VIGYAN PRASAR

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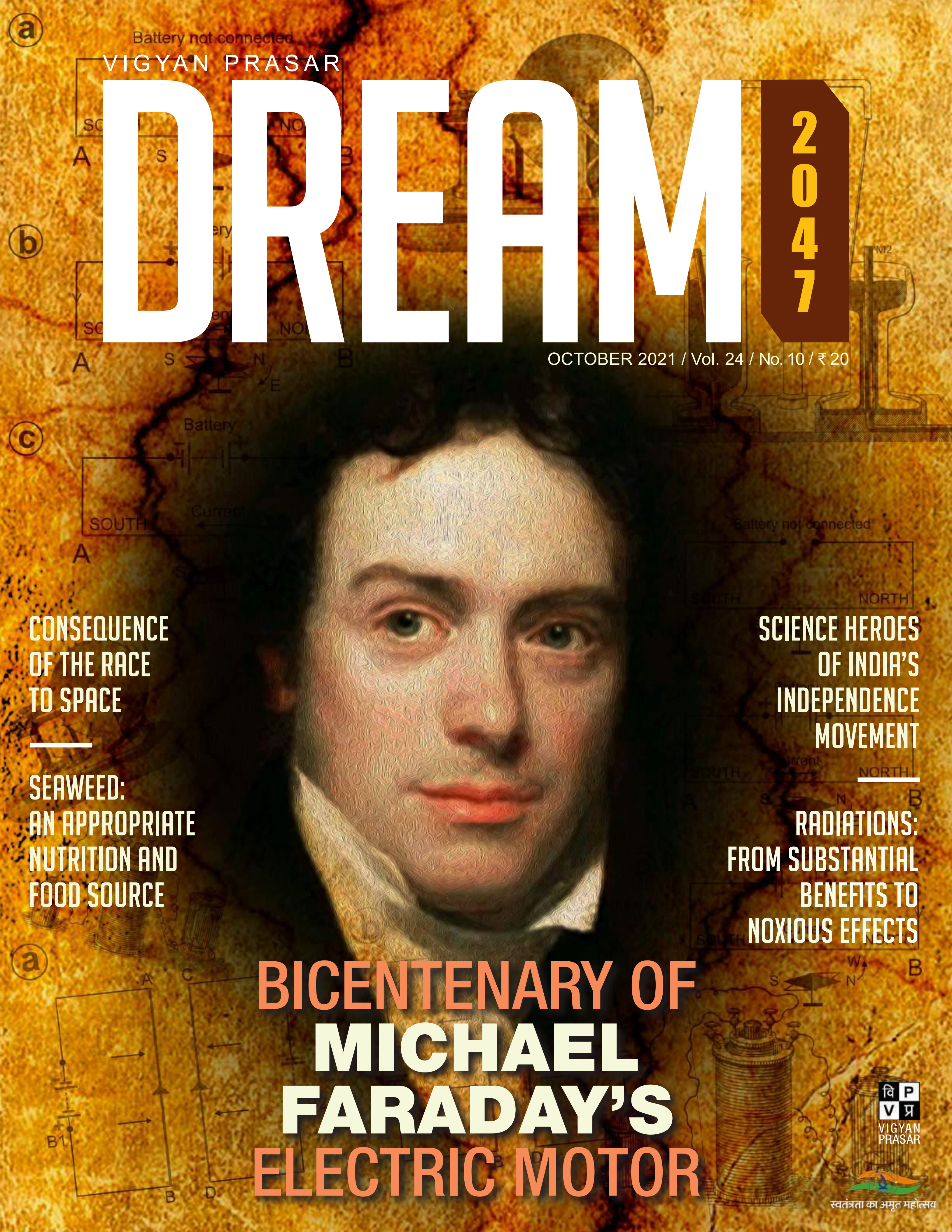

CONSEQUENCE OF THE RACE TO SPACE

SEAWEED: AN APPROPRIATE NUTRITION AND FOOD SOURCE

SCIENCE HEROES OF INDIA'S INDEPENDENCE MOVEMENT

RADIATIONS: FROM SUBSTANTIAL BENEFITS TO NOXIOUS EFFECTS

BICENTENARY OF MICHAEL FARADAY'S ELECTRIC MOTOR

VIGYAN PRASAR

स्वतंत्रता का अमृत महोत्सव

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MY WORD

NAKUL PARASHAR

Mahatma and Science

WE HAVE stepped into the 75th year of Indian independence. Festivities have commenced. Through year-long programmes, we remember the contribution of our freedom fighters. We also remember those who contributed greatly through their work in Science & Technology during the independence movement. Amidst these, comes in October, and the festive mood doubles up. Starting with remembering the father of the nation, Mahatma Gandhi on October 2nd, series of festivals follows one after the other.

Mahatma Gandhi and Science—a lot has been said and written on it. Despite his concerns over the impact of industrial revolution on society and environment, Mahatma is seen as one of the those social leaders who have always been an innovator and an inventor. In 1929, through a competition, he invited entries to design lightweight spinning wheel that could give him thread from raw cotton. In 1925, while addressing a crowd of students in Thiruvananthapuram, Mahatma said that "we cannot live without science". He further said, "Unfortunately, we, who learn in colleges, forget that India lives in her villages and not in her towns. How will you infect the people of the villages with your scientific knowledge?" Gandhiji further emphasised that he lauded the need that led scientists & technocrats to do fundamental research, and do all of this as 'science for the sake of science'.

Mahatma Gandhi's autobiography 'The Story of My Experiments with Truth' reflects that he was a keen student of experimentation. He did not rest till his queries were answered on the basis of scientific rationale. He supported the theme of sustainable development. In one of his papers published in 1928, a small passage mentions about his thoughts on industrialism.

The theme of sustainable development that Gandhiji was a great proponent of has evolved with the evolution of human civilization. In his Collected Works during 1888 to 1948, there are a number of places where Gandhiji certainly sought to humanize science & technology and make it more applicable to the poor.

Today, after so many years of his death, his vision to use science for the betterment of humanity and nature has become more relevant, more so, during the past two years since COVID-19 struck the world. Maintaining personal and public hygiene had always been high on Mahatma's agenda throughout his life. Thus, it would be quite appropriate that we shall remember the Mahatma by pledging to ensure that we would do our bit by aligning our daily actions with the national mission like Swachh Bharat.

In our previous issues we had mentioned about our year-long initiatives with regards to the contribution of scientists, science communicators and teacher during the Indian independence. In this regard, we would like to remind you that during 20-21 October, we are planning to hold a mega conference of science communicators in hybrid mode (partly offline and mostly online) at New Delhi. Keeping in the view of the importance of the theme, we also plan to hold yet another conference of science teachers on the same theme during 17-18 November in the same format. So, please do not forget to register for it at www.swavigyan75.in. By the way, you could also access a lot more through this site.

Wishing you a happy Gandhi Jayanti, Dussehra and Durga Puja!

Email: nakul.parashar@vigyanprasar.gov.in

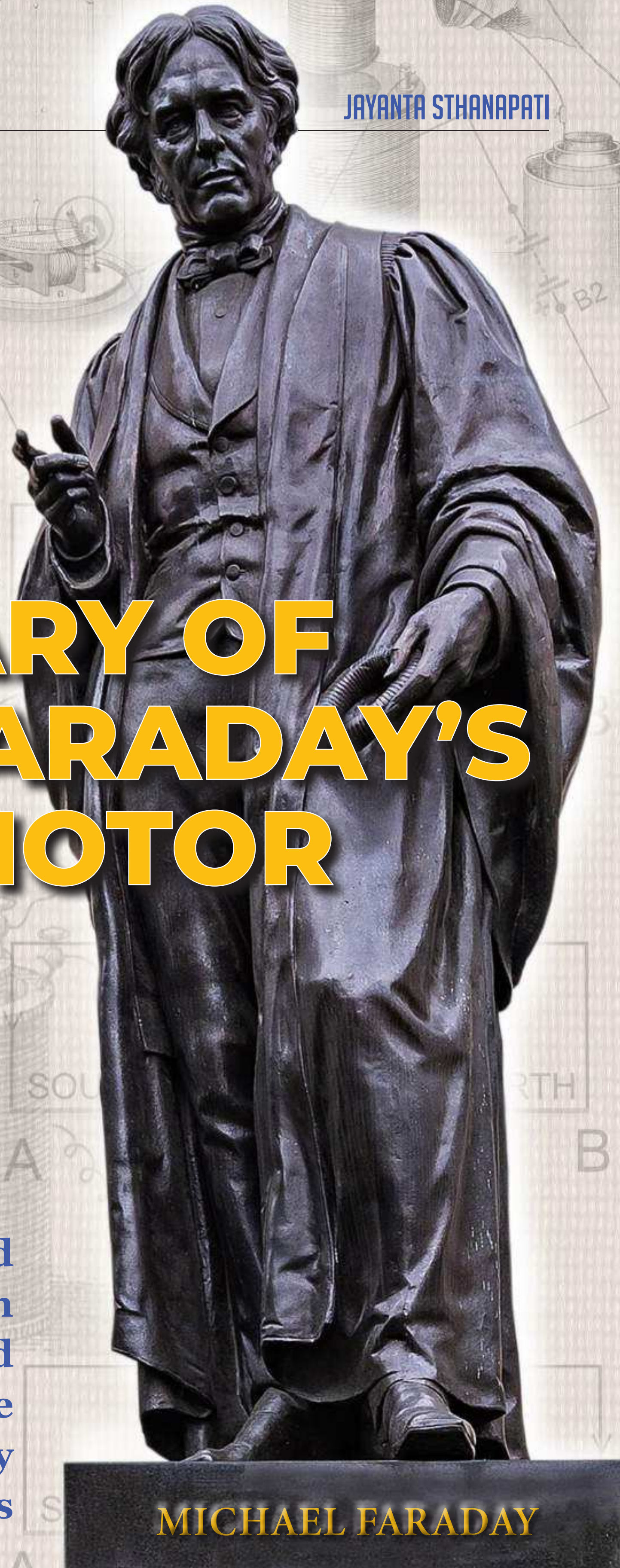
COVER STORY

JAYANTA STHANAPATI

Two hundred years ago, Michael Faraday successfully converted electrical energy into mechanical energy and thus created the world's first Electric Motor.

