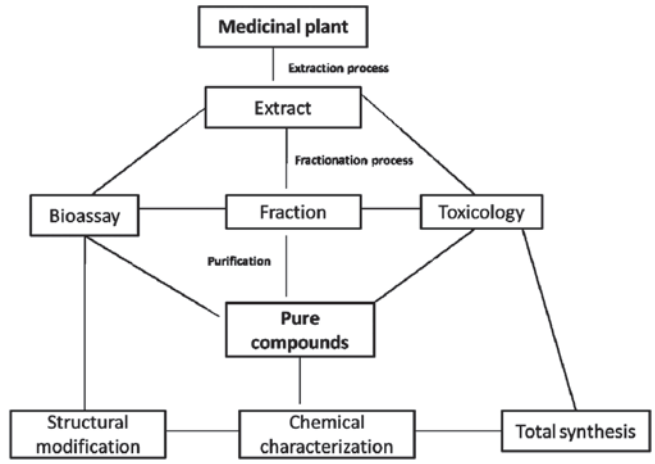
Traditional system of medicine

Ayurveda is an ancient health care system which evolved in India some 3,000-5,000 years ago. As per ancient literature on Ayurvedic system of medicine, it was practised during the Vedic period in India. About 700 plants were described in *Charaka Samhita* and *Sushruta Samhita* during the 1st millennium BC. This medical system is widely practised in other parts of world as form of complementary medicine. The Ayurvedic system of India aims at preserving, promoting, sustaining good health and preventing disease through healthy lifestyle practices. The literal meaning of Ayurveda is "science of life". It is estimated that about 7,500 plants are used in local health care traditions in mostly rural and tribal villages in India. Herbal treatments are the most popular form of Ayurvedic system of medicine.

The demand of herbal-based medicine, health products, pharmaceuticals, food supplements, nutraceuticals, cosmetics are increasing worldwide. Currently, natural products

Table 2. Popular bioactive compounds of medicinal plants				
S.No.	**Plant species**	**Common name**	**Bioactive compounds**	**Pharmacological properties**
1.	*Taxus brevifolia*	Pacific yew	Taxol	Antitumor
2.	*Catharanthus roseus*	Sadabahar	Alkaloid (Vinblastine and Vincristine)	Anticancer
3.	*Camptotheca acuminate*	Happy tree	Topotecan and Irinotecan	Anticancer agents (treatment of ovarian and small cell lung cancers)
4.	*Podophyllum peltatum*	Mayapple	Alkaloid (Etoposide and Teniposide)	Anticancer agents
5.	*Curcuma longa*	Haldi	Flavonoid (Curcumin)	Anticancer, anti-inflamamtory, hepatoprotective
6.	*Silybum marianum*	Milk thistle	Flavonoid silymarin (Silibinin)	Anticancer, anti-inflamamtory, liver tonic for hepatic disorders
7.	*Riccinus communis*	Castor bean	Alkaloid (ricinine), lectin (ricin)	Hepatoprotective, anti-oxidant, hypoglycaemic, anti-tumorous
8.	*Terminalia chebula*	Harra	Tannins, shikimic acid compounds, triterpenoids,ellagic acid	Anti-oxidant, anti-diabetic, renoprotective, hepatoprotective
9.	*Withania somnifera*	Ashwagandha	Steroidal lactones, withanolides, notably withaferin A	Chemopreventive, anti-cancerous, memory enhancer and immunomodulatory, used in Parkinson's and Alzheimer's disorders
10.	*Zinziber officinalis*	Ginger	Mono and sesquiterpenoids, Zingerone and gingerols	Anti-cancerous, Antioxidant, Hepatoprotective, hypercholesterolaemic, anti-atherosclerotic
11.	*Azadirachta indica*	Neem	Limonoids (nimbidinin), Di- and tri- terpenoids,	Inhibitor of carcinoma, chemopreventive, inhibit colon cancer, anti-allergic, Blood purifier
12.	*Piper nigrum*	Black pepper	Piperidine, dehydropipernonaline	Anti-carcinogenic, anti-hyperlipidaemic, Epilepsy
13.	*Tinospora cordifolia*	Geloy	Diterpenoid furanolactones (tinosporin), isoquinoline alkaloids	Immunomodulator, chemopreventive, Cardioprotective, Antidiabetic
14.	*Aloe vera*	Ghritakumari	Aloin and emodin, campesterol, β-sisosterol	Healing properties, Antiviral and antitumor activity Antidiabetic, Hepatoprotective, Antiseptic effect
15.	*Ocimum sanctum*	Tulsi	Apigenin, Taxol and Ursolic acid, Citral	Antidiabetic, Hepatoprotective anti-bacterial, anti-fungal, anti-pyretic and anti-cancer properties
16.	*Berberis vulgaris*	Barberry	Berberine	Antidiabetic, hepatoprotective, antimicrobial.
17.	*Bergeniaciliata*	Pakhenbhed	IS-01246	Anti-arthritis
18.	*Digitalis lanata*	Tilapushpi	Digoxin	Used in heart diseases.
19.	*Nigella Sativa*	Black cumin	Thymoquinone	Anti-diabetic, anticancer, antimicrobial, Hepato-renalprotective, and gastro-protective
20.	*Cinchona robusta*	Quina	quinine	Anti-malarial, antiparasitic effect
21.	*Artemisia absinthium*	Sweet wormwood	Artemisinin	Antimalerial drug
22.	*Swertiachirata*	Chirayita	Ophelic acid, sawertiamarine, mangeferin and amarogenitine	Antidiabetic effect, antiviral, Hepato-renal protective
23.	*Allium sativum*	Lahsun	Allicin	Cardioprotecitve, anti-inflammatory
24.	*Terminalia arjuna*	Arjuna	Arjunic acid, tannic acid, tannins, saponins, gallic acid and phytosterols	Cardioprotective, anticancer agents, hepatoprotective
25.	*Phyllanthus emblica*	Amla	Emblicanin A, emblicanin B, punigluconin and pedunculagin	Antiviral, antimicrobial properties, anticancer, hepatoprotective and anti-diabetic

represent more than 50% of all drugs in clinical use, and 252 drugs considered as basic and essential by the WHO are exclusively of flowering-plant origin. Up to 50% of the herbal drugs approved during the last three decades are either directly or indirectly from natural products including plants, microorganisms, fungi and animals. National Medicinal Plant Board (NMPB) has shown great interest in documenting of the use of medicinal plants across the India. However, India is moving forward in popularising traditional medical systems of AYUSH (Ayurveda, Yoga, Unani, Siddha and Homeopathy) in health care through global networks.

