

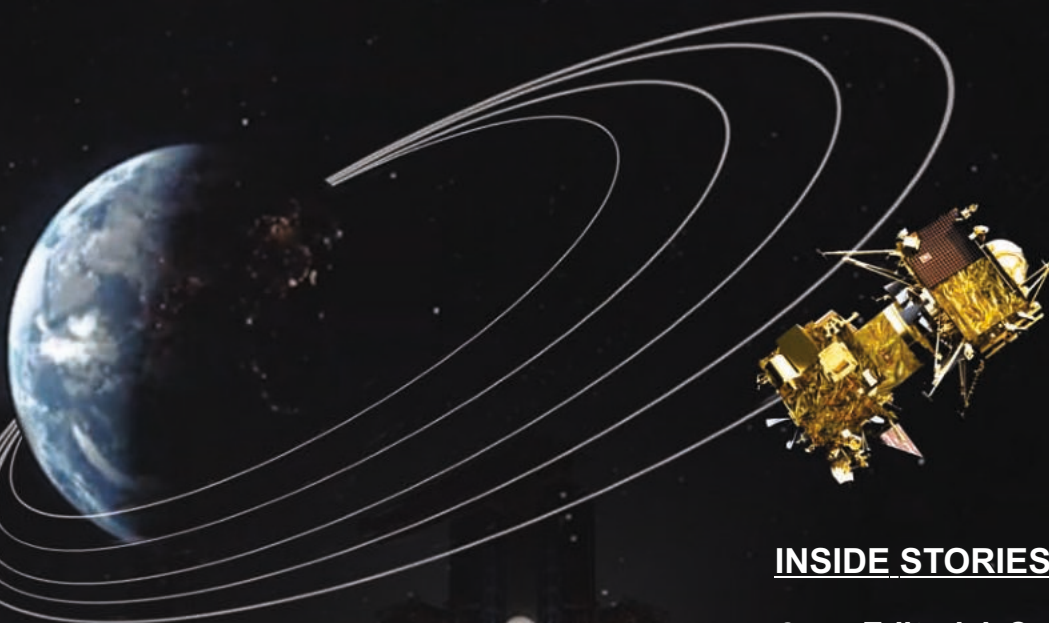
VIGYAN PRASAR

DREAM

2047

September 2019 • Vol. 21 • No. 12 • Rs. 5.00

Mission *Chandrayaan-2*



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Come September



Nakul Parashar

Interestingly, many of us have grown up hearing and dancing to a tune that came from the 1961-movie *Come September* starring Rock Hudson, Gina Lollobrigida. This year come September has a much more interesting moment for all of us to rejoice and remember. 7 September 2019 is when *Chandrayaan-2* is expected to land on Moon. We've brought information about it in this issue and will be bringing more about this prestigious mission in our forthcoming issues as well. A matter of national pride, isn't it?

Mission Shakti, *Chandrayaan-2*, and many more, much more – it's indeed heartening to see the pace of science & technology-related developments in almost every sphere of life. To showcase our scientific and technological prowess, every year, for the past four years we have been witnessing the famous India International Science Festival. Popularly known as IISF, this event attracts a huge number of visitors from the scientific and non-scientific community – scientists, technocrats, researchers, students, and people from every walk of life, who are interested to know, meet, hear, and interact with famous scientists about their achievements, and viewpoint. The last edition of IISF had happened in Lucknow last year and must say, it was a mini-*kumbha* of science & technology practitioners and lovers.

The event had more than two dozen

events that had successfully happened simultaneously. Being an international event, it had a noteworthy event called GIST or the Global Indian Science & Technology Stakeholders' Meet. An eminent group of scientists and technocrats belonging to the Indian diaspora was invited for brainstorming sessions where best practices were discussed and shared to assist the Indian S&T community.

We all know that India is a young country with a huge population of young scientists below the age of forty. A young scientists' conference was also organised at IISF. Popularly known as YSC, this was an opportunity for young scientists and scholars to showcase their innovations and scientific contributions for the benefit of masses.

Our country has witnessed a huge leap in terms of agricultural research and extension activities. The agricultural conclave at IISF was quite a popular one which was attended by a big group of agricultural scientists, farmers, and representatives of NGOs, and the industry associated with it.

Besides this, a science film festival, a women's S&T conclave, and National Science Teachers' Congress were also held at IISF. A special event on students from the North-East was also organised. Healthcare and researches made in the area of healthcare were also highlighted at the IISF. Face-to-face with scientists and entrepreneurs also happened at this mini-*Kumbha* of Indian

Science & Technology. There was a Science Village too which had more than five hundred school students.

It was indeed a mega event in the series of past four IISFs. Well, what about the IISF's edition this year? Stay tuned, and we'll bring the details about it shortly.

Back to *Come September* and some interesting facts again. September provides us a list of some famous scientists and inventors who were born this month. John Dalton, the famous British physicist who developed the theory of atomic matter was born on 6 September 1776. Carl Zeiss, founder of the famous optical lens making company from Germany was also born in September (11 September 1816). James Dewar, inventor of the thermos flask, and Seymour Cray, inventor of Cray 1 Supercomputer, were also born in September. Interestingly it was on 8 September 1994 when Microsoft planned to rename its operating system project from 'Chicago' to 'Windows 95'. We've all witnessed the journey of Windows since then and thereafter; rest is all history, an interesting one.

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

Mission Chandrayaan-2



Susheela Srinivas

Chandrayaan-2, India's second mission to the Moon, for the first time, will unravel secrets around the Moon's South Pole. This mission will not just capture information of the Moon and record data from orbit but will land on its surface and sample the Moon's terrain in detail. Chandrayaan-2 was launched on 22 July 2019 atop ISRO's GSLV Mk-III from the Satish Dhawan Space Centre at Sriharikota

We are off to the Moon again! This time around, on a bold mission to explore uncharted territories. *Chandrayaan-2*, India's second mission to the Moon will, for the first time, unravel secrets around the Moon's South Pole. *Chandrayaan-2* is a three-part spacecraft – an orbiter, a lander and a rover. The lander is named *Vikram* after Vikram Sarabhai, the founder of the Indian space programme. The rover is named *Pragyan*, meaning 'wisdom'.

This mission will not just capture information of the Moon and record data from orbit but will land on its surface and sample the Moon's terrain in detail. The lander carrying the rover will descend from the orbiter and soft land on Moon. After landing, the rover will roll out and explore the Moon surface.

Chandrayaan-2 was launched on 22 July atop ISRO's GSLV Mk-III at 2:43 p.m. from the Satish Dhawan Space Centre at Sriharikota. Performing as expected, the rocket released *Chandrayaan-2* in a highly elliptic orbit around Earth about 17 minutes later. In fact, it was released 6,000 km higher than planned. The solar arrays on *Chandrayaan-2* deployed smoothly as the probe began its journey.

Miles to go

Astronomically, the Moon at 3,84,000 km away from Earth. When a spacecraft is sent directly, (such as the Apollo 11 that took men to the Moon), it takes a little more than three days to reach it. However, such an operation calls for a very powerful rocket and enormous consumption of fuel to escape from Earth's gravity and go into lunar orbit. Compared to NASA's massive Saturn-V rocket, which was the most powerful rocket ever flown, the GSLV Mk-III is a much smaller and less powerful rocket. So, ISRO



Chandrayaan-2 was launched from Satish Dhawan Space Centre, Sriharikota, on 22 July 2019 onboard GSLV Mk-III.

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has chosen an indirect path for *Chandrayaan-2* which will take a few weeks to reach Moon.

After launch on 22 July, *Chandrayaan-2* was placed in a highly elongated Earth Parking Orbit; then, as it circled the Earth, a series of space manoeuvres and Earth's gravity assist propelled the craft farther and farther away from Earth. Finally, when the farthest point from the Earth and closest to the Moon was reached, the on-board propulsion system fired its engines and inject the craft into the lunar sphere of influence. The spacecraft was then placed in a 100-km high orbit around Moon.

The eight pillars

The orbiter will carry eight instruments all tuned to glean the minutest of data of the Moon. Here is what they will do once they reach the Moon.

Terrain Mapping Camera (TMC2): this high resolution, high signal to noise ratio output camera is designed to give spatial black and white images. The camera is highly sensitive to radiation and can pick up minor details of the moonscape. The pictures will help to develop a 3D map of the Moon.

Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS): A high-resolution instrument designed to detect the mineral wealth of the Moon. Moon is rich in minerals like aluminium, magnesium, silicon, titanium, iron and more, which when mined could yield abundant space commerce revenues. The materials emit specific X rays when excited by the Sun's rays, and as they do that, CLASS will capture the data and classify them.

Supporting CLASS is another instrument *XSM – Solar X-ray Monitor* that will measure the intensity of solar radiation. The spectral data from this instrument will be the input for analysing the readings of CLASS.