BICENTENARY OF MICHAEL FARADAY'S ELECTRIC MOTOR

Michael Faraday (1791-1867)



In September 1821, two hundred years ago, Michael Faraday in Royal Institute, London, invented an electromagnetic rotor, a device that converted electrical energy into mechanical energy. It was the world's first electric motor.

Faraday's creation and its subsequent developments had changed the human society forever. The use of electric motors in gadgets eases our daily life in numerous ways.

Early life

Michael Faraday, the third child of James Faraday, a blacksmith and Margaret Faraday, a homemaker, was born on 22 September 1791 at Newington Butts of Surrey village within Greater London. He received minimal schooling and did not show any spark of talent then. He used to spend out-of-school hours at home or playing games with the neighbouring children.

In 1804, 13-year-old Michael joined George Riebau, a bookseller and stationer on Blandford Street in London as an errand boy. After a year of his trial, he apprenticed under Riebau in bookbinding for seven years. Whilst an apprentice, Michael loved to read the scientific books under his hands, such as Conversations on Chemistry, Experiments on Electricity, and many more. He also did simple chemical experiments and constructed a static electrical machine at Riebau's shop.

Humphry Davy (1778-1829)

Michael had a turning point in his life in 1812. Mr Dance, a regular customer of his master's shop and a member of the Royal Institution of London, arranged Michael's invitation to hear four lectures of Sir Humphry Davy, a noted scientist, at the Institution. Of these, Faraday made notes and then wrote out the lectures in fuller forms, interspersing them with appropriate drawings. His desire was to be engaged in a scientific occupation, even though of the lowest kind. So, by late 1812, he took a bold step of writing to Davy, expressing his desire for scientific employment. A reply came from Davy, who offered him a position of assistant in the Royal Institution's laboratory. Davy, however, cautioned him by saying that science was a harsh mistress and poorly rewarding for those who devoted themselves to her service. Anyway, Faraday began his scientific career at the Royal Institution in March 1813 as a laboratory assistant.

From October 1813 to April 1815, Davy travelled to various European countries to meet leading scientists and see their laboratories. He took Faraday with him to assist in experiments and writing. The exposure enabled Michael to update his knowledge in contemporary scientific developments. Faraday began active research in chemistry at the Royal Institution in 1816, analysing a specimen of caustic lime for Davy and reported the findings in the *Quarterly Journal of Science*, a precursor of the *Proceedings of the Royal Institution*. Faraday's publications in the journal, chiefly of chemical nature, increased every year, six in 1817, eleven in 1818, and nineteen in 1819.

Michael Faraday began his fundamental research in electricity and magnetism at the Royal institution in early 1821. By that time, four European scientists, Luigi Galvani, Alessandro Volta, Hans Christian Oersted and Andre Marie, had contributed significantly to the fields. Here is a chronological account of the discoveries that led Faraday in creating the first electric motor.

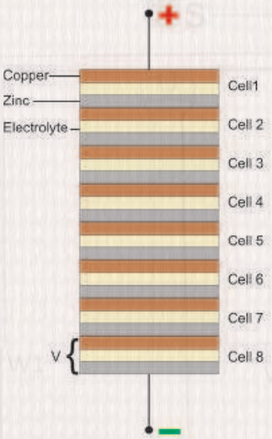
Animal electricity and the electric battery

In 1780, Luigi Galvani, an Italian physician and professor of anatomy, discovered a dead frog's dissected leg hung from a brass hook twitched when touched with a metal knife. After repeating the experiment a few more times, he concluded that the frogs' muscles generated a new kind of electricity. He announced this fantastic discovery of *Animal Electricity* in 1791.

Luigi Galvani (1737-1798)

Galvani's research excited Alessandro Volta, an Italian professor of physics. However, after conducting several experiments in line with Galvani, Volta, in 1792, realized that the crucial component of the investigation was the two different metals (the brass hook and the knife of some other metal) connected momentarily by dead frog muscle. He opined that these dissimilar metals had created electric current, and the frog's leg just conducted electricity. Further, Volta experimentally confirmed that electricity was created when a moist material was placed between two dissimilar metals.

Alessandro Volta (1745-1827)



Voltaic Pile or Battery

This image is an example of a Voltaic Pile or a battery having eight identical cells connected in series that produces eight times of voltage V. Each cell consists of a copper disc and a zinc disc separated by a moist material soaked in an electrolyte.

This understanding enabled him to invent Voltaic Pile, the world's first electric battery, as a continuous source of electricity.

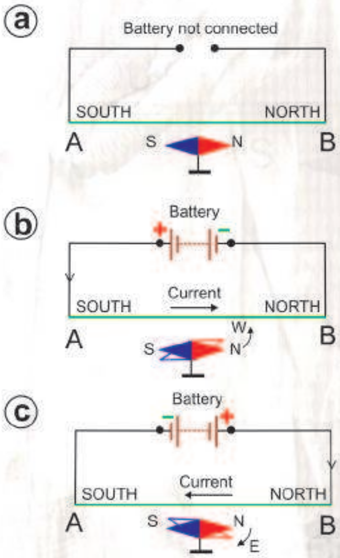
Electromagnetism

In 1820, Hans Christian Oersted, a Danish physicist, discovered the connection between electricity and magnetism. On 21 April, during a classroom demonstration, he observed that an electric current in a straight wire caused a nearby magnetic compass needle to orient itself perpendicular to the wire. It marked the beginning of the subsequent discovery of several phenomena of electromagnetism in nineteenth-century Europe and America.

We will discuss his findings with the help of schematic diagrams. Oersted, in his experiment, used an electrically conducting wire, a magnetic compass needle and a Voltaic pile that produced an electromotive force (emf) between 15 and 20 volts.

Hans Christian Oersted (1777-1851)

The magnetic compass is placed on a stable platform, and there is no second magnet kept nearby. As such, the compass needle aligns itself with the horizontal component of the Earth's magnetic field. An electrical conducting wire A-B having no electrical supply from a battery was placed above the compass needle, as shown in Figure a. The compass needle continued to remain in the same state, pointing towards the same direction. Now, without making any change to the positions of the wire A-B and the compass needle, a battery (Voltaic Pile) was connected to the wire. The needle deflected, as shown in Figure b. If he reversed the current flow in the wire by changing the battery's polarity, the compass needle deflected in the opposite direction, as shown in Figure c.



Oersted's Experiments (1820)

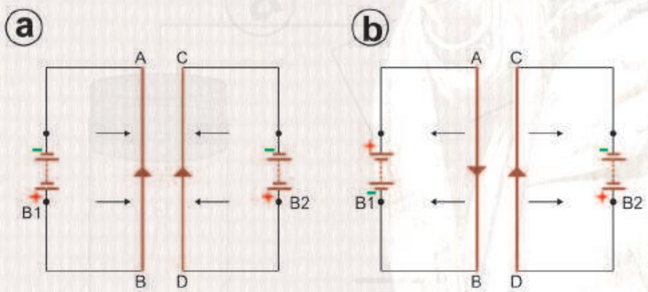
On 21 July 1820, Oersted published his experimental observations in a pamphlet and circulated them to scientific societies and select scientists in Europe. Although qualitative, his studies had undoubtedly proved that electricity and magnetism, hitherto believed as distinct phenomena, were closely related.

On 11 September 1820, academician Dominique François Arago, a French scientist, demonstrated Oersted's experiment before the galaxy of contemporary scientists at the Academy of Science (Académie des Sciences) in Paris. Only after seven days, on 18 September 1820, André-Marie Ampère, a French physicist and mathematician, presented his work on electromagnetism at the same Academy of Sciences. Ampere created magnetic attraction and repulsion without magnets. He exhibited that two parallel wires carrying electric currents in the same direction attracted each other. They repelled each other if the electric currents in the wires moved in opposite directions. The adjacent drawings depict his findings graphically.

André-Marie Ampère (1775-1836)

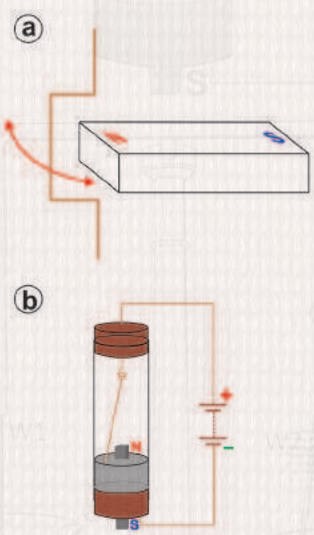
The Electric Motor

In September 1821, Faraday created a continuous rotation of a current-carrying wire around a magnetic pole. Thus, at the age of 30, Faraday became internationally famous for creating the world's first electric motor.