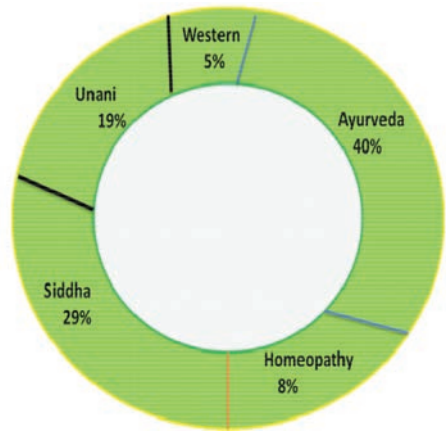


Development of herbal drug and challenges

The development of plant-based drugs started when developments in chemistry of isolation, purification, characterisation of plant active compounds were developed. Herbal medicine is cost-effective, has lesser side-effect and is less expensive than the medicines bought from an allopathic pharmacy. Herbal medicines include herbs, herbal materials, herbal preparations, and herbal products that contain different parts of plants or other plant materials as active ingredients. It has been well documented that herbal plants and their derivatives play critical roles in modern drug development. Medicinal plants are natural resources of development of new drugs.

In spite of the success of drug development research from medicinal plants in the past 2–3 decades, future endeavours face many challenges. The quality of a herbal product is often questionable; standardisation of raw material has emerged as a major issue for herbal industry. Herbal plants can be easily contaminated during growth, processing and collection. Adulteration and heavy metal contamination are the two major problems reported in herbal medicines. Pharmaceutical industry needs to improve the quality and quantity of bioactive compounds for developing new herbal drugs and keep pace with other drug discovery efforts.

Over the past decade, there has been a resurgence of interest in the investigation of herbal medicines as a source of potential drug substance. Currently used synthetic drugs often have toxic side-effects on human body. There is need for more research and study for the development and characterisation of new natural drugs from plants and other natural sources with the aid of better screening methods. As science advanced, however, it became possible to isolate bioactive compound of high-purity from plants through biotechnological methods.



Percentage (%) of different medical system using herbal medicines or primary healthcare.

In order to development of herbal drugs from medicinal plants, Ministry of AYUSH, Govt. of India along with Laboratories of Council of Scientific and Industrial Research (CSIR), some Indian Universities and other R & D institutes are working in the field of traditional system of medicines. Table 2 shows the list of medicinal plants and their bioactive compounds and pharmacological action which have been scientifically studied. Conclusion: Medicinal plants are considered as rich resources of phytochemicals which can be used in modern drug development. Herbal medicine are staging a comeback and it is growing field of science needs to more research for the discovery of herbal drugs in systemic manner. Therefore, herbal medicine may play an important for the treatment of human illness and help to maintain healthy body and mind.

VP website

Join Vigyan Prasar digital library to read online publications. You may also join the discussion forum to ask science and technology related questions and also answer fellow participants' queries. We also have streaming science videos, science radio serials, online science quiz, hand-on activities, and many more features and programmes related to science and technology. Log-on to www.vigyanprasar.gov.in

Fifty Years of International Physics Olympiad

Dr. Bhupati Chakrabarti

The International Physics Olympiad (IPhO) is an annual physics competition for high school students. Representing one's country in an International Olympiad in a science subject is considered a significant achievement.

The International Olympiads on science subjects now are not only very popular among students; these are now taken quite seriously by the concerned academic bodies as well. Representing one's country in an International Olympiad in a science subject is not only considered a significant achievement for a teenager student but also it fetches wide recognition if the performance is really good. The organisers of various international science Olympiads now face the challenging task of maintaining the high standard of the competition while at the same time bringing in larger participation. The second oldest among the international science Olympiads is the International Physics Olympiad (IPhO) which turns fifty this year. It may sound a bit like fiction that the first version of International Physics Olympiad (IPhO) for high school students, or better yet to say, for pre-college students was held with participation of only five countries, all from the Eastern Europe in 1967 in Warsaw, Poland. It took time for this happening to turn into a prestigious and highly competitive and truly international event with a peak of nearly 90 countries and more than 430 contestants participating.

Science Olympiads are now conducted in a wide range of subjects. At the same time, the emergence of regional competitions like Asian Physics Olympiad, Estonian-Finnish Physics Olympiad, and national-level physics Olympiads in the various countries underlines the popularity of the competition. IPhO or any other regional event has now become big-budget mega events, yet countries are showing ever-growing eagerness to host the programmes. India is not only participating in the events like IPhO and Asian Physics Olympiad (APhO), but has hosted both of them in recent years.

The idea of holding of such an international competition in physics originated from the International Mathematics Olympiad (IMO) that started in 1959. IMO worked as a model for Olympiads in other subjects. The initiative for the IPhO came from the academicians belonging to the same set of the countries that used to be referred to as the Soviet Block of nations. By 1967 IMO was a fairly known competition, particularly among these countries, but participation beyond the East European countries was limited. In 1979 the IMO was held in London, the first to be held outside East Europe, Cuba or the Soviet Union. And that was a turning point in the history of IMO. Similarly the history of IPhO is interesting because it not only has an academic aspect to talk about but also a political component that made it one of the many issues albeit in a subtle way among many countries during the days of Cold War. And like IMO the IPhO also met with a similar fate.