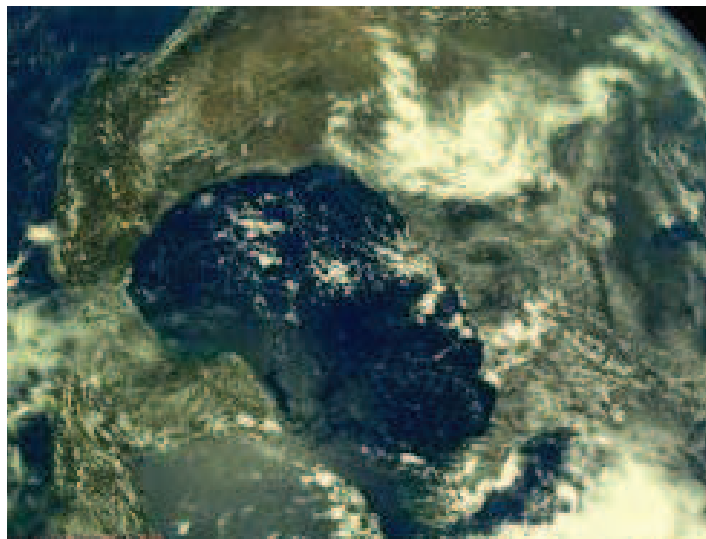
Imaging IR Spectrometer (IIRS): Another high-resolution instrument for mineralogical mapping and measuring the solar reflections from the surface.

The many firsts

- *Chandrayaan-2* is the first spacecraft to be attempting a soft landing in the South Polar Region.
- It is the first mission to be developed indigenously with home-grown technology.
- This is the first time ISRO is sending a Moon probe that will deploy the lander and rover.
- With the success of *Chandrayaan-2*, India will be the fourth nation to join the elite club to have soft-landed probes on the Moon. The other three nations to do so are the USA, Russia and China.



Artist's impression of Chandrayaan-2 in orbit.



First image of Earth sent by Chandrayaan-2.

IIRS will give a detailed picture of the suspected water ice source on the Moon.

The safety of the lander *Vikram* is in the hands of the **Orbiter High-Resolution Camera (OHRC)**. OHRC will peer at the landing site, leaving no stone unturned to ensure that *Vikram* will touch base safely. After *Vikram* is deployed, OHRC will serve the purpose of scanning the region for scientific measurements. The camera will scout an area of 12 km by 3 km with a resolution of 0.32 m.

Dual Frequency Synthetic Aperture Radar (DFSAR) is another water mapping device. This instrument – an enhanced version of its counterpart from the first *Chandrayaan* mission – will quantitatively estimate the water ice in the polar craters along with mapping the polar regions. Also, it will measure the thickness of lunar regolith – the soft, powdery sand covering the Moon's surface.

Chandrayaan-2 Atmospheric Compositional Explorer (CHACE 2) is an *in-situ* monitor to study the composition and distribution of lunar neutral exosphere and its distribution. The neutral exosphere is a barely detectable thin layer of a balanced flux vented out to space and partly recycled to the surface, resulting out of the interaction of the solar radiation, the decay of radioactive elements and meteorite bombardments.

Dual Frequency Radio Science Experiments (DFRSE) will focus on radiation and ionic experiments when on the Moon.

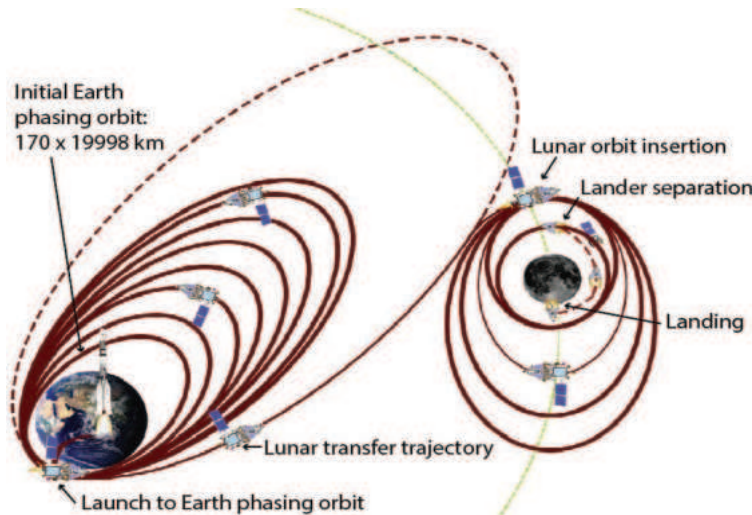
The three beauties

The lander, *Vikram*, will carry three payloads on to the surface of the Moon: **RAMBHA**, **CHaSTE** and **ILSA**.

Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA) is a plasma diagnostic tool called a Langmuir probe. RAMBHA will record the transient electron temperature variations, plasma density and other measurements at the surface of the Moon. These first-time measurements at the polar regions will be recorded under solar variations.

Chandra's Surface Thermophysical Experiments (CHASTE) will be involved in recording the thermal conductivity and vertical temperature gradients on the Moon surface. Consisting of sensors and heaters, the instrument will be inserted into the regolith to about 10 cm depth to make the recordings.

Instrument for Lunar Solar Activity (ILSA) is devoted to measuring the moonquakes. ILSA will be on high alert and not miss out even the minor tremors in the landing site area.



The trajectory of Chandrayaan-2 after launch.

Two to tango

Pragyan rover will carry with it two instruments which will scout the region along with the moving vehicle.

Alpha Particle X-Ray Spectrometer (APXS) will make an elemental determination at the landing site. The instrument will use X-rays to detect the composition of the rock-forming surface and look for elements such as sodium, aluminium, silica, magnesium, yttrium and others that have potential use.

Laser-Induced Breakdown Spectroscopy (LIBS) will fire high-power laser at different points on the surface and determine how abundant each element is.

Piggyback payload

Going along is NASA's passive experiment in the background which will be conducted by *Laser Retroreflector Array (LRA)*. This instrument will decipher the dynamics of the Earth-Moon system.

The landing site

The south pole of the Moon is a permanently shadowed area. Freezing temperatures and unknown terrains await *Vikram* and *Pragyan*. Before landing, the orbiter will take several high-resolution images of the terrain. This will provide a recheck of the designated landing site and ensure the lander-rover have a safe tenure on the Moon.

Vikram will land on a high plain between two craters Manzinus C and Simpelius N, at a latitude of about 70° south.

Why are we going again?

ISRO began plans for the second mission to the Moon, with a four-point agenda, soon after the success of *Chandryaan-1*. Steadily improvising and backed by indigenous technology, *Chandrayaan-2* was crafted over a decade.

To follow the water trail: Water is an essential commodity for our survival, whether on Earth or in space and is the primary pursuit of space missions to planetary objects – survivability and habitability on the space object scores high

with the availability of water.

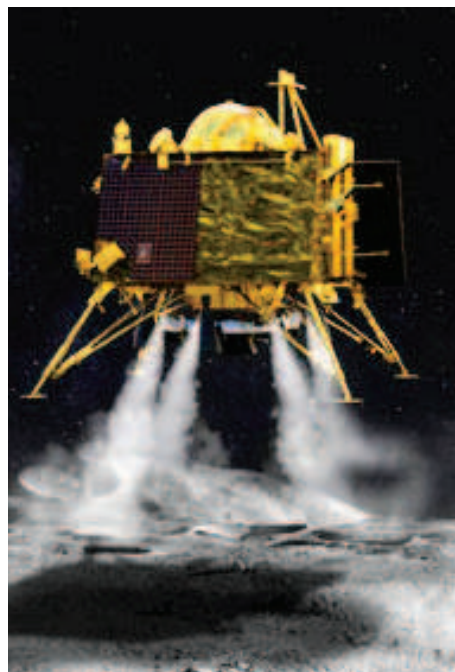
In 2008, ISRO's first Moon mission *Chandrayaan-1* brought back exciting data about our cosmic neighbour. *Chandrayaan-1* data showed evidence for water in the exosphere of Moon, on the surface of Moon and also subsurface (tens of metres deep). For the first time, traces of frozen water-ice were detected in the craters that abound in the south polar region by its instruments. This crucial discovery called for another exhaustive exploration.

Chandrayaan-2 is designed to investigate further about these frozen ice in lunar craters.

To size up the mineral wealth: *Chandrayaan-2* will be the first probe to go far down south from the lunar equator, as all the other probes have scouted only the equatorial regions. The mission will conduct extensive mineralogical studies to ascertain the mineral composition of the Moon. The collected data will open new vistas in space commerce in future missions.

To untangle Moon's mysteries: Detailed topographical explorations of the unexplored part of the Moon could unravel evolutionary secrets about it. The South Pole is like a deep freezer that can hold fossil mysteries from the past when the solar system was formed. *Chandrayaan-2* will investigate these secrets, which will help us understand our cosmic companion better and provide insights into our origins as well.