Ampere's Findings (1820)

We will now trace Faraday's route to the discovery. Oersted's work on electromagnetism in 1820 had inspired several contemporary European scientists, including Humphry Davy at the Royal Institution, to carry on experimental investigations on the subject. Richard Phillips, the editor of the Annals of Philosophy, a British journal, realized the need of the hour to publish a review on the studies conducted worldwide on electromagnetism and associated fields. So, he requested Faraday to write the historical account. Faraday accepted the offer, but to gain a thorough understanding of the subject, before writing, repeated all the experiments conducted by others. Annals of philosophy published his account titled 'Historical sketch of electromagnetism' in three parts in its July, August and September issues in 1821.

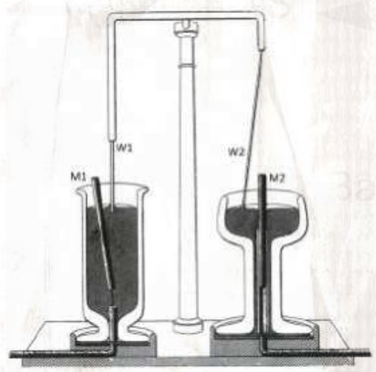


Faraday's Electromagnetic Rotation Experiments (1821)

Michael Faraday first investigated with a bar magnet and a straight electrical wire. He kept the wire vertically upright and passed a current through it using a Voltaic pile. He then brought one end of the bar magnet, held horizontally, close to the wire and noticed its deflection.

In the subsequent arrangement, he made some change to the straight wire. He bent the wire to form a crank (Figure a). When he passed the current through the wire, as was done in the previous experiment, he noticed the wire's rotary motion. The direction of rotation changed with the direction of flow of current in the wire. The motion, however, was interrupted due to the physical presence of the bar magnet. The discovery of the rotation effect excited Faraday immensely. In his diary, he wrote on 3 September 1821: "Very satisfactory, but make more sensible apparatus."

Within the next few days, he designed and created an apparatus to exhibit continuous electromagnetic rotation (Figure b). In his device, a stiff wire, which was a part of the electrical circuit, hung down with its lower end dipped in a mercury pool in a glass vessel. A bar magnet was fixed upright at the bottom of the container, and its other end protruded slightly above the mercury level. As soon as he connected the Voltaic pile to the circuit, the stiff wire created a magnetic field around it. That field interacted with the bar magnet's magnetic field, and as a result, the wire rotated continuously around the magnet. Conversely, when he fixed the wire upright and kept the pole of the magnet free to move, he found that the magnet rotated around the wire.



Faraday's Double Rotator

(1821) This drawing made by Faraday depicts his double rotator apparatus. While on the left side, a free magnet M1 rotated around the fixed wire W1, the free wire W2 rotated around the fixed magnet M2 on the right side of the apparatus.

Michael Faraday was a devoted researcher at the Royal Institution and held positions of Laboratory Assistant (1813-1825), Director of the Laboratory (1825-1867) and Fullerian Professor of Chemistry (1833-1867). His discoveries include electromagnetic rotation (1821), liquefaction of gases (1823), benzene (1825), electromagnetic induction (1831), laws of electrolysis (1833), magneto-optical effect (1845), and diamagnetism (1845). During the following years, he engaged himself in the formulation of the field theory of electromagnetism.

In 1821, at 30, Faraday married 21-year-old Sarah Barnard, daughter of Edward Barnard, then owner of one of the largest silversmith companies in London. They lived happily until Michael's demise in 1867.

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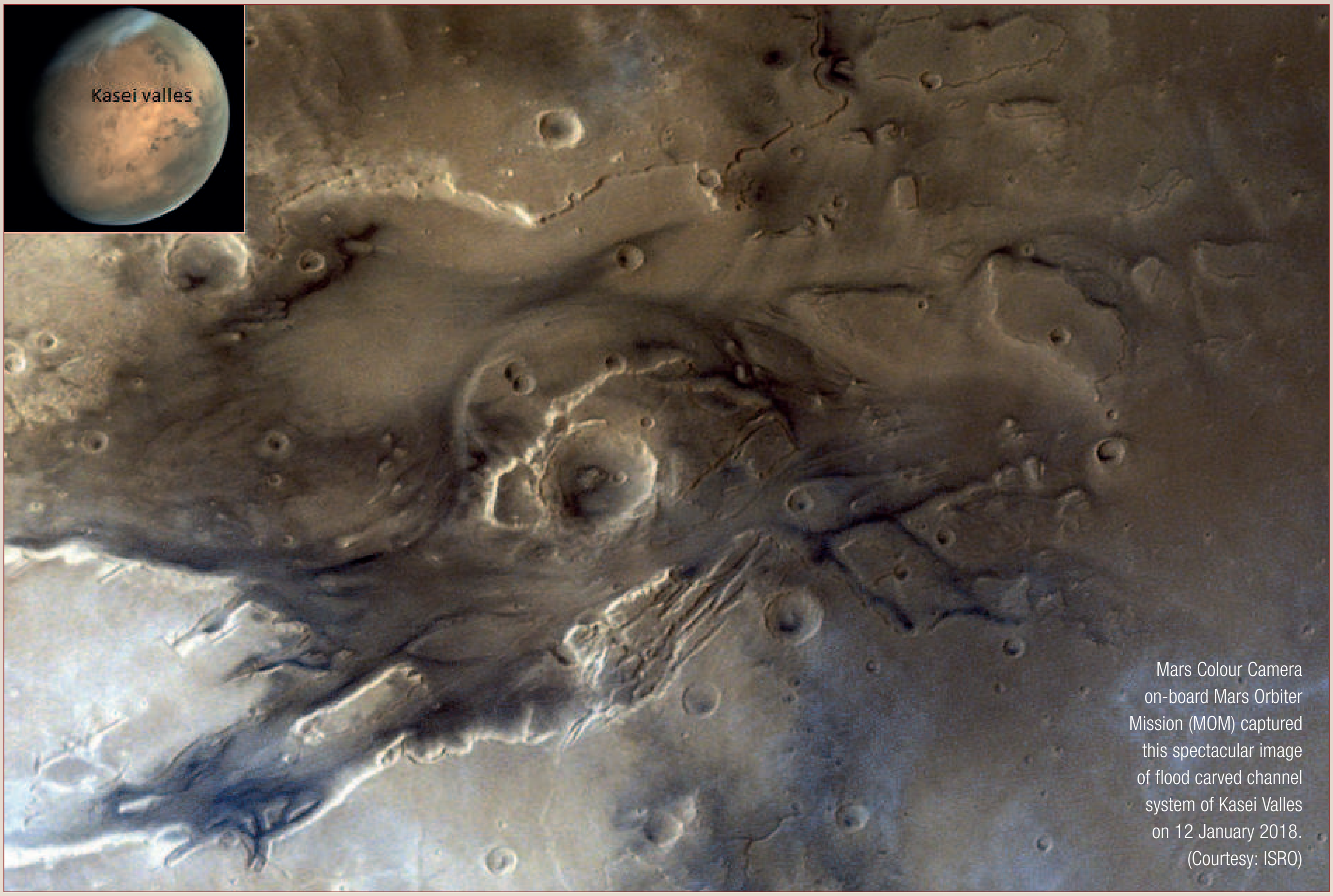
SOUMYA MAITRA



Mars Colour Camera on-board Mars Orbiter Mission (MOM) captured this spectacular image of flood carved channel system of Kasei Valles on 12 January 2018. (Courtesy: ISRO)

Consequence of the Race to Space

Amidst the COVID-19 disruption and chaos, 30 May 2020 marked a milestone in humankind's dream of travelling to space when Space X became the first private endeavour to fly astronauts to the International Space Station. Historically, space programs have always been initiative of government agencies like ISRO, ESA, or NASA. While several nations have government space agencies, only six have full launch capabilities and India's ISRO is one of them. The other five agencies are the National Aeronautics and Space Administration (NASA), the Russian Federal Space Agency (RFSA, also known as Roscosmos), the China National Space Administration (CNSA), the Japan Aerospace Exploration Agency (JAXA), and the European Space Agency (ESA) which is a collaborative organisation of several European nations.