Among the science Olympiads, one in chemistry started in 1968 more or less in a similar way. Its initial name was also not International Chemistry Olympiad but

The author is General Secretary, Indian Association of Physics Teachers. Formerly of Department of Physics, City College, Kolkata 700009. E-mail: bhupati2005@yahoo.co.in

International Chemical Olympiad. The Biology Olympiad is much younger and started only in 1990, virtually after the Cold War was over and had an entirely different genesis. More Olympiads have come into being after that and once again the initiation routes were different.

The first Indian Physics Olympiad was started with initiatives from some academicians in Poland, Hungary and Czechoslovakia and possibly from Romania and Bulgaria. Interestingly, Soviet Russia neither sent a team nor was formally involved in the organisation of the first IPhO. Yet, as it used to happen in the days of the Cold War, the efforts soon got branded as one of the Soviet Block to assert its capability. The growth of such an effort, it was felt, would be connected with the success of Soviet Russia and its policy in the field of academic advancements. As a result, the nations from Western Europe or those from Asia or other parts of the world looked at the things with a bit of a caution and did not join the competition for next few years. However, the participation increased a bit as more East European nations came with their teams. The next three years showed very modest increase both in the number of participating nations as well in the number of participants and Soviet Russia became the host for the first time of the fourth IPhO in 1970, which was held in Moscow.

Dr Waldemar Gorzkowski, a theoretical physicist from Warsaw University, Poland was associated with the official activities of IPhO practically from the beginning when he was very young. Later, in 1974 an International Committee was formed to oversee the organisation and overall supervision of the competition and a permanent secretariat was set up in 1984. Dr. Gorzkowski became its Secretary and later the designation was changed to 'President' but Dr Gorzkowski continued as the President of the International Physics Olympiad. He was a widely travelled man and visited the venues during the IPhOs. Dr Gorzkowsky continued in this position till he passed away in 2007 and that too in the venue of an IPhO. He has written a quite comprehensive history and the genesis of the IPhO.

The first IPhO in 1967 not only had a very limited number of participating nations but the number of students per country was also small – only three compared to today's five. The contestants in the first IPhO were accompanied by one supervisor for each team and apart from the host Poland the four other countries in the competition were Hungary, Bulgaria, Czechoslovakia and Romania. The number of supervisors accompanying each team was only one and the duration of the entire event was only 7 days. Students appeared for four theoretical problems in a day and then worked out one experimental problem on another day. All these things changed after a few years and the current format of five contestants from each nation, two leaders and duration of 9 or 10 day have become a standard format. In the beginning, the total marks for the competition was 40 that was changed to 48 in 1969 and was subsequently changed to 60 in the very next year, This full marks of 60 continued for a few years and then in 1974 the total marks became 50 with 60:40 weightage on theory and experiment. This format is now continuing.

Initially the experimental test involved only a single experiment that was later changed to a provision for maximum two experiments. The contestants initially had to solve four theoretical problems and one experimental problem. But now they need to solve three theoretical problems and the duration of both the theoretical and experimental tests have remained 5 hours each on two different days with the gap of a day in between. The Physics Olympiad needs to have experimental problems along with theoretical problems. So the development of suitable experiments, their multiplication, testing and standardisation, etc., provide big challenge for the organisers.

Yet if one now takes a look at the list of host nations for the future IPhOs one would find that the demand for hosting the event is quite significant and the list is filled up till 2028 or so. So the academic challenge and the expenditure are no barriers now and that makes students of physics as well as the International body comfortable. But this was not always so. Due to various reasons the event could not be held in 1973, 1978 and 1980 in spite of bringing in changes in the Statutes making it more

Continued on page 19

Table 1. Medal Tally of Indian Teams in different IPhOs

Year	Gold	Silver	Bronze	Honourable Mention	Host city
1998	-	1	1	3	Reykjavik, Iceland
1999	-	4	1	-	Padua, Italy
2000	2	2	-	1	Leicester, U.K.
2001	3	2	-	-	Antilya, Turkey
2002	1	4	-	-	Bandung, Indonesia
2003	2	-	1	2	Taipei, Taiwan
2004	1	2	2	-	Pohang, Korea
2005	2	2	1	-	Salamanca, Spain
2006	2	-	3	-	Singapore
2007	2	2	-	1	Isfahan, Iran
2008	4	1	-	-	Ho Chi Minh City, Vietnam
2009	4	1	-	-	Merida, Mexico
2010	1	3	1	-	Zagrev, Croatia
2011	2	3	1	-	Bangkok, Thailand
2012	1	3	1	-	Tiallin and Tartu, Estonia
2013	1	4	-	-	Copenhagen, Denmark
2014	2	3	-	-	Astana, Kazakhstan
2015	-	4	-	-	Mumbai, India
2016	3	2	-	-	Zurich, Switzerland

Period Pains — Causes and Treatments

Dr. Yatish Agarwal

Though some clinical surveys suggest that 80-90 per cent women May experience menstrual cramps just before and during their menstrual periods, the need for medication and the inability to function normally occurs much less frequently.

When it comes to "that time of the month", mild cramping, bloating, and irritability – although annoying – are all to be expected. However, crippling cramps, heavy bleeding, serious fatigue and other symptoms that affect the quality of life are not! If your periods are causing you significant pain, severe enough cramps to interfere with day-to-day activities or such difficulties that you seemingly can't handle, it's time to know a little more about this bodily symptom, which you may feel too shy to discuss with your family, friends, or doctor.