To perform ionic studies: The lunar probe will conduct a host of other scientific experiments and observations related to the effects of solar winds and ionisation on the surface of the Moon.



Artist's impression of Chandrayaan-2 lander Vikram.

Nail-biting moments ahead

From the lift-off to the landing of the rover, the mission is fraught with several challenges. The Earth-Moon duo has a non-uniform gravitational system which calls for advanced planning and calculations. The trajectories must be planned to take the orbital motion of the Moon into consideration.

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The Buzz About Transgenic Plants



Dr Anu Priya Minhas

Genetically modified crops are plants used in agriculture, where plant breeders select and transfer a desirable trait from one plant to the plant they want to improve. The inserted sequence is known as a transgene. Transgenics may provide valuable advantages such as improved shelf-life, higher crop yields, improved food quality, and many more. Although more research is required to determine the true safety of these plants, most would agree that the potential advantage of producing crops, which provide the human population with more and cheaper food, makes transgenic technology a useful invention.

Genetically modified organisms (GMOs) refer to organisms including plants developed through genetic engineering technique, allowing plant breeders to select and transfer a desirable trait from one plant to the plant they want to improve. The inserted sequence is known as transgene, which may be isolated from an unrelated plant or from an entirely different species. The transformed gene/s may have altered genetic code in order to modify their function. In addition, different regulatory sequences can be spliced on to switch on or off gene expression in the host plant. Stable transgenes from a successful transgenic plant can be inherited by further generations through pollination, resulting in transgenic progeny. Plant breeders can also use a transgenic plant for conventional breeding to develop transgenic varieties (new trait provided by the introduced genes) of the crop that are well-adapted for specific uses. Transgenic plants are also referred to as genetically engineered (GE), or genetically modified (GM), or bioengineered plants. For some, GM crops are the crop plants developed by genetic modification from their original wild state by domestication, selection and controlled breeding over long periods of time. Thus, according to the U.S. Food and Drug Administration, the term bioengineered is more preferred to describe transgenic crops.

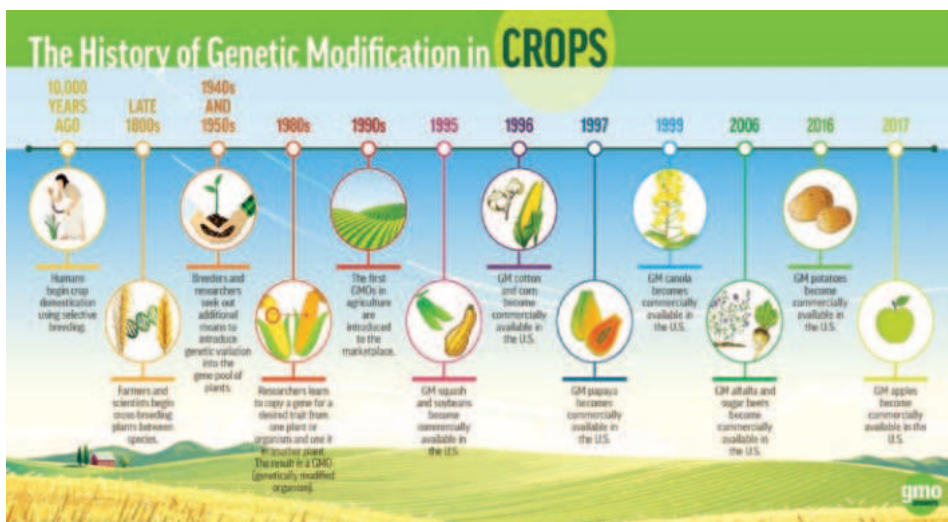
Why do we want to make transgenic plants?

Addressing the challenge of all forms of hunger, malnutrition and food insecurity is the second major goal of the 2030 Agenda for Sustainable Development and the SDGs. The attainment of this goal could largely contribute to the achievement of the other goals such as ending poverty, gender equality, improved health, clean water access, education and sanitation, and peace and justice. By 2050, the world population is expected to reach 9 billion and we need to satisfy the food-related needs of this large population from same area of agricultural land under adversely changing climatic



conditions. Already, there are examples of drought, storms, and hot days already taking a toll on crop yields.

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Unfortunately, the number of undernourished or chronic food-deprived people has grown over the past three years, (nearly 2 billion in 2016). Therefore, to cater to their needs, one obvious way is to use genetic techniques to improve agricultural crop productivity by introducing desirable traits for better plant survival under harsh environmental conditions. Limited genetic diversity is available within the closely related species of each crop. For improved traits, traditional breeding is solely dependent on randomly generated mutations. The process of developing transgenic plants increases the level of genetic variability, which is of prime importance to plant breeders. Sometime, genes responsible for useful traits might be absent in a particular plant species and have to be transferred from other species through genetic engineering methods. Exploiting genes from a wide range of species and genera beyond the crop species itself will allow plant breeders to produce more useful and productive crop varieties. Transgenics may provide valuable advantages such as improved shelf-life of perishable plant products, higher crop yields, improved food quality, resistance to various biotic stresses and tolerance to abiotic stresses and eliminate the use of harmful and environmental-unfriendly insecticides, fungicides, herbicides and pesticides. Transgenic plants may also be able to express foreign proteins of industrial and pharmaceutical value. The nutritional content of a crop can also be enhanced through genetic engineering. Developing edible vaccines or antibodies produced by plants using the genetic engineering is especially distinct as plants are

free of human diseases and can reduce the cost of screening viruses and bacterial toxins from the produced products.

In addition to the ability to produce crops with novel traits, genetic engineering also offers the promise of making plant breeding more efficient by reducing the time required to make new varieties. The ability to insert just one or a few specific genes into varieties without also affecting the other genes is the major benefit of using technology to produce transgenic plants. The knowledge gained from this kind of research can be applied in many areas of plant science, not just in the creation of new crop varieties with novel traits.

Techniques used for developing transgenic plants

For developing transgenics, the nucleus of a plant-cell is targeted for transgene insertion using either biolistic or *Agrobacterium tumefaciens*-mediated transformation methods. The “biolistic” method (also known as “gene gun”, “micro-projectile bombardment”, or “particle gun” method) can efficiently transform almost all cell types and has been used successfully to transform corn, rice, wheat and maize genomes. Briefly, DNA is bound to gold or tungsten particles and shot into plant tissue or plant cells using a high-pressure gun. The accelerated particles penetrate the cell wall and membranes. The coated DNA separates from the metal particles and integrates into the plant genome. Although the process is clean and safe, it may result in serious damage to cellular tissue.

The “*Agrobacterium*” method involves the use of soil-borne bacterium *Agrobacterium tumefaciens*. This bacterium can infect plant cells using tumour-inducing plasmid (Ti plasmid) and integrate later into plant DNA. The Ti plasmid is a large circular DNA containing regions of transfer DNA (tDNA). Transgene inserted in-between tDNA can be transferred to a plant cell through “floral dip” method, followed by harvesting transgenic seeds from the transformed plant. This process being natural might be more acceptable method of transformation. Further, *Agrobacterium* can be used to transfer large DNA fragments efficiently. However, limited host range is the biggest limitation of *Agrobacterium*.

Major advantages of transgenic plants

- 1. Stronger crops:** With GM technology, crops are engineered to withstand weather extremes and fluctuations, resulting in enough crop yields even under a poor or severe weather and soil conditions. As populations across the world grow and more lands are utilised for housing instead of food production, farmers are prompted to grow crops in areas that were originally not considered suitable for plant cultivation such as soils with high salt content and drought-prone soils.
- 2. Environmental protection:** GM crops often requires less chemicals and field management, therefore help reducing greenhouse gas emissions, soil erosion and environmental pollution. This means improvement in the general health and beauty of the environment that surrounds farms, contributing to better preservation of water and air quality, which can also indirectly benefit every person’s well-being.
- 3. Longer shelf-life of the food products:** Genetic manipulation method used in GM crops allows farmers and merchants to preserve the good quality of foods for longer time interval.
- 4. More nutritious foods:** According to the Food and Agricultural Organisation (FAO) of the United Nations, GM foods have also been biofortified for vitamins. This not only helps people get the nutrients they need, but also plays a significant role in fighting

against malnutrition in third-world countries. In fact, the United Nations recommends that rice that is enhanced with vitamin A (golden rice) can help in reducing deficiencies of such nutrients around the world.

5. **Less deforestation:** To sufficiently feed the growing population of the world, more plants are required to be grown in larger areas including those that were previously considered unsuitable for farming. Therefore, deforestation can be discouraged for acquiring more arable land.

Concerns about GMOs

The main opposition to GMOs arises from the intuitive notion “natural is inherently good”. It also combines the general belief about humans as hostile and selfish to rob nature of its worth. These notions make consumers more susceptible to claims related to health and safety as described below, despite little evidence to support such.