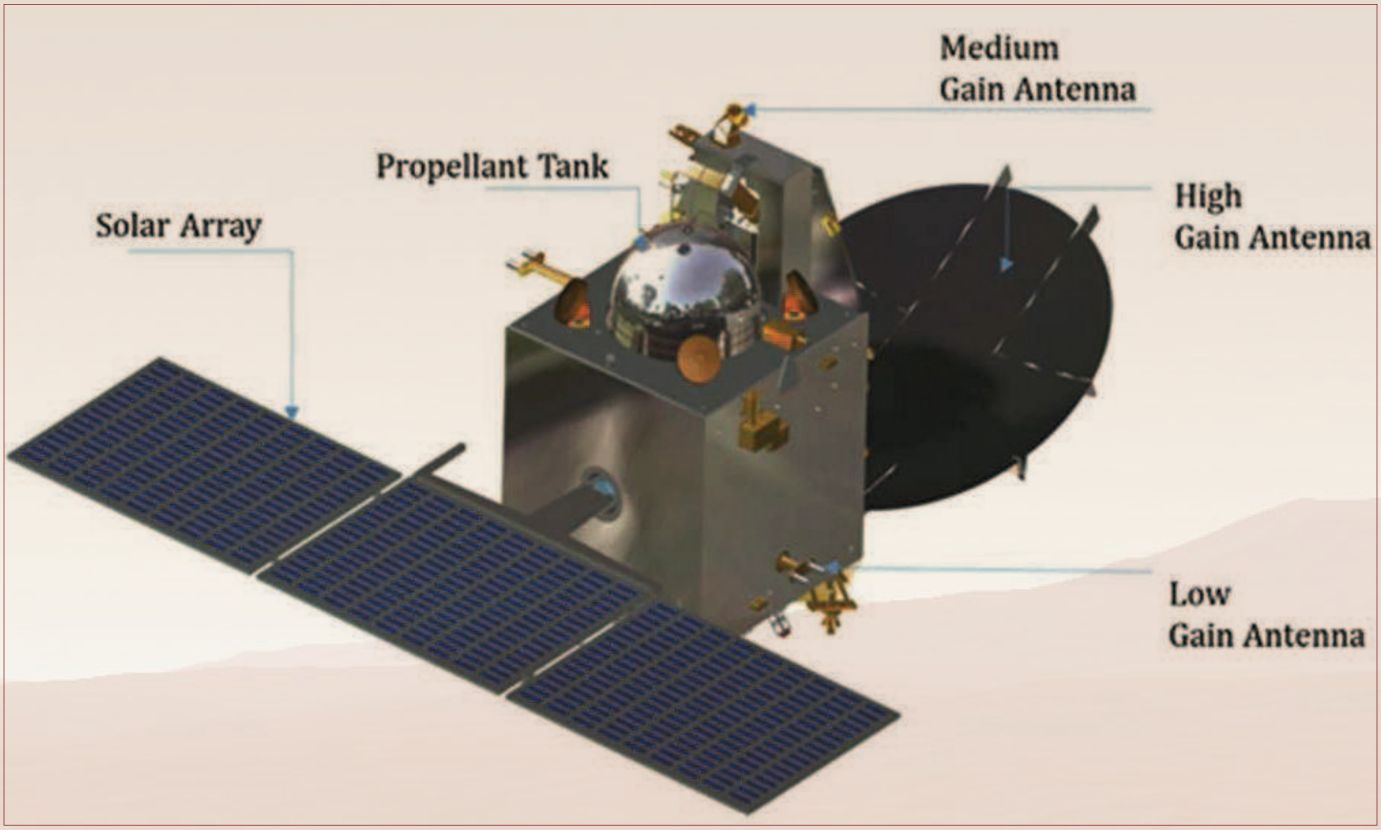
Space travel is no longer limited to orbits around Earth, landing on Moon, or even a Martian landing. A manned mission to the red planet is no longer a matter of if, but when. India has already got a Mars Orbiter in place since September 2014. With the privatisation of space launch capabilities and entry of players like Space X and Boeing, we are entering the teenage years of space travel. But like any other privatisation exercise, space travel is now going to be more competitive and therefore economical, and drive innovation faster. We don't have to look hard in the annals of history for a suitable analogy. The world of computer science and applications was conceived in the universities, research institutes, and defence labs. Internet, for instance, had its infancy in the 1960s when the United States Department of Defense built the ARPANET (Advanced Research Project Agency Network), which served as the "internet" of that era (the 1960s and 1970s) for universities and the military.

Computing and technology innovation disrupt the global market and human behaviour every so often. All this would not have been possible so fast and on such a scale without opening up technology to the public and privatisation of the computing industry. Drawing a similar analogy to the space program, space travel is now going to be an achievable dream for the common man in the foreseeable future. You don't need to be an astronomer to be in space. You need only to be able to pay for space travel service. It may take longer to fruition compared to advances made in other technologies, but the eventual human colonisation of the Solar System in a few hundred years from now is not hard to envision anymore.

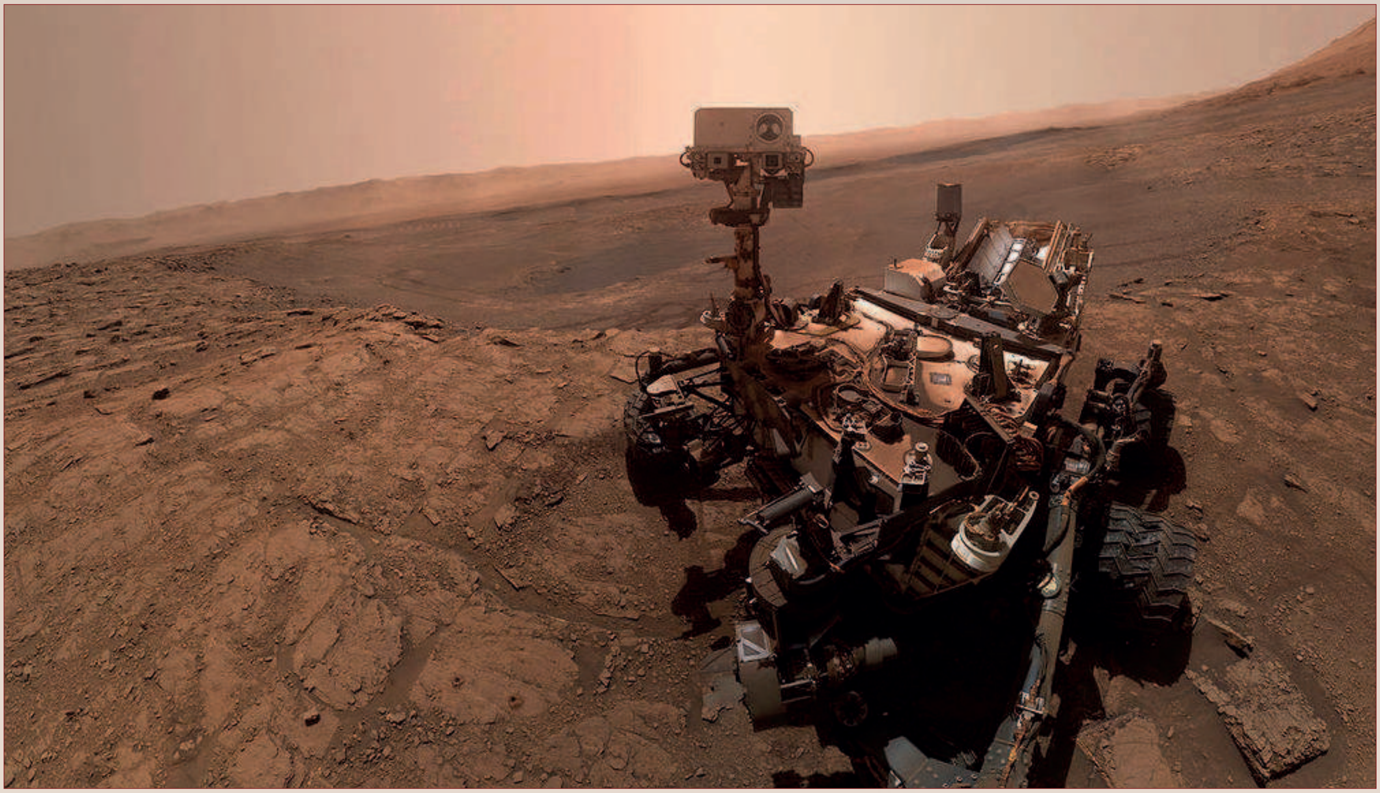
The accompanying question that may bother pundits is whether it is the right decision to open up space travel to the private competition. What kind of governance should a mixed bag of commercial and government space programs be subjected to? The human footprint on the Earth's ecology is already known to be destroying much of the natural habitat and creating non-biodegradable waste. Most scientists concur with the notion that we are the cause of the prevailing and escalating global warming, and one of the major driving forces for the extinction of many endangered species. And no one disputes the fact that we are guilty of irreparable deforestation and environmental damage. Are we going to perpetuate these maladies in our extraterrestrial adventures as well? Space, closer to our home, is already seeing a buildup of debris from our current and past space explorations. With extensive commercialisation of the space program in the offing, the problem of junk in space is only going to get worse, unless there is strict governance and controls in place. The question is who is going to define that? Who owns space?

There are no national boundaries in space. It is not owned by any nation and no singular law applies. US have recently instituted the US Space Force which is the space warfare service branch of the U.S. Armed Forces. This may persuade other countries to follow suit. Is this the shape of things to come? Are these nations going to claim first rights to hotspots in space as exclusive rights? Or are the Fortune 100 billionaires going to own pieces of real estate on Moon or Mars, like they own private islands here on Earth? Are we going to have lines of control in space or will human camaraderie thrive in the true spirit of collaboration? Will space belong to anyone in particular or remain universal in ownership? Are we opening up space to Star Wars like we have in our fantasies, and continue breeding the same human problems in space that we are afflicted with on the blue planet? These are questions that the leaders in space travel (India and the other five leading nations which have space programs) will have to answer to ensure ecologically and geopolitically sustainable space collaboration.