Menstrual cramps are common

Menstrual periods can be light and easy for some teens and young women, but for others, they can be heavy and/or accompanied by painful cramps. Cramps can be a big reason why girls are absent from school, why they miss sport practices, and why they may avoid social events with their friends. Though some clinical surveys suggest that 80–90 per cent women may experience menstrual cramps just before and during their menstrual periods, the need for medication and the inability to function normally occurs much less frequently. Nevertheless, at least one in four women experiences distressing menstrual pain characterised by a need for medication and absenteeism from study, work, or social activities.

Kinds of menstrual cramps

Doctors name the painful cramps that may occur immediately before or during the menstrual period as "dysmenorrhoea". There are two types of dysmenorrhoea: primary dysmenorrhoea and secondary dysmenorrhoea.

Primary menstrual cramps

Primary dysmenorrhoea is another name for common menstrual cramps. Such cramps usually begin one to two years after a woman starts getting her period. Pain usually is felt in the lower abdomen or back. It is a cramp-like, dull, throbbing pain that usually emanates from the lower abdomen and is a little more severe than a discomfort. It starts shortly before or at the onset of the period and continues for the first one to three days of the period.

Young women who begin their menstrual life later or earlier than usual, suffer prolonged and heavier than normal menstrual flow, possess low bodyweight and body mass index, often skip breakfast, indulge in less than adequate physical exercise, carry a familial genetic predisposition, take pleasure in active and passive cigarette smoking, and take too much stress in their lives are thought to be more likely candidates for developing common menstrual cramps.

The good bit about these primary menstrual cramps is that they usually become less painful as a woman ages and

The author is physician and teacher at New Delhi's Safdarjung Hospital. He has authored 47 popular health-books.
E-mail: dryatish@yahoo.com

may stop entirely after the woman has her first baby.

You may be at greater risk of menstrual cramps if:

- You're younger than age 30
- You started puberty early, at age 11 or younger
- You have heavy bleeding during periods
- You have irregular menstrual bleeding
- You've never given birth
- You have a family history of dysmenorrhoea
- You're a smoker
- You've a low bodyweight and body mass index
- You're lazy do not do physical exercise
- You take too much stress

Secondary menstrual cramps

When a woman has a disease or an abnormality in her reproductive organs, she may be faced with menstrual cramping. This type of cramping is called secondary dysmenorrhoea. Such cramps usually begin earlier in the menstrual cycle and last longer than common menstrual cramps.

Conditions that can cause secondary dysmenorrhoea include:

Endometriosis

Common in women between the ages of 25 and 40, in endometriosis, the tissue that lines a woman's uterus becomes implanted outside her uterus, most commonly on her fallopian tubes, ovaries or the tissue lining her pelvis.

This displaced endometrial tissue continues to act as it normally would — it thickens, breaks down and bleeds with each menstrual cycle. As this displaced tissue has no way to exit a woman's body, it becomes trapped. Surrounding tissue can become irritated, eventually developing scar tissue and adhesions — abnormal bands of fibrous tissue that can cause pelvic tissues and organs to stick to each other.

Endometriosis can cause pain — sometimes severe — especially during the period. Fertility problems also may develop.

Adenomyosis

In adenomyosis, the tissue that lines a woman's uterus begins to grow into the muscular walls of the uterus. This condition can cause menstrual cramps, lower abdominal pressure, and bloating before menstrual periods and can result in heavy periods. The malady can be located throughout the entire uterus or localised in one spot.

Uterine fibroids

Uterine fibroids are noncancerous growths of the uterus that often appear during childbearing years. They can range in size from seedlings, undetectable by the human eye, to bulky masses that can distort and enlarge the uterus. A woman can have a single fibroid or multiple ones. In extreme cases, multiple fibroids can expand the uterus so much that it reaches the rib cage.

Many women who have fibroids don't have any symptoms. In those who have, symptoms can be influenced by the location, size and number of fibroids. In women who have symptoms, the most common symptoms of uterine fibroids include heavy menstrual bleeding, menstrual periods lasting more than a week, and painful periods.

Pelvic inflammatory disease

Pelvic inflammatory disease is an infection of a woman's reproductive organs. It is a complication often caused by some sexually transmitted bacterial infections, like Chlamydia and gonorrhoea. Other infections that are not sexually transmitted can also cause pelvic inflammatory disease.

The condition may remain silent or cause a number of symptoms, including pain in lower abdomen, fever, an unusual vaginal discharge with a bad odour, pain and/or bleeding during sex, burning sensation during urination, and painful periods.

Cervical stenosis

In some women, the opening of the cervix may be so small that it slows down menstrual flow, causing a painful increase of pressure within the uterus.

Recognising the symptoms

For some women, this discomforting pain that occurs at "that time of the month" is merely annoying. For others, these

menstrual cramps can be quite incapacitating for a few days every month. The symptoms may present as a throbbing or cramping pain in the lower abdomen that may be intense, a dull, constant ache, or pain that radiates to the lower back, hips and inner thighs.

When the cramps are severe, a woman may suffer upset stomach, sometimes with nausea, headache and dizziness. She may also feel nauseated, vomit, or experience loose stools.

The basic cause

During a menstrual period, the uterus contracts to help expel its lining that it is shedding off. These uterine muscle contractions are triggered by hormone-like substances, called prostaglandins. Higher levels of prostaglandins are associated with more severe contractions. If the uterus contracts too strongly, the blood vessels which supply oxygen to the muscle tissue of the uterus are cut off. Starved of oxygen, the muscle tissue must experience pain. This is the basic mechanism which produces common menstrual cramps.

Easing out of the symptoms

A number of simple steps and home remedies can help provide relief from menstrual cramps. These include:

Applying heat may be just as effective as over-the-counter pain medication for relieving menstrual cramps. Place a heating pad, hot water bottle or heat patch on your lower back or abdomen. Soaking in a hot bath may also provide some relief.

Massage lower back and abdomen

A gentle massage of the lower back and abdomen can work wonders giving you a great sense of well-being.