1. **Allergic reactions:** As genetic modification in transgenic plants often adds or mixes proteins that were not indigenous to the original plant, they might cause allergic reactions in our body. Concern is that proteins from organisms that you are allergic to might be added to those food plants that you were not originally allergic to. However, normal diets for humans and other animals contain large amounts of DNA from the cells of the various kinds of plants or animals constituting the food and from any contaminating microorganisms (if present). Most of the DNA we eat is degraded in the digestive system, but even if left intact, it is unlikely that this DNA would be incorporated into the DNA of our cells. Therefore, there is negligible chance of any undesirable effect on the whole organism.
2. **Reduction in biodiversity:** When we are selectively targeting a certain pest, we might be removing a food source from a food chain. This might be expected to lower the level of biodiversity.
3. **Cross-pollination:** Cross-pollination can introduce new genes into distant but compatible crop plants resulting in transfer of transgene into non-target crop plants. Genetic pollution resulting from inadequate sequestering of

genetically modified crop populations could affect the wild varieties around them through insects and winds and could have dramatic effects on the ecosystem. Though there is need for long-term research to gauge such impact.

What genetically engineered crops are being grown now?

The United States is the country with the highest cultivated area under transgenic crops (75 million hectares). According to Time magazine (US), the time first GM was planted into U.S. soil in 1996, they have observed a dramatic increase in crop production. Currently, ten transgenic crops are grown regularly. The most common genetically engineered crops now being grown are transgenic varieties of soybean, canola, cotton, and corn. Varieties of each of these crops have been engineered to have either herbicide tolerance or insect resistance (or in a few cases, both). All the genetically engineered insect-resistant crop varieties produced so far use specific genes taken from *Bacillus thuringiensis*, to produce proteins that are toxic to certain groups of insects feeding on them. India is presently ranking fifth largest in cultivated area under GM crops (11.4 million hectares in 2017). However, unlike other countries, the entire GM crop area in India is under a single crop, namely Bt-cotton, which is exhibiting resistance against bollworm insect pests.

Transgenic trait	Crops
Insect resistance	Corn, Cotton, Potato, Tomato
Herbicide tolerance	Corn, Soybean, Cotton, Canola, Sugar beet, Rice, Flax
Virus resistance	Papaya, Squash, Potato
Altered oil composition	Canola, Soybean
Delayed fruit ripening	Tomato
Male sterility and restorer system (used to facilitate plant breeding)	Chicory, Corn

Should we use transgenic crops?

The perceived advantages and disadvantages of transgenic crops must be married to each other, to provide a crop that is environmentally sound and non-hazardous. Producers of transgenic crops and the agencies that study their effects are aware of this point. However, to date, there has been little evidence to support either case. More research is required in this field to determine the true safety of these plants and to decide, whether they are safe for both the environment and for humans. At the least, most would agree that, the potential advantage of producing crops, which provide the human population with more and cheaper food, makes transgenic technology a useful invention.

How does Government of India regulate genetically engineered crops?

The Ministry of Environment, Forest & Climate Change (MoEFCC) has framed The Rules for the Manufacture, Use/ Import/Export and Storage of Hazardous Micro-Organisms/ Genetically Engineered Organisms or Cells in 1989 with a view to protect environment, nature and health as a result of application of gene technology and micro-organisms. India is among the earliest countries to institute a biosafety system for regulation of GMOs. The ‘Rules 1989’ cover research and large-scale applications of GMOs and their products including experimental field trials and seed production in support with the bio-safety following guidelines and following the international norms prescribed by the Organisation for Economic Cooperation and Development (OECD), CODEX Alimentarius Commission and International Plant Protection Convention (IPPC), etc.

1. Recombinant DNA Safety Guidelines, 1990 & 1994.
2. Revised Guidelines for Research in Transgenic Plants and Guidelines for Toxicity and Allergenicity Evaluation, 1998.
3. Guidelines for Generating Pre-clinical and Clinical Data for rDNA Vaccines, Diagnostics and other Biologicals, 1989.

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Mining for Rural People: An Oxymoron



Ankit and Kuldeep Bauddh

An intriguing fact is that, states like Odisha, Chhattisgarh, and Jharkhand, which are dependent on mineral resources, have low per capita incomes. Negative externalities associated with mining need to change through regulated and responsible mining. There is a serious need to fix the issue of faulty mining practices and the need to address a vital question whether the acts and rules and regulations legislated in this regard are helping the rural people or not.

India is endowed with numerous mineral deposits including fossil fuels and ranks as one of the top nations in key mineral production. However, metallic minerals and fossil fuels in India are very uneven in their geographical distribution. The states of Madhya Pradesh, Jharkhand, Chhattisgarh, Odisha and some areas of Telangana, Andhra Pradesh and Maharashtra are rich centres of metallic minerals and coal in central and eastern India. Huge deposits of iron ore can be found in Jharkhand, Odisha, Karnataka, Chhattisgarh and Goa. Deposits of zinc, lead, and copper are primarily found in Rajasthan, whereas, bauxite is found in Andhra Pradesh, Chhattisgarh and Odisha. Chhattisgarh, Jharkhand and Odisha are among top mineral-bearing states in India.

Minerals are found not only under unfertile wastelands, but also below large forests inhabited by tribal populations. Tribal people are an integral part of the forest; they derive their products of livelihood from forest and in many ways are dependent on it, so much so, that their economy and livelihood are intertwined with water resources and fate of the forest. Mining brings a lot of vagaries in terms of degradation of forest, which affects the ecosystem and makes the tribal population economically and socially vulnerable. An intriguing fact is that, states like Odisha, Chhattisgarh, and Jharkhand, which are dependent on mineral resources, have low per capita incomes in comparison with those states which have sources of income other than mining. According to an estimate done by the

Union Ministry of Tribal Affairs in 2014, more than 75% of rural tribal population in Odisha resides below poverty line. In other states like Madhya Pradesh, Maharashtra, Jharkhand and Chhattisgarh, the figure is above 50%. Mineral-dependent states are indeed in a sorry state, as these states also suffer from lower growth rates, malnutrition, morbidity and higher mortality rates.

Current status of mining in India

India is endowed with large reserves of various minerals across the country. The strategic location of India is such that it assists the mining sector in multiple ways, namely convenience in exporting minerals as well as fast developing markets of Asia. At present, India is known to produce around 88 minerals which include 24 minor, 50 non-metallic, 10 metallic, 3 atomic and 4 fuel minerals. Growing infrastructure and rapidly expanding industrial and domestic sector are the key drivers of the sector. In addition to this, cement and power industries are also responsible for the growth of mining sector.

Need for regulated and responsible mining

Sustainable mining is the need of the hour, but the prudent question is whether it is possible. Mining companies, internal agencies and the World Bank promote 'sustainable mining', but the bitter truth is that, mining carried out on a large scale is always destructive

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and the quantity of minerals that can be safely mined is limited. Mining is called a 'boom and bust' industry, which means that at the beginning, huge wealth can be generated when a new deposit is discovered, but when the mineral is exhausted, it leaves the area in the state of poverty. 'Sustainable mining' is an ambiguous term. Mining can

never be sustainable because the ore bodies are non-renewable and finite. Even those mines that are managed ideally also have an impact on the environment; they disturb the ecological balance, reduce the biodiversity, devastate land and forest and render it unfit for cultivation. Mass displacement of people and depletion in the livelihood of locals are some of the inevitable consequences brought through mining.

The fact is that modern economy cannot survive without mineral resources. If mineral is at the centre then all the industries be it jewellery industry, energy sector, automobiles, telecom industry or any other industry, are at the periphery. The question is not whether mining should be undertaken or not, rather it is regarding how it should be carried out. It is regarding the norms, policies, procedures that must be established to ensure that it is conducted in a socially acceptable and eco-friendly manner. It is also regarding exploring greener ways to undertake mining.

In the name of national development, local communities have been shoved deeper into poverty. They have been dispossessed, displaced, persecuted and marginalised. The main reason behind this includes inadequate policies, incompetent laws and weak institutions. All of these must be changed. There is an urgent need to reframe the contract between mining establishment and communities so that they get a share in the wealth generated. Mining must not be carried out without the consent of the community. Community consent is the bedrock of mining policies, but these safeguards are being diluted. Relationship between communities and companies has a legacy of distrust and abuse. This is reflected in the fact that India's most mineral-rich states are also the poorest, as communities receive the least from the immense wealth generated through mining; this is called

Status of India's minerals at a glance		
Minerals	India's rank	Production (million tonnes)
Coal	3	554.13
Iron ore	4	192
Steel	3	83.01
Bauxite	5	2908.15

Status of some major minerals of India (Source: ibef.org)

'Mineral Paradox'. The way forward is reframing of rules for mine closure.

Every open mine is a source of pollution. Mineral Concession Rule of 1960 and Mineral Conservation and Development Rules of 1988 were amended in 1993 and 2003 respectively. According to these amendments, mining companies are required to submit a 'progressive mine closure plan'. It is prudent to open a mine for mineral extraction, followed by quick removal of minerals and closing the mine.