The heavens have always been a place of wonder, awe, and at times, of fear for as long as man has learned to think. Lying under the starry skies, our ancestors sure have wondered what it would be like to be up there, what makes space tick? Over the millennia, Space has sown the seeds of imagination behind myriad superstitions and folklores. Many cultures believed and practised different



Mars Orbiter Mission Spacecraft (Courtesy: ISRO)



Selfie taken by NASA's Curiosity rover on 11 October 2019 (Courtesy: NASA)

customary observances during Solar and Lunar eclipses, some of which defied scientific outlook or common sense. However, it was not until the early 17th century when the Italian Galileo Galilei started pointing his telescope to the heavens that the science of astronomy kicked in high gear. It was followed quickly by discoveries of planets and moons of those distant cousins in our Solar System that started becoming visible through a telescope. Today, we not only use our eyes to look into space but also make use of a large part of the electromagnetic spectrum to make sense of what is out there. We have built radio telescopes and infrared telescopes to see beyond human visual capabilities. We have built these telescopes on permanent spots on Earth called observatories, and also have satellites in space like the Hubble Space Telescope to observe distant planets, stars, and galaxies from space.

Observation is just one dimension of mankind's curiosity of what lies out there. The true human spirit of space exploration was always in our DNA; it was only limited by the technology of the times. As Indians we are proud to be the only country to be able to send a Mars orbital satellite (*Mangalyaan or the Mars Orbiter Mission*) on her maiden attempt, and at the lowest cost amongst the competing nations. It has been orbiting Mars since September 2014. Similar to these initiatives, the adolescent years of space exploration now are going to be fuelled by the private players like Space X and Boeing. It will not be surprising if other entrepreneurs venture into this "space" of opportunity very soon.

Human colonisation of space, starting with the Moon, Mars, and farther away is inherently going to be futuristic, and therefore evolutionary in nature. This is simply because of the fact that space is mind-numbingly vast beyond human comprehension, and as we keep reaching farther and farther out from our blue planet, the time taken to reach our destination is going to grow exponentially. Such extra-terrestrial colonisation may very well be conceived in one generation, spent by the next generation in interstellar travel, and experienced by a generation farther down the line. Such timelines will benefit from ever-changing technological advances, but at the same time also fraught with newer and novel problems that we cannot possibly contemplate now.

The race to space is not just about personal, political, or national ego, and who wins and who loses. It is about the human spirit to conquer the impossible. It is a quest to survive beyond the constraints of the space and time where humanity was born – our planet Earth. And finally, it is also a quest to know the unknown, to know whether we are alone in this Universe. After all, if Earth is the only laboratory of life, it is going to be awfully disappointing. Like Carl Sagan said, *"The universe is a pretty big place. If it's just us, it seems like an awful waste of space"*. Given an opportunity to find out, I wouldn't hesitate to travel to space. Would you?

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MUDASSAR ANISODDIN KAJHI AND VAIHBAV A. MANTRI

Seaweed: An appropriate nutrition and food source

Food products made of seaweeds in Japan
(Photo credit: Dr Pooja Kumari)

Many South-East Asian and African countries have shown significant improvement in Global Hunger Index published in 2020. Though the Index does not explain aspects related to nutrition, for India this is going to be crucial as, according to United Nations, our population would reach 180 crore by 2050. Consequently, availability of nutritious food for a huge section of the population, especially for the people at lower economical level, is going to be a big challenge. The objective of National Food Security Act 2013 is to provide food and nutrition to people by giving an assurance of quality food in sufficient quantity at reasonable prices. Seaweed, one of the major renewable marine resources, can be a great source as food for human and animals.

There are many seaweed species and various marine environments across the world that are great for their adaptation. Seaweeds are one of the living renewable resources that play a crucial role in maintaining the marine ecosystem. Apart from that, they help in the process of mineralization and saprophytic food chain which help in maintaining the marine ecosystem. Seaweeds are classified in three groups on the basis of their colour—Rhodophyta (red seaweed), Phaeophyta or Ochrophyta (brown seaweed) and Chlorophyta (green seaweed).

People who live in coastal areas have been using seaweed in food items, medicine, manure and fertilizer, etc. for a long time. Algae are considered to be a sustainable food source as it is available during the whole year and can be stored easily. Similarly, some algae of class Phaeophyta, like remains of Sargassum, have been found at Japanese pre-historic archaeological sites. A long history of using seaweed explains that some components of the algae are better and more valuable than other land-based plants. Although in western food items seaweeds are not used traditionally, many western countries are now adopting it as an alternative to vegetables. Lately, people have grown taste towards functional foods. Functional foods are those that procreate beneficial effects to physiological functions and lessen the risk of suffering from any specific disease and further curb its development. Seaweeds are capable of enhancing such functions making the body strong apart from providing nutrition. For example, it works as hypertensive, anti-inflammatory or antioxidant.

Some red and brown algae are used in producing three types of hydrochlorides: Alginate, Carrageenan and Agar. Hydrochloride is a non-crystalline substance containing larger atoms, which produces a thick and sticky solution when mixed with water. Globally only around 221 species of seaweeds are used and out of them, 145 species are used directly for food.

Carbohydrate

Algae have a great amount of carbohydrate in the form of structural polysaccharides, storage polysaccharides and functional polysaccharides. In various species, it may be present in the range of 20% to 60% of dry mass. Agar and carrageenan in red algae and alginate in brown algae are the examples of structural polysaccharide. These polysaccharides are especially used in food industry extensively in pure form to make the food thick and clean, like ice-cream, curd, candy, meat products, drinks etc. Laminarin in brown algae and Floridian in red algae are found in the form of starch storage polysaccharides. Although algae contain carbohydrates in abundance, most of polysaccharides of them are indigestible by human and therefore, they are also called dietary fibres. Edible algae contain 33-50% of fibres which is more than most of the plants grown on land. Porphyra umbilicalis, which is often used to wrap rolls of 'nori', contains more fibre than banana (3.8 g versus 3.1 g per 100 g). Similarly, laminaria digitata (which is also called kombu) contains more fibre than brown rice (6.2% versus 3.8%).

Protein

Proteins are present in algae in different parts of the cells in various forms. They are found in the inner parts of the cell or cell wall in the form of fermenter, pigment or with polysaccharide. Generally, red and green species have more protein than brown species (4-50% of average versus 1-29%). Red algae contain protein similar to vegetables like soybean. Proteins in algae contain all necessary amino acids and are available during the entire year despite diversity of seasons. Amount of necessary amino acids of some species like Porphyra can be compared with the amount of protein found in soya and egg. Apart from that, many species of algae contain plenty of amino acids like arginine, aspartic acid and glutamic acid.

Lipids

Algae contain relatively low (1-5%) amount of lipids. But half of that is polyunsaturated. These polyunsaturated fatty acids have omega-3 and omega-6 fatty acids like eicosapentaenoic acid and arachidonic acid in abundance. In most of the algae eicosapentaenoic is the main polyunsaturated fatty acid which may be close to 30% of total fatty acids. Polyunsaturated fatty acids help in preventing heart disease, knee and joints pain and diabetes. Besides fatty acids, algae contain carotenoids, tocopherol, sterols and terpenoids.

Minerals

As algae grow in the sea they absorb various minerals. Algae have ample amount of calcium, iron and copper. Sodium, magnesium, calcium, potassium, chlorine, phosphorus and sulphur are included as macronutrients and zinc, copper, iodine, selenium, manganese, molybdenum, cobalt, fluoride, nickel and boron are included as micronutrients. Iodine is an essential nutrient for physical development and metabolic regulation and is found in most of seaweeds in great amount. Algae has greater amount of iodine than any land-based vegetation; for example, 1500-8000 ppm iodine is found in brown algae. Food sources which we obtain from animals and land-based vegetation do not contain much iodine; therefore, algae can be included as most reasonable food to meet iodine requirements. In most of the species of seaweeds, level of heavy metals is naturally lower than food security limit. However, regular monitoring of minerals in seaweeds may be necessary.

Vitamins

Seaweeds contain vitamins soluble in both fat and water. Plenty of provitamin A and B1 and B2 are present in most of the red algae like palmaria palmata and porphyra tenera. These species and some green algae like ulva lactuca (sea lettuce), undaria pinnatifida (wakame) and Gracilaria are rich source of vitamin C (10mg/100 g wet mass).

Source of animal nutrition

Seaweeds are being used as animal food from thousands of years. In the beginning of 19th century dried and preserved seaweeds were used to feed sheep and other animals. Species like laminaria or alaria are often used as fodder in Norway and Finland.

Algae as food products

Algae are traditionally consumed as sea vegetables in Asian countries. Japan is the leading consumer of seaweeds, where around 4-8 g/person (dry mass) is eaten every day. French administration has accredited the use of 11 species of seaweed as food ingredients in human diet. The algae which is chiefly used as food in the whole world are, undaria pinnatifida (wakame), hizikia fusiforme (hijiki), himanthalia elongate (sea spaghetti), laminaria (kombu), ecklonia cava, Ascophyllum nodosum (goemon), fucus vesiculosus (warek, goemon noir), ulva lactuca (sea lettuce), Monostroma and Ulva lactuca (aonori), gracilaria (ogonori), grateloupia filicina (mukadenori), palmaria palmata (dulse) and lithothamnion calcareum (maerl).