Exercise regularly

Studies have found that physical activity may ease the pain of menstrual cramps. Women who exercise regularly often have less menstrual pain. To help prevent menstrual cramps, make exercise a part of your daily routine. Go for walks, jogging, aerobics or gyming.

Use pain relieving pills

Over-the-counter pain relievers, such as aspirin, paracetamol, ibuprofen, or naproxen also may help. For best relief, take these medications as soon as menstrual cramps are felt.

Take rest

Rest can act as a balm and soothe both your body and mind. However, there's no need to overdo it.

Ease out of stress

Psychological stress may increase a woman's risk of menstrual cramps and their severity. Try meditation, yoga, positive imagery, and other proven stress reduction strategies. Follow what works best for you.

Austerity pays

Stay away from foods that contain too much salt. Avoid too much coffee and cola drinks. Shun smoking and drinking alcohol. These substances can make menstrual cramps worse.

Dietary supplements

A number of studies have indicated that vitamin E, omega-3 fatty acids, vitamin B_1 (thiamine), vitamin B_6 and magnesium supplements may effectively reduce menstrual cramps.

Seeing a doctor

If you've started menstruating within the past few years and have menstrual cramps, chances are your menstrual pain isn't a cause for concern. However, if menstrual cramps disrupt your life every month, if your symptoms progressively worsen or if you're older than 25 and just started having severe menstrual cramps, you must consult a doctor.

Seeing your family physician or gynaecologist (a doctor who specialises in the female reproductive system) may be best. Your doctor will review your medical history and perform a physical exam, including a pelvic exam. During the pelvic exam, your doctor will check for any abnormalities in your reproductive organs and look for signs of infection.

If your doctor suspects that your menstrual cramps are being caused by an underlying disorder, s/he may recommend some tests.

Investigations which may help

Should your medical history, physical exam and pelvic exam reveal a finding which your doctor needs to probe more deeply, s/he may recommend one or the other cross-sectional imaging tests. Of them, the simplest and most frequently ordered test is a pelvic ultrasound. This test uses high-frequency sound waves to create an image of the uterus, cervix, and ovaries. When you go for a pelvic ultrasound, be sure your urinary bladder is full. That is a technical requirement, without which the ultrasonologist cannot map out your pelvic organs in detail.

Sometimes, and rarely, other imaging tests, such as a CT scan or magnetic resonance imaging (MRI) may be asked for. They provide more detail than an ultrasound and can help your doctor diagnose underlying conditions. Both tests are non-invasive and painless. While a CT scan combines X-ray images taken from many angles to produce cross-sectional images of bones, organs and other soft tissues inside your body; an MRI uses radio waves and a powerful magnetic field to produce detailed images of internal structures.

If the doctor suspects endometriosis, adhesions, fibroids, or ovarian cysts, s/he may recommend a laparoscopy. During this outpatient surgery, the doctor views the abdominal cavity and reproductive organs by making tiny incisions in the abdomen and inserting a fibre- optic tube with a small camera lens.

Medical treatments

Menstrual cramps are easily treatable. When caused by identifiable problems, such as endometriosis or uterine fibroids, the key to remedy lies in treating the underlying cause.

Pain relievers

The doctor may suggest taking over-the-counter pain relievers, such as ibuprofen or naproxen sodium, at regular doses starting the day before you expect your period to begin. Prescription nonsteroidal anti-inflammatory drugs (NSAIDs), such as nimesulide also are available. If you can't take NSAIDs, paracetamol may lessen your pain.

Start taking the pain reliever at the beginning of your period, or as soon as you feel symptoms, and continue taking the medicine as directed for two to three days, or until your symptoms have gone away.

Oral birth control pills

Oral birth control pills contain hormones that prevent ovulation and reduce the severity of menstrual cramps.

Surgery

If your menstrual cramps are caused by an underlying disorder, such as endometriosis, fibroids or cervical stenosis, surgery to correct the problem may help reduce your symptoms.

Recent Developments in Science and Technology

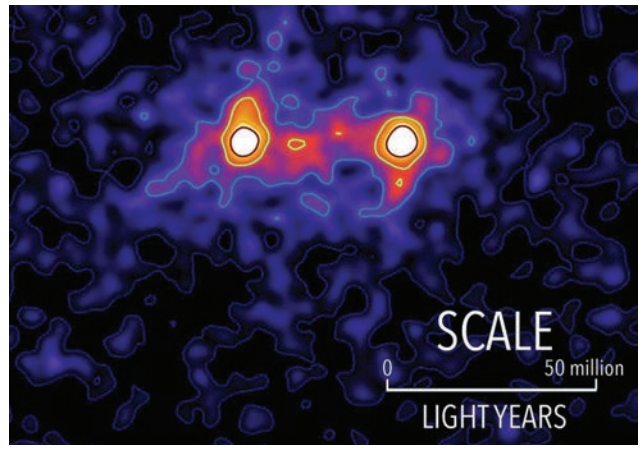
Biman Basu

Astronomers capture the first composite "image" of dark matter. An inexpensive method of desalination using graphene oxide filters. Link found between DNA repair and ageing. The science behind shoelaces coming untied.

Astronomers capture the first-ever "Image" of dark matter

It has been known since early 19th century that all matter that we see around – the Earth, Sun, stars and galaxies – is made up of atoms comprising protons, neutrons and electrons. But 20th century brought a surprising discovery that ordinary, or baryonic, matter that makes up the visible universe comprises less than 5 percent of the mass of the universe. The rest is made up of unknown entities dubbed dark matter and dark energy. Dark matter is an invisible substance that makes up 25 percent of the universe, and dark energy is a force that repels gravity and makes up the rest 70 percent. Although dark matter makes up about 25 percent of the universe, it doesn't shine, reflect, or interact with light in any way, so it is difficult to study. The only way to study it is by observing its gravitational effect.