Socioeconomic impacts of mining

Apart from macro-level changes, mining also brings changes at micro-level that are of equal credence. Although, mining plays a substantial role in development of infrastructure and increasing financial capital, mining also brings about socioeconomic changes in the society. Mining plays an important role in development of a region. Currently, the picture is not encouraging as it fails to bring parity among the project-affected community. Mining has cost on the environment too. In other words, we can say that, mining activities have an effect on the health of the people and the environment we inhabit. Mining requires acquisition of very large areas which puts a check on the accessibility and availability of economic housing options. At the same time, another spill-over effect of mining comes in the form of mining affected communities getting involved in various criminal and anti-social activities. While the present generation is battling with social problems like inequality in terms of social, economic and political opportunities, unfair competition, lackadaisical approach of the government as well as administration, mining companies divert the attention of the local communities on the short-term benefits leaving aside the long-term negative impacts like

pollution, displacement and relocation.

Mining attracts another set of socioeconomic problems as well; they are responsible for pollution of water bodies, shrinking croplands, increasing number of landless farmers, etc. Expanding mining activities is not only displacing the farmers

away from their fields but also converting them into landless farmers. This situation coerces them to deviate from their unique cultural inheritance as they have cultural and emotional affinity with their native farmlands. Farmers are affected the most as they lose their lands to mining, rendering them economically vulnerable. At times they express their anger through road blocks, strikes and destroying mining company's assets. Though mining companies justify their activities citing Corporate Social Responsibility (CSR) activities, without building a healthy relationship with the communities residing there, profits are meaningless. Apart from this, ever-increasing technological advancements is also a reason behind growing unrest among the masses.

Impact of mining on health of women and children

Mining has a heavy cost on the environment which in turn has an effect on the health of people, but the most vulnerable sections are women and children. As children are dependent on their mother for their basic necessities including food and upbringing, a child's health is intertwined with the health of mother. Here, woman's health must be seen from a larger perspective of direct as well as indirect impacts. It must be noted that the impact of mining is diverse and is based upon the type of mineral that is extracted.

Despite the fact that due to mining, people suffer from physical and mental deformities and ill health, there is a very large gap in the scientific study and data on the ill effects due to mining in India, especially women in the areas affected by mining. In one way or the other, such a gap in the knowledge helps the mining companies to run away from their responsibilities. Moreover, in a country like India where

health of a woman is already a marginalised issue, such type of data is all the more important. Benefit arising from mining diminishes the importance of women and child's health. It must also be noted that even those women and children who don't work in the mines are also constantly exposed to diseases like skin problems, respiratory problems, etc., and it also has long-term effect on the reproductive health of women.

It is imperative that effect of mines on women's health is studied. Some of the recommendations for addressing the problem of a woman worker in the mining are as follows:

1. Educating woman vis-à-vis safety issues, health and nutrition.
2. Promoting opportunities for women to work together
3. Regular screening and health check-ups for women and children.
4. Providing regular counselling and support for mental health services, addictions, prevention of violence and access to health services.
5. Outreach programs for identifying solution to problems related to community health.

Mining Rules: Are they really helping rural people?

Mining rules were legislated keeping multiple objectives in mind vis-à-vis the

equitable sharing of benefits, protecting the environment and protecting biodiversity and above it, protecting the rights of the rural communities affected by mining. But, the effect of these laws and amendments do not produce a bright picture. Rural people affected by mining are in a state of misery. Despite these rights, these people are used and abused at the mining site by mining companies. Also, there has been a constant dilution in the commitments of companies and government in sharing the profit; government's recent efforts for bringing reform in the sector are not well thought of.

Institutional reform is the single largest problem that has gripped mining industry. Weak law enforcement, irregularities and improper monitoring have largely been responsible for such a systemic failure. The result of such approach is reflected through several mining scams surfacing frequently, also there have been irregularities in iron ore mining in Bellary, Goa and Odisha to name a few. It is clear from the observations that, rather being helpful to poor these laws have proved to be anti-poor to a great extent.

Need of the hour is to look for environment-friendly ways to undertake mining. We are still mining using archaic techniques. The problem with open-pit mining is that minerals extracted through this process are very limited, that increases the amount of ore needed to be mined. Every open-pit mine is a huge source of pollution.

Extraction of ore from these pits produces a large amount of metallic dust. The problem with underground mining is that they require large-scale movement of vegetation and rocks and contaminate water and air. There is an urgent need for greener mining as well as refining techniques and reduce environmental damage by strengthening the existing rules and regulations.

Conclusion

This article was an attempt to emphasise upon the fact that mining is largely an anti-poor activity. There are several negative externalities associated with mining and there is urgent need to change this perception through regulated and responsible mining. The windfall gains of the mining companies are at the cost of the health of rural mine workers and on the health of their women and children. Also, there is a serious need to fix the issue of faulty mining practices and the need to address a vital question whether the acts and rules and regulations legislated in this regard are helping the rural people or not. Their rights must be safeguarded. Unless we bring about a sea change, mining will never be a pro-poor activity. It may be concluded that although mining has helped poor people in their financial uplift, it has also attracted multiple problems that should also be addressed with some sustainable mining approaches.

Mission Chandrayaan-2 *(Continued from page 32)*

When the probe reaches the Moon, *Chandrayaan-2* has to perform a gymnastic flip and fire its retro thrusters. The manoeuvre will slow down the craft sufficiently to remain in the lunar capture zone and place it in a 100 x 100 km radius orbit.

After being in lunar orbit for some time, the *Vikram* lander with *Pragyan* rover will separate from the orbiter and descend to a lower, 30-km orbit. Then on 7 September, the lander-rover combine will soft land on the surface of the Moon. There will be no parachutes to help *Vikram* as the Moon lacks an atmosphere. This is the trickiest part of the mission when the lander has to fire its retro-thrusters and



Artist's impression of Chandrayaan-2 rover Pragyan.

descend to the surface. By working against free-fall, the lander will gently glide down,

inching closer metre by metre. The procedure spanning about 15 minutes will be the toughest. If the landing succeeds, *Pragyan* rover will roll down from the belly of the lander and go exploring the moonscape.

This mission comes with bold ambitions and huge responsibilities, which, when fulfilled successfully, will play a crucial role in the way we perceive future Moon missions. "Through this mission, we aim to expand India's footprints in space, inspire a future generation of scientists, engineers and explorers, and surpass international aspirations," says ISRO on its website.

Lessons from the Wilderness



Dr Felix Bast

Turf grasses are narrow-leaved grass species that form a uniform, long-lived ground cover that can tolerate traffic and low mowing heights. These grasses are referred to as the cool-season turf grasses. Cool season turf grass lawns are notorious for their direct environmental impact. We need to water it year-round amidst rapidly diminishing freshwater resources of the world. On the other hand, plastic lawns are far more environmentally friendly compared with manicured lawns, as they demand no water, synthetic chemicals or lawnmowers during their lifetime that lasts for a decade or so.

With all the amenities of modern lifestyles and urban dwellings that come in various brands and standards like flats, studio apartments, mansions and condominiums reflects postmodern human civilisations; function over forms sans purpose. However, industry-grade design elements of post-modernism often overlook the humble simplicity and relaxing atmosphere of green surroundings— hallmarks of rustic countryside dwellings. Consider an urban apartment; chances are high that it is sparsely decorated with greenery. Modern research has repeatedly revealed that green ‘living’ surroundings relieve our psychological stress and make us happier and more productive. No wonder many modern habitations feature prominent well-landscaped and manicured lawns all around.

However, there is a catch that almost all of us are oblivious of. The question is how natural are they. Suppose I gave you two options to pick the one that is more natural and environmentally friendly: a lush green lawn vs. a fake artificial ‘plastic’ lawn. Many would pick the former; after all, it is a living entity rather than the non-living one. The issue is as philosophical as empirical; how would we objectively define the term natural or environmentally friendly.

Turf grasses are narrow-leaved grass species that form a uniform, long-lived ground cover that can tolerate traffic and low mowing heights. These grasses are referred to as the cool-season turf grasses. Cool season turf grass lawns are notorious for their direct

environmental impact. We need to water it year-round amidst rapidly diminishing freshwater resources of the world. They also demand copious amounts of synthetic chemicals, including pesticides, weedicides and fertilisers. Modern research is revealing how synthetic chemicals irrevocably change the soil microbial community structures. Plant growth promoting activities of a number of symbiotic and free-living soil bacteria and fungi are now being unfolded and detrimental effects of synthetic insecticides and fertilisers on them are coming to the fore. Many of the synthetic chemicals ultimately find their way to water bodies through nutrient run-off. Synthetic chemicals, especially the older ones, also get into our (and other organisms’) body through the process of bio-magnification, as exquisitely illustrated by Rachel Carson in her 1962 classic *The Silent Spring*. Despite all these negative impacts, an often-cited argument for lawns is that they sequester (remove) CO₂ from the atmosphere and help in mitigating global warming to a certain extent. However, note that lawns demand frequent (indeed weekly) ‘manicuring’ by mechanical lawnmowers; an hour usage of a typical lawnmower is estimated to release 11 times more CO₂ compared with an hour use of new cars, and that alone would offset whatever CO₂ that the lawns remove from the atmosphere.