Farming of Ulva, port Okha, Gujarat.
(Photo credit: Dr P.V. Subbarav)

Availability of possible edible seaweeds in Indian oceans

Porphyra/pyropia of bangiales order is the most loved traditional and delicious food in Asian countries like Japan, China and Korea. It is called 'nori' or purple laver in Japan, jikai in China and kim in Korea. Pyropia acanthophora and pyropia vietnamensis have recently been analysed for their nutrients in India. Pyropia acanthophora, robusta (subspecies) contains all necessary minerals, fatty acids in large amount, vitamin C and dietary fibres which fulfil human requirement. Analysis of Pyropia vietnamensis has been done for its nutritional values, collected from 18 western coastal areas of India. As per the prescribed dietary approval of heavy metals, amount of daily intake of pyropia vietnamensis, found in Indian region, must be 1.3 g (dry mass). Likewise, the species caulerpa collected from coastal areas of Gujarat is believed to be a great food source due to its high nutritional values and presence of antioxidants. Gracilaria edulis, ulva lactuca and sargassum gathered from Mandapam, Tamil Nadu are found as an important source of dietary fibre, protein, minerals and vitamins and act as functional food components.

Indian food processing industry was there are around 1000 types of snacks and their demands are on the rise. Use of seaweeds like Enteromorpha compressa in traditional snacks like pakoras can increase its nutritional values.

Farming of edible seaweeds in Indian oceans and their future

Farming of seaweeds using modern technology, developed at Central Salt and Marine Chemicals Research Institute (CSIR), has opened the doors of golden opportunities to get new employments in the seaweed-based industries. Also, it has promoted and encouraged farming of seaweeds. Around 1000 fishermen are engaged in growing seaweeds and they are growing 2000 tons of seaweeds. It includes farming of the species kappaphycus and gracilaria. Similarly, farming of ulva lactuca, gelidiella acerosa and hypnea musciformis are also established in the laboratory as well as outer and maritime zone. Farming of seaweeds is technically easy and simple to adopt. It does not need water for irrigation or any kind of fertilizer.

Translated by Kshama Gautam

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MANISH MOHAN GORE

Science Heroes of India's Independence Movement

India's independence movement fills every Indian with an indomitable spirit and reverence for the freedom fighters. During the pre-independence era, our scientists have also faced discrimination and insult and sacrificed their careers. British rulers doubted their merit and talent and often considered them unfit for scientific research. They opined that the intellectual capabilities of Indian scientists were lower than that of the British scientists. Science education and scientific research in India were severely ignored. The western scientific community did not recognize scientific research performed by Indian and other Asian scientists. Research works of Indian scientists like Jagadish Chandra Bose, Prafulla Chandra Roy, C.V. Raman, and Pramatha Nath Bose were undermined. However, our scientists continued their pursuance of science. Their talent could not be dominated for long. Chandrashekhar Venkata Raman won Nobel Prize in 1930. The world recognized the merit of Indian scientists. Let us explore the life and works of some of the science heroes who helped India earn respect globally.

The spiritual and cultural heritage of India is known to the entire world. But its scientific treasures and achievements of modern-day Indian scientists are not that well known. Indian scientists have contributed tremendously for the growth of science, technology and industry in pre-independence era. The significant role these scientists played to strengthen the development of the country must be told and spread across the world.

Indian scientific nationalism was greatly impacted by the discriminatory policies of the colonial government. The colonial scientific enterprises were entirely under government control. Indians faced discriminations in appointment, recruitment, promotion, and salaries. In 1920, Prafulla Chandra Ray mentioned that in 11 scientific services, including the educational service, there were only 18 Indians out of 213 scientific personnel.

The struggles faced by our scientists in colonial period can be considered as the *Vaigyanik Satyagrah*. *Azadi ka Amrit Mahotsav* gives us an opportunity to remember our great scientists whose struggle provided the firm foundation of science and technology based on which the country has been marching ahead.

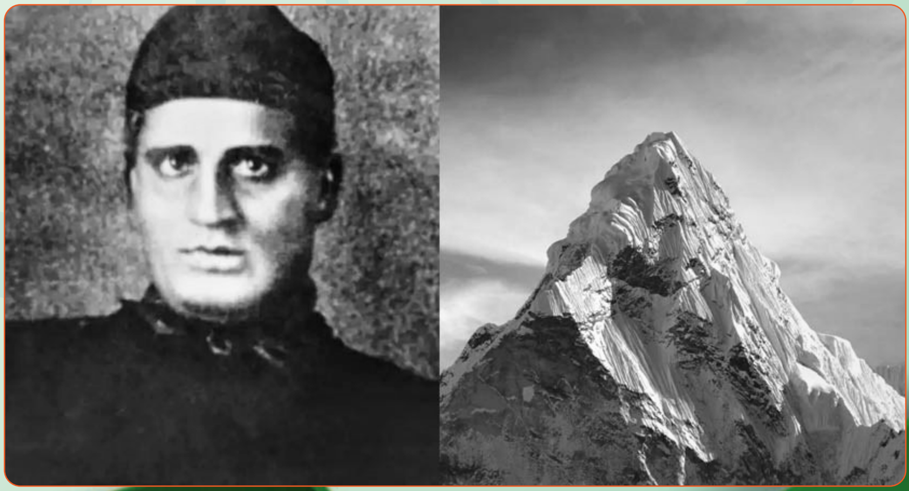
Radhanath Sikdar (1813-1870)

During the colonial period, quite often, Indian scientists were not given due credit for their achievements. Indian mathematician and surveyor Radhanath Sikdar is one such example. He played a significant role in measuring the height of Mount Everest but was not acknowledged. After his death, another injustice was meted out to Sikdar. He contributed in preparing the Manual of Surveying for India (Edited by Capt. H. L. Thullier and Capt. F. Smyth) and was duly acknowledged in the Preface of the first and second Editions. Sikdar died on 17 May 1870. In September 1875, when the third edition of the Manual was brought out, his name was deleted from the publication. However, this incident did not go unnoticed. In 1876, the newspaper 'Friend of India' reported this as the 'Robbery of the Dead'.

Pramatha Nath Bose (1855-1934)

Born on 12 May 1855, in a remote village of Gaipur, in Bengal, geologist Pramatha Nath Bose graduated in Science from London University and passed out from the Royal School of Mines in 1878. During his years as geologist with Geological Survey of India (GSI) he discovered, along with many other remarkable discoveries, iron ore mines in Dhulli and Rajhara in Madhya Pradesh.

H.B. Medlicott, the Director of the GSI once said, "Indians are incapable of any original work in natural science. .... so let us exercise a little discretion with our weaker brethren and not expect them to run before they can walk." The most shocking act of discrimination was faced by Pramatha Nath when in 1903 a European T. Holland superseded him for the directorship of GSI who was 10 years junior to him in the service.



Indian mathematician Radhanath Sikdar who played a key role in mesauring Mount Everest

Pramatha Nath Bose

Pramatha Nath retired from GSI and was appointed by the Maharaja of Mayurbhanj as his geological adviser. The most remarkable achievement of his life was to discover deposits of iron ores in the Gorumahisani Hills of Mayurbhanj. Following the discovery, Bose wrote to Jamsetji Nusserwanji Tata which led to the establishment of Tata Iron and Steel Company at Sakchi in 1907.

Jagadish Chandra Bose and Prafulla Chandra Ray

Readers are requested to read four detailed articles on lives and works of these two remarkable scientists in the August 2021 issue of Dream 2047.

Kadambini Ganguly (1861-1923)

Kadambini Ganguly was one of the first two female graduates (along with Chandramukhi Basu) from India. She was also one of the first female doctors of the country. Besides Kadambini's professional capability, her contribution to the Indian freedom struggle is also noteworthy.

In 1882, she graduated in arts degree and decided to study western medicine. She successfully graduated in 1888 from the *Calcutta Medical College* in spite of several obstacles from the college as they were not open to the admission of women candidates. Kadambini was also awarded a scholarship of Rs. 20 per month for studying medicine. After her medical graduation, she worked for a very short period at the Lady *Dufferin Women's Hospital*. She faced great discrimination and strong opposition from her colleagues and administrative staff for being Indian and a female.

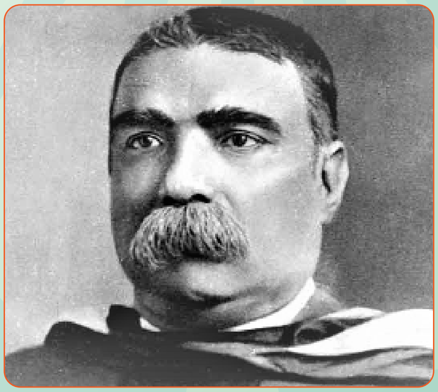
Besides her professional engagements, she was also involved in several movements aimed at India's freedom

Kadambini Ganguly

struggle. During the partition of Bengal, she spearheaded many movements and organized the *Women's Conference* in Calcutta in 1908. Kadambini also worked extensively for the rights of female coal miners in the Eastern India.

Ashutosh Mukherjee (1864-1924)

Ashutosh Mukherjee was a prolific educator and brilliant mathematician.



Ashutosh Mukherjee

He was appointed as the Vice Chancellor of Calcutta University by the British authority. But he skilfully utilized this position to achieve the goals of scientific nationalism. He identified Indian talents in various streams of science who later on proved to be the stalwarts. P.C. Ray and C.V. Raman were some of them. Although Indian scientists faced a lot of challenges in pre-independence India, in spite of the adverse situation, Mukherjee established several scientific

C.V. Raman

organizations to promote indigenous science and motivate Indian scientists. Bengal Technical Institute (1906), Calcutta Mathematical Society (1908) and Calcutta University College of Science (1914) were few such organizations.