What dark matter is actually made of remains a mystery, and finding evidence of something that cannot be seen is a daunting task. This is mainly because it does not interact with baryonic matter and is completely invisible to light and other forms of electromagnetic radiation. Previously, the closest proof of dark matter was its gravitational effects, but now, researchers have something even better: a composite picture that proves that galaxies are indeed connected by dark matter. By combining photographs of more than 23,000 galaxy pairs located 4.5 billion light-years away, taken over several years, researchers at the University of Waterloo in Ontario, Canada have been able to capture the first composite image of a dark matter bridge that connects galaxies together (*Monthly Notices of the Royal Astronomical Society*, 1 March 2017 | DOI: 10.1093/mnras/stx517). According to the researchers Mike Hudson, a professor of astronomy, and Seth Epps at the University of Waterloo, the composite image confirms predictions that galaxies across the universe are tied together through a cosmic web connected by dark matter that has until now remained unobservable. The effect was



False colour image showing one of the dark matter bridges between, two galaxies visible as large white dots. (Image credit: University of Waterloo)

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

measured in images from a multi-year sky survey at the Canada-France-Hawaii Telescope on Mauna Kea Mountain in Hawaii.

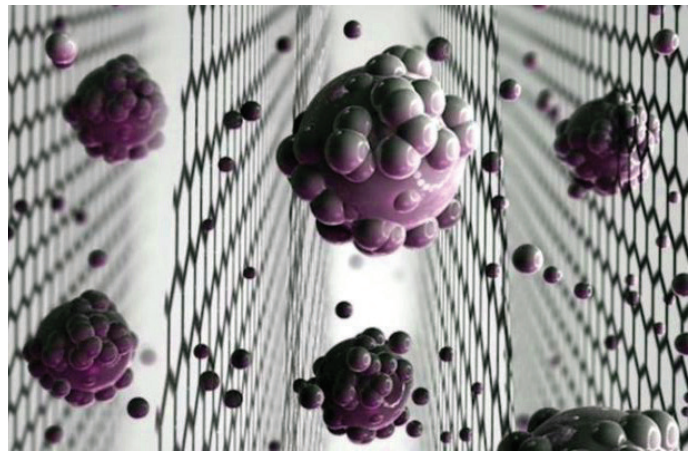
For decades, in their search for dark matter, scientists have tracked hints of a thread-like structure that ties together galaxies across the universe. Theories, computer models, and indirect observations have indicated that there is a cosmic web of dark matter that connects galaxies and constitutes the large-scale structure of the cosmos. But while the filaments that make up this web are massive, dark matter is incredibly difficult to observe.

The key to the recent success was the clever use of a phenomenon called weak gravitational lensing. Although dark matter is invisible, it does have mass and that means it deflects light ever so slightly, as predicted by Einstein's general relativity theory. So, by observing the way light from distant galaxies is distorted, it is possible to map the distribution of mass between the Earth and the galaxies. Comparing this to the visible matter of galaxies allows astronomers to map the presence of dark matter.

Explaining the image Hudson says, "For decades, researchers have been predicting the existence of dark-matter filaments between galaxies that act like a web-like superstructure connecting galaxies together. This image moves us beyond predictions to something we can see and measure."

Desalination using graphene sieve

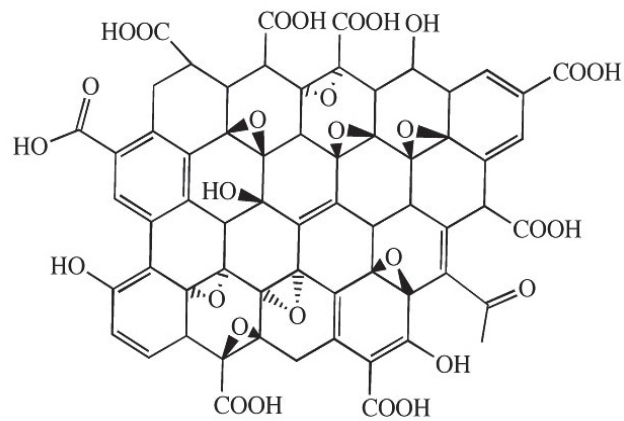
Almost three-fourths of the Earth's surface is covered with water, but still, fresh water is getting scarcer and scarcer. The reason is simple: saline water is not drinkable. There are several methods of desalination currently available, such as distillation, ion-exchange, reverse osmosis, etc., but most are expensive and, except solar distillation, others require large energy inputs. Recently, an entirely new route to removing salt from water has been reported by a team of researchers of the University of Manchester in UK that uses a graphene-based sieve capable of removing salt from seawater (*Nature Nanotechnology*, 3 April 2017 | doi:10.1038/nnano.2017.21).



Scientists have developed a graphene oxide sieve which removes the salt from seawater.

In simple terms, graphene is a thin layer of pure carbon; it is a single, tightly packed layer of carbon atoms that are bonded together in a hexagonal honeycomb lattice. It is an allotrope of carbon. Layers of graphene stacked on top of each other form graphite.

Graphene oxide is not as expensive as pure graphene and it can, in fact, be made easily using only graphite powder and some inexpensive chemistry. The channels or pores inside the graphene oxide membrane can be modified with different methods depending on what type of membrane is required. Modifying the membrane pores allows membrane permeability to be fine-tuned to make it ion-selective. This high selectivity coupled with a low cost and long operational lifetime is why there is so much interest in graphene oxide advanced membrane technology.



Structure of graphene oxide.

Before the current breakthrough, graphene oxide membranes developed at the National Graphene Institute in Manchester had demonstrated the potential of filtering out small nanoparticles, organic molecules, and even large salts from water. When immersed in water, graphene-oxide membranes become slightly swollen and smaller salts flow through the membrane along with water, but larger ions or molecules are blocked. However, they could not be used for sieving common salts found in saline water, which require even smaller sieves.