For me, lawns and golf courses are like treadmills in a gym. Often I wonder why anyone should walk or run in the cloistral,

monotonous and stressful gym treadmill, expending substantial loads of electricity and money while the free-to-access outdoor spaces are everywhere stretching out all the way to horizons in all directions. Irony is that most people drive in big cars to work, and to gyms. I had been bicycling to work for a long time now, merging two chores in one (commute and exercise) thereby saving three of my precious resources (time, money and health). Even the latest research that have surmised the job with highest life expectancy in India is that of postal delivery people owing to their cycling culture won't motivate car owners to switch to cycling, as today's egocentric social systems seek status and validity over education and unpretentious reality. Like cars and gym treadmills, lawns were born nine centuries ago in England and Northern France, originally as a status symbol. Well-maintained lawns had been a hallmark of Victorian mansions and continue to be so everywhere in the West (Fig. 1).

Even in India, our affluent neighbourhoods and parks had been imitating their western counterparts for at least a century. Ironically, our parks had never been like this in the past; traditional Indian landscapes were more or less centred on large fruit trees like mango, banyan and Bodhi (*Ficus religiosa*). Landscapes oftentimes featured muddy ponds with wild aquatic plants (like the lotus and water lily, *Nymphaea nouchali*), natural meadows and pastures with ample of wildflowers (frangipani, white baubinia, jungle geranium, hibiscus, rhododendron, golden shower tree, Ashoka, and so on) and fragrant vines like jasmine. Mughuls introduced the symmetry and strategically intersecting water channels. They also introduced a number of non-native plants from Persia and elsewhere that are widely believed by Indians to be native to India, including the *imli* (tamarind) and cashew nuts. Even today, one can see quintessential Mughul gardens inside Rashtrapati Bhawan, Taj Mahal, and Lodi Gardens—all devoid of lawns. Carpeting with turf grass lawns had never been part of the Indian



Figure 1. Swath of a hillside crop monoculture field at Nottinghamshire, UK. Image: Dave Massey via www.natures-desktop.com

style; Europeans introduced it in 18th century. Traditional Japanese gardens too never had any lawns; the difference is that the imperialists had never colonised Japan and that their traditions remained more or less same in the last millennium. The carpeting is achieved in Japanese gardens by mosses wherever available (Fig. 2). A prominent design element of Japanese Zen gardens is strategically placed, out of symmetry rocks exemplifying the Japanese concept of *wabi-sabi*— the wild beauty in things that are imperfect and impermanent. Embracing Nature as it is, with all its imperfections, is the highest form of nature connectedness and environmentalism, in deed.

Concept and ethics of the term “natural” are surprisingly complex. Have you ever pondered why anyone should crave for pure breeds of cats and dogs paying exorbitant amounts while millions of stray animals are freely available and ‘waiting’ to



Figure 2. Prominent turfgrass lawns are integral component of Victorian mansions like the pictured Eden Mansion, England. Image: Deadline News, UK

be adopted by good-hearted people? How ‘natural’ are those pedigrees anyway, sculptured by generations of intentional, human-mediated ‘artificial’ breeding? Perhaps you might have seen bonsai trees or cubical fruits when fruits are grown inside cubical jars. The consensus among ethically conscious people is that all these practices construe under the broad framework of inhumane and unethical pursuits. While the term ‘pain’ is often defined within the context

of consciousness and is controversial to say that plants do feel pain, modern research has revealed that plants do elicit a series of stress responses when harmed. The typical—often nostalgic— smell of a freshly mowed lawn is caused by nothing but aromatic volatile organic chemicals produced by the plants in response to being wounded. By providing great nourishment in the form of excessive and year-round supply of water and fertilisers and cutting the blades before the plants reach sexual maturity is analogous to a heartless sadist flaying (excruciatingly painful method of execution by removing the skin from the live body) and castrating a group of well-fed children to ensure perpetual sexual immaturity!

Now consider I gave you two options to choose which is more environmentally friendly; a genetically modified Bt-cotton and normal cotton. While the case of GMOs is contested among the world's moral and ethical philosophers, the environmental and philanthropic impacts are more objectively measurable. While normal cotton plants are disease susceptible and demand an inordinate use of synthetic chemicals to ward off pests, the Bt-cotton is far more disease resistant. The environmental impact of disease-resistant GM plants like Bt-cotton is indeed far less than the susceptible counterparts. The widespread introduction of GM crops in the late 1990s

paved a way to drastically reduce world's food crisis. Contrary to popular perception, myths and hoaxes, the scientific consensus is that GM plants are as safe as wild variants and its use have not lead to a single case of the human disease. Prior to the advent of molecular cloning techniques for the development of GM plants, the route that agrarian civilisations of the world followed over the last thousands of years was that of crop breeding—an example of artificial breeding. Genetic engineering and crop breeding programmes are very similar, both are human-mediated and both are for the development of high-yielding and disease-resistant varieties.

Perils of turf grass lawns were known in the early 1900s; however, the practice continues till date. After all, we are a social animal; like owning a car and a big house are status symbols, so are lush green carpeted turf grass lawns— an obvious case of conformity towards social identity, also called 'groupthink'. Despite social stigma, many non-conformist counterculture groups in the west have fought against lawns by looking for alternatives. Native low-lying perennial grass varieties are an excellent alternative to the introduced British turf grass. Left untouched, fertile grounds often revert to the wilderness attracting its natural pollinators. While in the west, meadows with chamomile, self-heal, thyme, daisies, etc., are often planted to create a natural meadow-like habitat, in India we could use the locally abundant and endemic turf-forming groundcover species like spider grass, clover, Brahmi (*Bacopa*), ivy, mint and so on. Ten sacred wild ivies and flowers of Kerala, known as the '*dasapushpa*', are all traditional low-maintenance alternatives (Mountain knotgrass, golden eye-grass, false daisy, little ironweed, morning glory, slender-dwarf morning glory, lilac tassel flower, little tree plant, Indian doab, and balloon plant). For shaded and humid regions, moss is an excellent alternative. Moss was at one time a highly admired plant even in Great Britain—the birthplace of turf grass lawns. A prized possession and ornamental souvenir during the Victorian times was the so-called moss terrariums; a miniature low-maintenance



Figure 3. The moss garden at Saijoui Temple, Kyoto, Japan. Image: Wikimedia

landscaped moss garden in a glass jar. The wild alternatives to the turf grass demand far less maintenance; need no synthetic fertilisers or weedicides for growth, and water consumption is also very minimal.

A major advantage of turf grass lawns is their resilience to physical stress—like when used as a playground with a high level of physical stress. A good alternative to such areas that are subjected to high-intense physical stress is artificial lawns. Of course, these fake, plastic lawns are artificial; but they are far more environmentally friendly compared with manicured lawns, as they demand no water, synthetic chemicals or



Figure 4 Polyculture at The Eden Project, Cornwall, England. Image: The Eden Project

lawnmowers during their lifetime that lasts for a decade or so.

Turfgrass lawns are an example of monoculture, a vastly common agronomical trend in modern times with huge environmental repercussions. In monoculture, just one species is cultivated in a large area. This leads to population fragmentation of pollinators, especially bee population. Fields of crop plants are indeed examples of monoculture. Biodiversity of such monoculture fields is minimal. Many studies have revealed that bee populations around the world are on a decline, perhaps owing to

the excessive crop monoculture around the world. In nature, no single species is living on its own; species occupy its own unique position in a complex and interwoven web of ecological niche. Consider any forest; you will find a vast number of plant, animal and microbial species living together. Several studies have revealed that a mixed community involving multi-trophic level ecological niche is far superior and stable compared with monoculture. This phenomenon is sometimes referred as 'portfolio effect'; analogy here is a stock portfolio containing a diversified admix of stocks from various sectors and various risk levels that have far stable and superior returns than a portfolio consisting of just a single stock. The diversified portfolio is more resilient as well (it can recover from sudden market collapse). Similarly, a multi-trophic community is far more stable and resilient (able to recover from natural calamities faster). As mixed communities are the norm in nature, poly culture is a healthier alternative to monoculture. Modern agricultural practices especially that of the cereal crops, has started a marked shift from crop monoculture to a polyculture or 'multi-trophic' agriculture (Fig.3).

For example, one can cultivate carrots and onions together—the so-called companion planting; the onion smell wards off pests infesting carrots like carrot root fly, and carrot smell keeps onion flies away. Ferns like *Azolla* is grown in rice fields as the ferns have algal symbionts like cyanobacteria *Anabaena* that fix atmospheric nitrogen to ammonia and nitrates making these readily available for the rice plant. Many modern farming practices encourage polyculture.