Mukherjee had a vision of qualitative education for the youth of the country. To fulfil his vision and dreams, he set up several new academic graduate programmes at the Calcutta University including anthropology, applied psychology, industrial chemistry, ancient Indian history and comparative literature. He wanted to spread knowledge through Indian languages and made necessary academic provisions for postgraduate teaching and research in Pali, Hindi, Bengali and Sanskrit. Indian as well as European educators felt honoured to teach in Calcutta University those days.

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VARINDERJIT KAUR AND SIMRAN KAUR

Radiations: From Substantial Benefits to Noxious Effects

"Knowledge leaves no regrets. Except for radiation. I wish I'd never messed with that." *Marie Curie*

Marie Curie was the first woman to win the Nobel Prize and the first and only woman to win the Nobel Prize twice in two different scientific fields - physics and chemistry. Have you ever wondered why, after studying the theory of 'Radioactivity' and even after contributing so much regarding radiations, polonium, radium in physics and chemistry, she regreted messing with radiations? Well, little did she know that the cause of her death would be radiation itself.

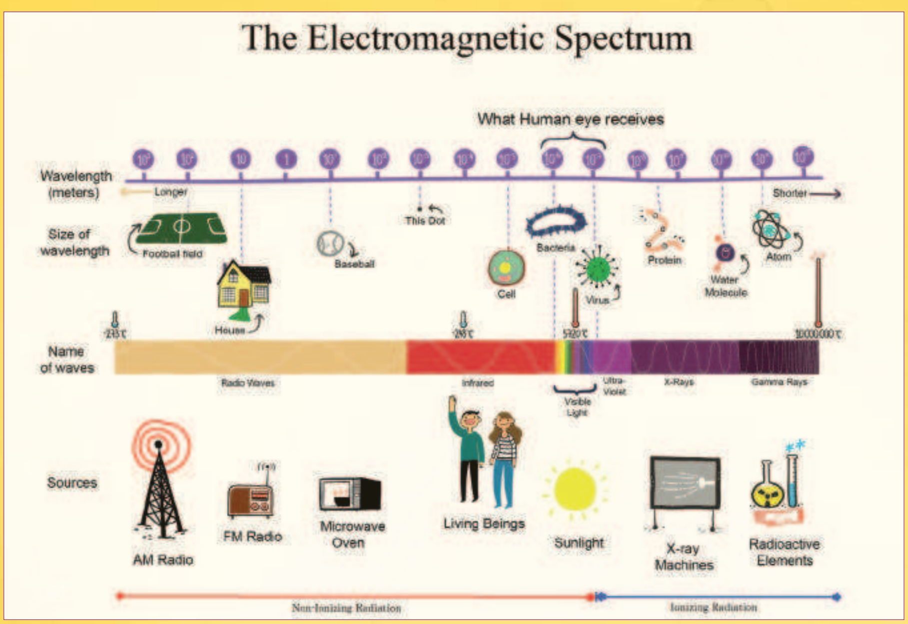
So what exactly are these radiations? The heating of food in microwave oven, the X-ray images we get of a broken bone, the carbon-dating of fossils, the radiotherapy treatment of cancer, all work because of radiations.

Radiations come in different forms. Electromagnetic (EM) radiations refer to the energy that travels in the form of waves through space at the speed of light. They have neither mass nor charge but travel as packets of energy called quanta or photons. These radiations exhibit a dual nature: of both particles and waves. The characteristics of various forms of EM spectrum vary according to their frequency which is inversly proportional to the wavelength. Since the velocity is constant, any increase in frequency results in a subsequent decrease in wavelength. An inverse relation also exists between energy and wavelength since $E=h\upsilon$. The energy of EM radiation is generally represented in electron volt (eV), where 1eV is the energy gained by an electron as it is accelerated through a potential difference of 1 volt.

EM radiations deposit energy mainly in two forms: Ionization and excitation radiations. Ionizing EM radiations have enough energy to eject one or more electrons from the atom. The electromagnetic spectrum can be divided into two main categories: Non-ionizing radiations and ionizing radiations.

Non ionizing radiations are those which cannot ionize matter. These radiations carry less energy and are referred as low-frequency EM radiations. These radiations only energise the electrons to the higher energy state. Visible light, infrared (IR) waves, microwaves and radio waves are all forms of non-ionizing radiations. Non-ionizing radiations are generally less damaging than the ionizing radiations.

Radiation quantity	Conventional units	SI units
Exposure	Roentgen (r)	Coulomb/kg
Absorbed dose	Rad	Gray (Gy)
Integral dose	Gram-rad	Joule (J)
Equivalent dose	Rem	Sieverts (Sv)
Effective dose	Rem	Sieverts (Sv)



Electromagnetic Spectrum showing Ionizing and Non-ionizing radiations.

Ionizing radiations are those which can ionize matter. These radiations are referred as high-frequency EM radiations due to their ability to remove an outer electron from the atom. The release of bound electrons leads to the generation of ions and free radicals. UV rays, X-rays, gamma rays, and cosmic rays are forms of ionizing radiations. The ability of radiations to ionize depends on the nature of the material it interacts with because different materials have different densities and binding energies. Within the living cells, ions and free radicals have a potential to alter DNA and living tissues which can ultimately lead to cell death. Ionizing radiations can ionize matter either directly or indirectly. Direct ionizing radiation includes all charged particles such as electrons, protons, alpha particles, heavy ions, etc. Indirect ionizing radiation include neutral particles such as photons (X-rays, γ-rays) and neutrons. Ionizing photon radiations are further classified into four categories:

1. **Characteristic X-rays**, which result from electronic transitions between atomic shells.
2. **Gamma rays**, which result from nuclear transitions.
3. **Bremsstrahlung radiation**, which

results from electron-nucleus Coulomb interactions.

4. **Annihilation rays**, which result from positron-electron annihilation.

X-rays and gamma rays are forms of EM radiation that do not differ in their nature and properties; rather they differ in their origin; i.e., the way in which they are produced. The production of X-rays is an extra-nuclear process, which means that they are generated in an electric device that accelerates electrons to very high energy and then stops them abruptly in a target (usually gold nuclei). Part of the kinetic energy of motion of electrons is converted into photons of X-rays. The production of gamma rays is an intra-nuclear process, which means that they are produced when unstable nuclei, e.g., Cobalt-60 or Caesium-137, break up and decay into stable nuclei. X-rays and gamma rays themselves do not produce any damage chemically or biologically to matter. But when these radiations pass through a medium, they get absorbed and give up their energy to produce fast moving electrons by photoelectric, Compton and pair production processes, which cause the damage.

Measurement of radiations

In medical field, radiations serve a very crucial part. Radiation quantity is generally measured in terms of 'Exposure' and 'Dose'. Exposure is the concentration of radiations at a specific part of the body. As air is exposed to large number of radiations, the amount of air ionization is measured in terms of most widely used radiation quantity known as "exposure".

The conventional units of exposure are "Roentgen" while SI units are Coulombs/kg. The total radiation delivery to a body is called Surface Integral Exposure (SIE) and is measured in R-cm^2. For example, if the two persons are exposed to the same radiation concentration, the SIE will be greater in the person with a large surface area exposure. Exposure alone is of no use as dose plays the lead role to determine the amount and effect of radiations. Dose, here specifically, does not mean the amount of medication taken in absolute measureable quantity. It is the combination of exposure due to radiation, intensity of radiation and the type of matter with which radiation is interacting-which in medical terms refers to the sensitivity of skin. Dose is further divided into four categories: Absorbed dose, Integral dose, Equivalent dose and Effective dose.

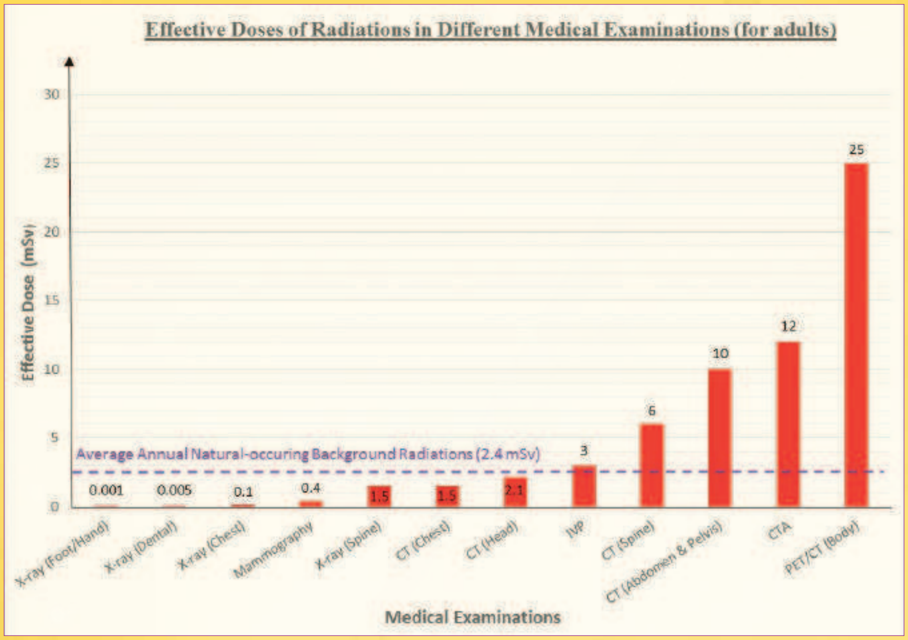
1. **Absorbed dose** - Absorbed dose is the average amount of energy deposited on human tissue per unit mass through ionizing radiations. Radiations affect the organs less which are covered by bones (e.g., lungs covered by ribs), but have more impact on the directly exposed organs (e.g., stomach).