Professor Rahul Raveendran Nair of the University of Manchester and his colleagues found that placing walls made of epoxy resin (a substance used in coatings and glues) on either side of the graphene oxide membrane was sufficient to stop the swelling when immersed in water. By restricting the swelling in this way allowed the researchers to tune the properties of the membrane, letting through less or more common salt, for example.

Prof. Nair explained that when common salts are dissolved in water, they always form a 'shell' of water molecules around the salt molecules known as 'hydration' which makes the salt molecule to appear larger. This allows the tiny capillaries of the graphene-oxide membranes to allow water molecules to pass through, but blocks sodium chloride, thereby effectively separating salt from water. The researchers found that water molecules are able to pass through the membrane barrier and flow "anomalously fast" which is ideal for application of these membranes for desalination.

The recent breakthrough is significant in view of the growing water scarcity around the globe. By 2025 the UN expects that 14% of the world's population will encounter severe water scarcity. The new technology has the potential to revolutionise water desalination across the world, in particular in countries which cannot afford large-scale desalination plants.

According to Jijo Abraham, another member of the research team, "The developed membranes are not only useful

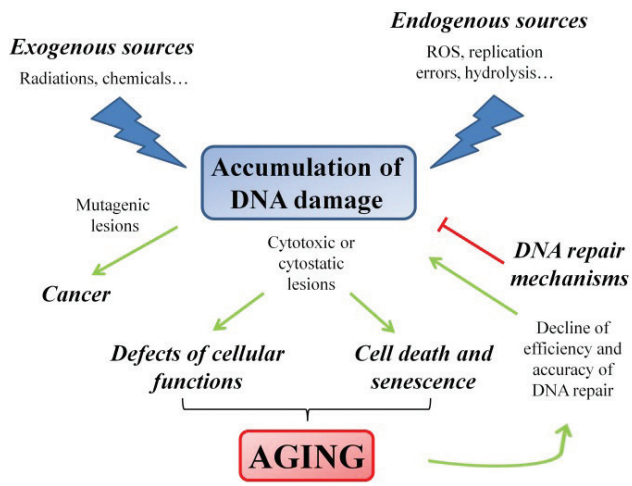
for desalination, but the atomic scale tunability of the pore size also opens new opportunity to fabricate membranes with on-demand filtration capable of filtering out ions according to their sizes."

DNA repair linked to ageing

Ageing is a natural process during which structural and functional changes accumulate in our body as a result of the passage of time. The changes manifest as a gradual decline in the overall performance – both physiological and mental – until death. The rate and progression of cellular aging can vary greatly from person to person. But generally, over time, aging affects the cells of every major organ of the body.

For ages mankind have been trying to find ways to delay ageing and maintain eternal youthfulness, which of course is impossible. But ageing can indeed be delayed by judicious selection of healthy diet and regular physical activity and a contented lifestyle. At the cellular level, ageing is related to damage to DNA in the cell. DNA repair is essential for cell vitality, cell survival and cancer prevention, yet the ability of cells to patch up damaged DNA declines with age for reasons not fully understood. New research has revealed a critical step in a molecular chain of events that allows cells to mend their broken DNA. A research team led by Harvard Medical School professor of genetics David Sinclair has found that a compound known as NAD (nicotinamide adenine dinucleotide), which is naturally present in every cell of our body, has a key role as a regulator in protein-to-protein interactions that control DNA repair. NAD, identified a century ago, is already known for its role as a controller of cell-damaging oxidation. In an experiment, Sinclair and his team found that treating mice with a NAD+ precursor called NMN (nicotinamide mononucleotide) improved their cells' ability to repair DNA damage (*Science*, 24 March 2017 | DOI: 10.1126/science.aad8242). The researchers say the discovery could lead to a revolutionary new drug that allows cells to repair DNA damaged by aging, cancer, and radiation and could reverse the ageing process. According to the researchers, "The cells of the old mice (in the study) were indistinguishable from the young mice, after just one week of treatment."

The researchers say that in addition to reversing aging, the treatment could also help deal with radiation damage to astronauts during long space missions such as a mission to Mars, which could cause muscle weakness, memory loss, and other symptoms, and more seriously, leukaemia and weakened immune function. The other group, according to the researchers, that could benefit from this work would be survivors of childhood cancers, who are likely to suffer a chronic illness by age 45, leading to accelerated aging, including cardiovascular disease, Type 2 diabetes, Alzheimer's disease, and patients with cancers unrelated to the original cancer.



Schematic representation of the factors and the pathways that modulate the aging process. (Credit: Aging)

Sinclair said human trials of NMN therapy could begin within six months to see if these results translate to people. "This is the closest we are to a safe and effective anti-ageing drug that's perhaps only three to five years away from being on the market if the trials go well," he added.

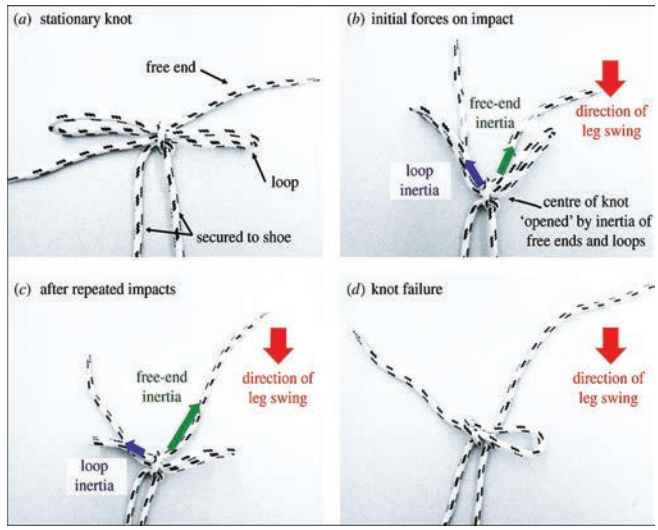
The science behind shoelaces coming untied