Examples include permaculture (permanent agriculture), devised by Australian researcher Bill Mollison, which is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems; no-till, no-herbicide grain cultivation and natural farming and re-vegetation of desertified lands developed by Japanese farmer and philosopher Masanobu Fukuoka; and forest farming, or the cultivation of high-value specialty crops under a forest canopy that is intentionally modified or maintained to provide shade levels and habitat, propagated by Japanese missionary Toyohiko Kagawa. Similarly, instead of culturing a single species of marine animal (for example, a species of fish), modern aquaculture has adopted Integrated Multi-Trophic Aquaculture (IMTA) wherein several species of animals and plants occupying its own unique niche in the mixed community is being fostered. For example, a number of seaweed species are deliberately introduced into shrimp or fish aquaculture systems that can assimilate excess inorganic nutrient, while a number of shellfish species (like abalone) can extract

the organic nutrient load such as the fish excrements. As excess nutrients are effectively used by other trophic levels and sequestered, problems such as eutrophication can be prevented. A number of filter feeders, such as coprophagous organisms (organisms assimilating excreta such as echinoderms like sea urchins), decomposers, detritivores (such as fungi) can also be introduced as part of this system. Such a system is more balanced, resilient, stable, and is more economical (as the fisherman can as well harvest abalones and seaweeds in addition to the fish/shrimps).

Like polyculture, yet another 'back to wilderness' trend of postmodern counter-culturists is foraging. Before the advent of agriculture, human societies were primarily hunter-gatherers. They had been gathering our plants and fruits from wild nature for a long time like other animals do in nature at present. I remember in my own childhood days in Kerala we used to forage in the uncultivated lands and valleys for edible wild berries and tree nuts. Foraging virtually disappeared in modern lifestyle, perhaps owing to our aversion towards risks

and uncertainties. Of course, there are risks associated with foraging; there might be snakes and other venomous creatures in the wilderness, and we will never know whether those colourful berries are poisonous or not. However, there is an innate desire and wild joy in the pursuit of foraging that only those who deeply love nature could feel. To differentiate between what is edible and what is not, we need to identify commonly occurring wild plant species- a skill almost non-existent in the modern times.

Foraging is increasingly getting popular in the west, especially in Scandinavian countries where I had the first-hand experience a year ago. Creative counter-culturists advocating back to wilderness campaign, culinary experts and computer programmers around the world have been joining their hands together to create a number of foraging guidebooks and apps that guide the users towards various locally abundant edible botanicals (including seaweeds). One such a notable mobile app is VILD MAD developed by the Danish team that included the famous chef René Redzepi.

The Buzz About Transgenic Plants *(Continued from page 29)*

4. Guidelines and Safe Operating Practices (SOPs) for Confined Field Trials of Regulated Genetically Engineered Plants (GE).
5. Guidelines for the Safety Assessment of Foods derive from Genetically Engineered Plants, 2008 (Updated 2012).
6. Protocols for Food and Feed Safety Assessment of GE crops, 2008.
7. Guidelines and Handbooks for Institutional Biosafety Committee 2011.
8. Guidelines on Similar Biologics: Regulatory Requirements for Marketing Authorization in India, 2012.

Currently, there are six committees for handling of various aspects of "The Rules 1989". The mandate of the six Committees notified under Rules 1989 is as follows:

1. The Recombinant DNA Advisory Committee (RDAC) advises and reviews developments in biotechnology at national and international levels. The Committee recommend suitable

and appropriate safety regulations for India in recombinant research, use and applications from time to time.

2. The Review Committee on Genetic Manipulation (RCGM) was founded under the Department of Biotechnology, Ministry of Science and Technology to monitor the safety-related aspects of on-going research projects and activities. The Committee brings out manuals and guidelines stating procedure for regulatory process with respect to activities involving genetically engineered organisms in research, use and applications including industry with a view to ensuring environmental safety.
3. The Genetic Engineering Appraisal Committee (GEAC) established under the Ministry of Environment, Forest & Climate Change (MoEFCC) is the apex body to agree to the notifications under Rules 1989. Committee reviews and approves the activities involving large-scale use of hazardous microorganisms and recombinants in research and

industrial production from the environmental angle. The Committee also looks in proposals related to release of genetically engineered organisms and products into the environment including experimental field trials (Biosafety Research Level trial-I and II known as BRL-I and BRL-II).

4. State Biotechnology Coordination Committees (SBCCs) are monitoring committees with powers to inspect, investigate and take punitive action in case of violations of statutory provisions.
5. District Level Committees (DLCs) are involved in monitoring the safety regulations in installations engaged in the use of genetically modified organisms/hazardous microorganisms and their applications in the environment.
6. The Institutional Biosafety Committee (IBSC) is an institution-level committee to oversee ongoing GMO research in the institute and to interface with the RCGM in regulating it.

Recent Developments in Science and Technology



Biman Basu

Our planet's magnetic field arises from the circulation of molten iron and nickel in the Earth's outer core, deep within our planet's interior. In the outermost crust of the Earth, rocks also produce magnetic field, but their contribution to the overall magnetism of the Earth is not significant. However, a new finding not only suggests that Earth's mantle might not be as magnetically inactive as previously considered. The research could have implications for other branches of science, such as palaeomagnetism.

New light on Earth's magnetic field

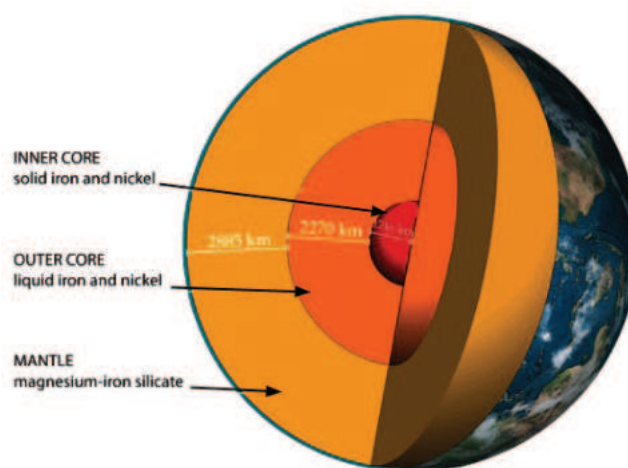
The magnetic compass point north because the Earth behaves like a giant magnet. The Earth's magnetic field is an invisible shield that protects our planet from energetic rays such as cosmic rays, charged particles and other harmful radiations coming from space by deflecting them away from the surface. It serves to deflect most of the solar wind, whose charged particles would otherwise strip away the ozone layer that protects the Earth from harmful ultraviolet radiation.

Through seismic studies, it has been known that at the heart of the Earth is a solid inner core, two-thirds the size of the Moon and composed primarily of iron. At a temperature of 5,700°C, this iron is as hot as the Sun's surface, but the tremendous pressure caused by gravity prevents it from becoming liquid and it remains solid. Surrounding this is the outer core, a 2,270-km thick layer of iron, nickel, and small quantities of other metals. Here, the pressure being lower than at the inner core, keeps the metal in fluid state, which circulates due to the Earth's rotation.

For a long time, it was believed that our planet's magnetic field arises from the circulation of molten iron and nickel in the Earth's outer core deep within our planet's

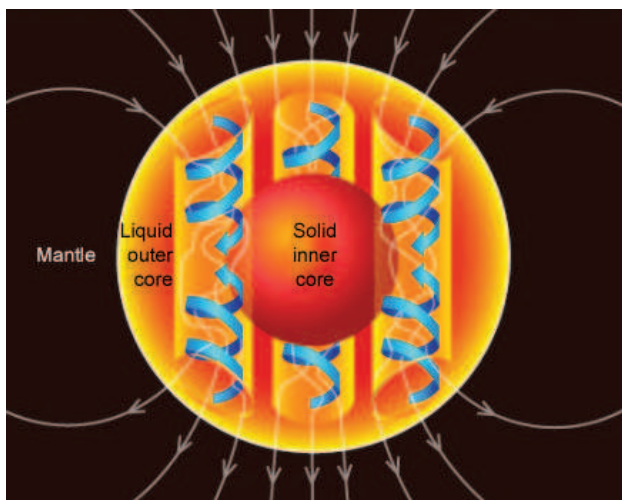
interior. Differences in temperature, pressure and composition within the outer core cause convection currents in the molten metal as cool, dense matter sinks whilst warm, less dense matter rises. The Coriolis force, resulting from the Earth's spin, also causes swirling whirlpools. This flow of liquid iron generates electric currents, which in turn produce magnetic fields. Charged metals passing through these fields go on to create electric currents of their own, and so the cycle continues. This self-sustaining loop is known as the geodynamo.