2. **Integral dose** - Integral dose is the product of absorbed dose and the mass of tissue irradiated. In other words, it is the product of volume of matter and mean dose.

3. **Equivalent dose** - Equivalent dose calculates the impact or effectiveness of radiations on a specific tissue/organ. It addresses the damage caused by radiation on the tissues.

4. **Effective dose** - Effective dose is the quantity of total effect of radiations on the whole body. In medical field, it is a general quantity which is determined by the type of medical procedure (e.g., X-ray, CT scan, etc.).

To estimate the radiation quantity/exposure/dose received by an individual through exposure to radiations present in the environment, one must have a thorough knowledge of benefits and risks of these radiations. So, it is very important to quantify the radiation quantity. For example, the CT scan of a head should have an absorbed dose of the range 42-71 mGy (milli-Gray) and an effective dose of 2.1 mSv (milli-sievert). During an examination, the doctor is concerned about the effective dose i.e., the long-term effects of the radiations on body. Usually, the absorbed dose and equivalent dose are not considered much because a perfectly performed procedure will have negligible short-term risks. But an average person is also exposed to the naturally-occurring background radiations. Hence the ultimate effect is much more than anticipated.



Shows conventional units and SI units of Exposure, Absorbed dose, Integral dose, Equivalent dose, and Effective dose.

Effects of Radiations

Although there is a plethora of radiations used in the field of medicine, agriculture, research, industry and energy production, beyond a certain point, these "effective" radiations become "destructive". So, radiations are like a "double-edged sword". On the brighter side, they have the potential to cure cancer, but on the other side, they can lead to cancer itself.

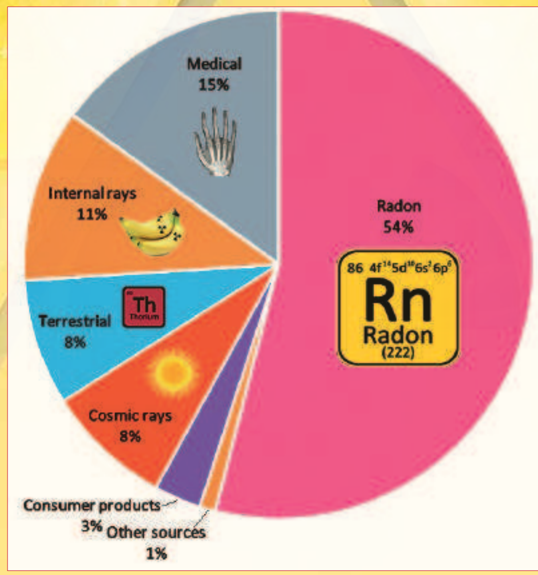
Effect of naturally-occurring and man-made radiations

If you look at your surroundings,

naturally-occurring radiations are everywhere. These include Radon from minerals, rocks and soil, cosmic rays coming from space, UV rays from Sun, radiations from fruits and vegetables, radiations from radioactive elements in air, etc. Since these radiations are found in nature, they affect nature as well. The air we breathe, the water we drink, the food we eat, the sunlight we get-everything is affected by these radiations. Although solar radiations are the main source of solar-power, yet the shortwave UV rays possess a threat to living cells. The naturally-occurring background radiations have an effective dose of about 2.4 mSv.

The man-made radiations (nuclear plants, food preservation, etc.) also affect our day-to-day life. The level of radiations increases as we go near the source of radiations, e.g., cosmic rays are more at high-altitudes, radiation levels are high in mines or near nuclear reactors, etc. Nuclear radiations from nuclear plants affect both human-life and the environment. These can cause mutations by altering the DNA and sometimes even kill certain types of tissues. Both flora and fauna are negatively affected by nuclear radiations.

The Chernobyl disaster was the worst nuclear accident in history which caused radioactive contamination of air. The effects of Chernobyl incident can still be seen in the abandoned city and mutated lives as the city will not be habitable for the coming several thousand years.



Amount of Naturally-occurring background radiations and man-made radiations.

Effect of Medical Radiations on health

In medical imaging various forms of EM radiations are used. The energy of EM radiation determines its usefulness for diagnostic imaging. Both gamma rays and X-rays have extremely short wavelength, so these radiations are capable of penetrating large body parts. These radiations are clinically the most important form of ionizing EM radiations in the treatment of tumours. Testicular cancer has a cure rate of 95% using radiotherapy. Forty per cent of the all types of cancer are cured using radiotherapy all over the world. Radiotherapy uses ionizing radiations to eliminates cancer-cells/damage cancer-cells and tumour cells, besides stopping bleeding of organs and reducing pain. X-ray machines are used in hospitals for diagnostic purposes in computed tomography (CT) scan and to treat malignant lesions.

However, radiations, can also cause "biological injuries". These radiations start affecting living cells as the effective dose increases. Even under the effective dose of 100 mSv, radiations can cause hair-loss, burns, development of cancer-cells, etc. Foetus exposure to radiations under effective dose of even 100 mSv can cause permanent brain damage. Effective dose over 5,000 mSv can lead to death if exposed for a short period of time.

Prevention and Management

Ionizing radiation has the potential to destroy large areas of environment and flora and fauna which are under its influence. Humans, being a superior species, can still manage to survive these exposures but it is hard for the plants, animals, birds and water animals to escape radiation damages. Hence, it is important to prevent and manage ionizing radiations from affecting life on Earth.

As described earlier, effective dose of radiations decreases as it passes through different types of matter. These types of matter that reduce the intensity of radiations are known as "absorbers". Thick shielding of the absorber (e.g., walls) can stop ionizing radiations such as α, β, and γ rays to penetrate, thus can be an effective measure to prevent the damage.

To prevent future exposure and pollution, proper treatment of radioactive waste and control of accidents should be done properly. Some of the radioisotopes take years to convert half of the reactant into product, for example Uranium-233 has a half-life of 160,000 years, which means that these radioactive elements stay active for a very long time. Hence, correct disposal of radioactive waste is very important for the safety of life on Earth. At present, deep geological disposal is the most effective way to treat radioactive waste by storing it in deep underground repositories which are 250 m to 5,000 m deep.

In medical treatments, regulation of exposure and dose limits needs be done regularly to ensure the safety of tissues of human body. A face mask should be worn if one is getting exposed to airborne radioactive materials. A reduction in personal usage of radiations can also prove to be helpful. For instance, checking irradiated food properly because radiations can seriously degrade the food quality which can be hazardous to human bodies or reducing the consumption of cigarettes as they contain small amounts of radioactive elements which, over time, can cause lung cancer.

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VIDYARTHI VIGYAN MANTHAN 2021-22

INDIA'S LARGEST SCIENCE TALENT SEARCH EXAMINATION FOR NEW INDIA USING DIGITAL DEVICES

Vidyarthi Vigyan Manthan (VVM) is an initiative of Vijnana Bharati (VIBHA), in collaboration with Vigyan Prasar, an autonomous organization under the Department of Science and Technology, Government of India and National Council of Educational Research and Training (NCERT), an institution under the Ministry of Education . VVM is a national program for popularizing science among school students of standard VI to XI, conceptualised to identify the bright minds with a scientific aptitude among the student community.

STRUCTURE OF VVM (JUNIOR AND SENIOR):

1. **School Level Examination:** VVM is a unique online examination to be conducted at national level. The registered students will take the exam using his/her own digital device namely a laptop/ tablet / smart phone (mobile with any OS - Except Apple devices) with internet connectivity. Level-I (School Level) examination will be conducted nationwide, on 30 November and/or on 05 December, 2021 anytime between 10:00am to 08:00pm. Evaluation of student will be based on their individual performance at every level.

2. **State Level Camp (SLC):** Top 20 rankers per class per state will be identified to participate in the one or two days State Level Camp (SLC). The camp will be organised anywhere within the state.

3. **National Camp (NC):** From each State Camp, top two students from each class i.e. total 12 students per state, will be invited to a two-day National Camp.

SYLLABUS FOR VVM:

CONTENT	CONTRIBUTION	MARKS	DURATION	CURRICULUM
Indian Contribution to Science	20% (20 questions) [1 Mark each]	20	30 Minutes	VVM Study Material*
Life story of Acharya Prafulla Chandra Ray and India's Freedom Struggle & Science	20% (20 questions) [1 Mark each]	20		VVM Study Material*
Science and Mathematics from Text Books	50% (50 questions) [1 Mark each]	50	60 Minutes	NCERT Curriculum
Logic and Reasoning	10% (10 questions) [1 Mark each]	10		General Reading

* VVM Study Materials will be made available in PDF format on https://vvm.org.in by 15 August 2021. No printed copies will be provided.

- **Bhaskara Scholarship of Rs. 2000/- per month to the National Winners (Himalayans) for one year. Extensive training cum internship of 1 to 3 weeks for all National Winners (Himalayans and Zonal) in any one reputed National Lab or Research Institute like ISRO, CSIR, DRDO etc.**
- **Registered students will be a part of Eat Right - Mega Science Experiment. Students will get to know about the nutritional value and environmental impact of our food habits.**

KEY POINTS:

Eligibilty	Students from classes VI to XI
Language of Exam	English, Hindi and 10 major regional languages
Exam Venue	**Open Book Exam** (Students will write exam from their home)
Fee	Rs. 100/- (without late fee)
Registration	Online on https://vvm.org.in

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