Many of us must have experienced accidental untying of our shoelaces while running or playing in our childhood. Athletes and those engaged in sports activities also face the problem of shoelaces spontaneously coming untied, often at the most inopportune time. But despite the problem being so common, little was known and even less was documented about the physical mechanisms responsible for this persistent problem, although there have been some interesting observations. For example, it has been found that a shoelace knot that often came loose very quickly when walking (typically within 15-20 metres) did not fail when the leg was simply swung back and forth a similar number of times, while sitting at one place without stomping the foot on ground. Again, simply stomping the foot on the ground the same number of times without swinging the legs also did not lead to untying. It was clear that for the shoelace knot to come untied both swinging of the feet and stomping on the ground was necessary. In other words, it involved interplay between the forces generated in the swing and stomping of feet during the walking or running motion. Recently, a team of engineers of the University of California at Berkeley have come out with a scientific explanation of the phenomenon. Their study suggests that a combination of stomping and whipping forces acts like an invisible hand, loosening the knot and then tugging on the free ends of the laces until the whole thing unravels (*Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science*, 12 April, 2017 | DOI: 10.1098/rspa.2016.0770).

To find out why even the best knots fail, Oliver O'Reilly, a mechanical engineer at the University of California, Berkeley, and colleagues studied the problem in a series of experiments that involved filming one of their colleagues with a high-speed camera as

A sportsman tying his shoelaces in the field.

she ran on a treadmill. The researchers attached sensors to shoelace knots as co-author Christine Gregg, a runner, walked and ran on a treadmill. There are two common types of knot used to tie shoelaces, known as the 'granny knot' and the 'square knot' of which the latter is stronger. Ms Greg tied her shoes with the weaker granny knot so that the researchers could have a better chance of watching it unravel. The researchers also repeatedly swung a pendulum arm with a shoelace knot tied on it to better analyse forces the knots experienced. Using slow-motion video, the team uncovered two stages of knot slippage: a gradual loosening with each step, and a sudden 'catastrophic failure'. When the knot started to unravel, it fell apart within two strides. The researchers were surprised by the g-force the knot experienced as it bobbed up and down, which was more than seven times the force of gravity. They said that the impact makes the knot in the shoe stretch and then relax while the action of swinging the leg pulls on the ends of the laces. The researchers found these forces could lead to the failure of a knot in just a few strides. They discovered that the dynamic forces acting upon laces while jogging or walking are a bit like an 'invisible hand' undoing the knot.



Representation of hypothesised stages of knot failure. Repeated impact causes the centre of the knot to incrementally loosen which reduces frictional effects and magnifies the effects of the inertial imbalance between the free ends and loops. Additionally, the impact of stomping causes slight pull through of the free end, which increases the inertial effects of the free end, enabling further free-end pull through. Eventually, the inertial effect of the free end is sufficiently large that the knot fails suddenly and catastrophically. (Credit: Daily-Diamond CA, Gregg CE, O'Reilly OM., Proc. R. Soc. A, 2017)

Of course, not all knots come off in a few strides. The researchers found that different knot-tying techniques, types of laces and levels of knot tightness all factor into how long it takes shoelaces to come undone. A really tight double knot can usually get an athlete through a run, for example. Nevertheless, scientists have at last unravelled a knotty problem: the forces behind the accidental untying of shoelaces. For the first time, researchers have documented the mechanics of shoelace knots in motion, to understand what makes them loosen and ultimately fall apart.

Fifty Years of International Physics Olympiad (continued from page 26)

participation friendly. There was lack of funding, diminishing interest and of course the limited number of participating nations. So although the competition completes 50 years in 2017 the Physics Olympiad to be held in Bali, Indonesia in July 2017 will be the 48th and not the 51st.

After the inception of IMO, India took 30 years to participate in the competition and sent its first team in 1989. Participation in IPhO came nine years after that! It was the second Science Olympiad for our students. India actually took 31 years after the inception of IPhO to send its first team to the competition in 1998. The performance of the first team at Reykjavik, Iceland was encouraging and India never looked back. It sent the first contingent to International Chemistry and International Biology Olympiads in 1999 and 2000 respectively. This year (2017) turns out to be the 20th year of Indian participation in IPhO. Performance of Indian students in IPhO has always remained excellent as will be evident from Table 1. It needs to be mentioned that our students have been able to create very good impression in the international community for their performances over the years.

Since the science Olympiads are essentially contests among the individual students and not among the nations participating there is no official list of the countries in order of their performances. Yet this is done unofficially in one way by assigning some suitable marks or grade for the gold, silver or bronze medals and Honourable Mentions. Or sometimes people prefer to straight away add the marks obtained by all the participating students from a country and compare. In whatever way we go India has mostly finished among top 5-6 countries and have been rarely below the first ten positions in these unofficial estimates.

India hosted the 13th Asian Physics Olympiad at New Delhi in 2012 where 21 countries participated. Banking on that experience India was able to host the 46th IPhO in 2015; it has held in Mumbai with 85 participating countries. It was a grand success and drew appreciation from the International community. Homi Bhabha Centre for Science Education (HBCSE) that is a part of TIFR in Mumbai is the nodal centre for imparting training and selection of the students not only for the IPhO but for other International Olympiads where official Indian teams participate. Indian Association of Physics Teachers (IAPT), an all-India body of physics teachers conducts the first level all-India screening test for the selection of the pre-college students for IPhO and the members of IAPT are involved in the exercise of training and selection of the students. This organisation was also instrumental in organising the APhO in 2012 and its members formed a significant part of the academic workforce for the 46th IPhO in 2015.

References

http://olympiads.hbcse.tifr.res.in/