In the outermost crust of the Earth, rocks also produce magnetic signal, but their contribution to the overall magnetism of the Earth is not significant. In the deeper regions of the Earth's interior, however, it was believed that the rocks lose their magnetic properties due to the very high temperatures and pressures. The mantle – the mostly-solid



Earth's inner structure

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An image showing the Coriolis effect in the core creating “rolls” of material that create Earth’s magnetic field. (Credit: <http://www.abc.net.au>)

bulk of Earth’s interior – stretching from 35 to 2,900 kilometres below the Earth’s surface, was believed to be non-magnetic and play no role in Earth’s magnetism. But recent research has thrown new light on the contribution of Earth’s mantle to our planet’s overall magnetism.

An international team of researchers from Germany, France, Denmark and the USA has now demonstrated that a form of iron oxide called haematite, can retain its magnetic properties even deep down in the Earth’s mantle. The researchers used a technique known as ‘ID18 beamline’ to study the iron oxide hematite (Fe_2O_3), a strongly magnetic mineral, at temperatures and pressures found down to the Earth’s lower mantle. Their study provides evidence that haematite retains magnetic properties at the depth of the transition zone between the upper and lower mantle at certain temperatures and could therefore be a source of the overall magnetism of Earth (*Nature*, 6 June 2019 | DOI: 10.1038/s41586-019-1254-8).

For the study, the scientists used samples of synthetic haematite in single crystal and powdered form and combined two methods. Using a so-called ‘diamond anvil cell’, they squeezed micrometric-sized samples of haematite between two diamonds and heated them with lasers to reach pressures of up to 90 gigapascal (about 900,000 times atmospheric pressure) and temperatures of over 1,000°C. The researchers combined this method with a technique known as Synchrotron Mössbauer Source spectroscopy

to probe the magnetic state of the samples. They were surprised to find that the haematite remained magnetic up to a temperature of around 925°C, the temperature prevailing in the subducted slabs beneath the western part of Pacific Ocean at the Earth’s transition zone, located between the lower mantle and the upper mantle, between a depth of 410 and 660 km.

According to the researchers, the new finding not only suggests that the Earth’s mantle might not be as magnetically inactive as previously considered, but the research could also have

implications for other branches of science, such as palaeomagnetism.

The truth behind bitter almonds

Almonds have had a place in the human diet for thousands of years, even before they were cultivated and sweetened. Almond (*Prunus dulcis*) is the seed of the fruit of the almond tree. Almonds are tasty and nutritious, but some almonds taste bitter and are dangerous to eat because they contain amygdalin – a substance containing cyanide. Amygdalin reacts with enzymes in the intestines and consuming enough of it can be deadly.

Cultivated almond is mostly sweet, but wild almonds are bitter. Almond breeders have long endeavoured to cultivate varieties that lack the potent poison, but without success. Now, an international team of researchers from Spain, Switzerland, Denmark and Italy has found the genetic difference between bitter wild almonds and the sweet domesticated variety by sequencing the complete almond genome for the first time. Nearly 28,000 genes and roughly 246 million sets of DNA letters, or base pairs – almost 95 per cent of the genes – are represented in the genomic sequence. The researchers were

able to uncover a cluster of genes encoding transcription factors linked to kernel taste (*Science*, 14 June 2019 | DOI: 10.1126/science.aav8197).

The team’s work involved sequencing the genome of the almond and then studying differences between varieties to determine which part of the genome was responsible for producing amygdalin. After comparing the different varieties over the course of two years, the researchers found what they were looking for – a protein called bHLH2. They found that in wild almond trees, bHLH2 binds to two genes, instigating the production of amygdalin. In sweet, domesticated varieties, a mutation in the bHLH2 protein – caused by swapped amino acids that make up proteins – prevents it from binding to these genes, stopping them from making amygdalin.

“It made me laugh that, in the end, a very simple thing made such a difference,” says plant biochemist Raquel Sánchez Pérez of the University of Copenhagen and the University Campus of Espinardo in Murcia, Spain who was a member of the research team.

The new finding may be significant commercially. Growing and selling almonds is big business – recent statistics show that California in the US alone exported approximately 10,700 tonnes of the nuts last year, earning more than \$21 billion in revenue. The researchers believe their findings will help almond growers become more efficient. Currently, nature sometimes interferes with human cultivation efforts, allowing some almond trees to grow with the wild version of bHLH2 – but farmers are not able to identify them because they must wait three or four years for a tree to



Almonds are tasty but some are bitter. Scientists have discovered the genetic cause of bitterness in almonds.

fruit before they find out. But now that this “sweetness gene” has been identified, scientists can pluck a leaf off of a months-old sapling, analyse its genetic makeup and discard undesirable varieties.

According to the researchers, the genetic information can also provide clues to other traits such as resistance to pests or when a tree will bloom during the flowering season. This is particularly helpful for regions heavily impacted by climate change, including Spain – where breeders are already beginning to see shifts in the growth cycle, with many almond varieties flowering later and later in the year.

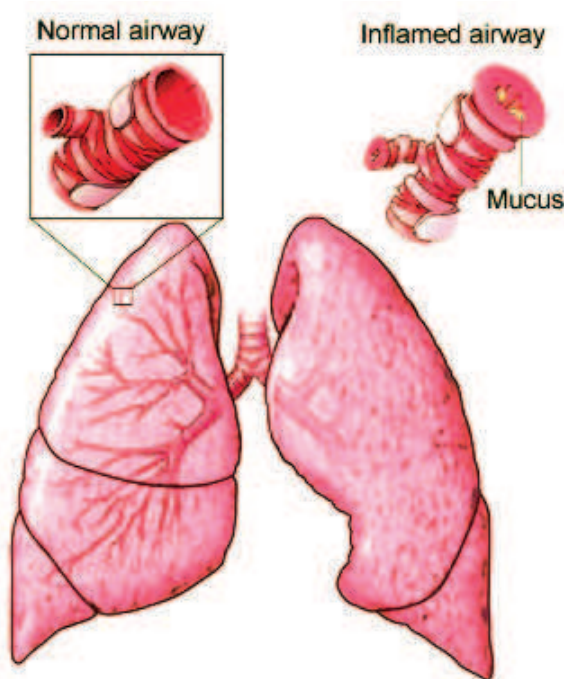
First lung map provides new insights into asthma

Asthma is a common lung condition that makes breathing difficult and triggers coughing, wheezing and shortness of breath. It is caused by swelling of the tubes that carry air in and out of the lungs making it difficult to get enough oxygen. According to the Global Asthma Report 2018, asthma kills around 1,000 people every day and affects as many as 339 million people globally and its prevalence is rising. Low- and middle-income countries disproportionately suffer the most severe cases.

Asthma is characterised by variable and recurring symptoms, reversible airflow obstruction caused by excessive production of mucus in the lungs and easily triggered bronchospasms. Symptoms include episodes of wheezing, coughing, chest tightness, and shortness of breath. It can last for years or be lifelong. Although the disease is not always fatal, asthma can be severely debilitating and leads to significant loss of human productivity.

While it is often manageable with medication, over long time, asthma can cause ongoing problems and there is the risk of severe, life-threatening asthma attacks. A better understanding of healthy lung cells and the differences with asthmatic lungs is required to develop new effective medications.

Till now, it was not known that asthma was caused by different cell types although it was known to be triggered by allergy



Asthma is characterised by swollen airways and release of excessive mucus that makes breathing difficult.

and to be hereditary in some cases. Now, for the first time, researchers have mapped the building blocks of the human lungs and airways, in both asthma patients and normal people. The research was conducted jointly by the Wellcome Sanger Institute, UK; University Medical Centre Groningen, The Netherlands; Open Targets, a public-private initiative to generate evidence on the validity of therapeutic targets based on genome-scale experiments and analysis; and GlaxoSmithKline, a British multinational pharmaceutical company. The research revealed the identity of each cell type, creating the first draft Human Cell Atlas of the lung. The researchers also discovered an entirely new cell state that produces mucus in asthma patients (*Nature Medicine*, 17 June 2019 | doi: 10.1038/s41591-019-0468-5).

For their study, the researchers used single cell technology to study samples from 17 people without asthma to explore cell types within normal lungs and upper airways. They analysed more than 36,000 individual cells from the nasal area and from three different areas of the lung. This allowed them to see exactly which genes were active in each cell and identify the specific cell type.

The researchers then detected the different cell types and activities in lung samples from six asthma patients, comparing them to normal lungs. They discovered

there were clear differences between the cells in normal and asthmatic lungs. One symptom of asthma is an overproduction of mucus. However, not all the cells responsible for this were known. The researchers discovered a new mucus-creating cell state – the muco-ciliated state – in asthmatic lungs, that had not been seen before.

In normal people, all kinds of cells in the lungs communicate with each other in order to keep the airways functioning well. But in asthma patients, almost all of those interactions are lost. Instead of a network of interactions, in asthma the inflammatory cells seem to completely dominate the communication in the airways. The anatomical map, published in *Nature Medicine*, shows the differences between healthy airways and asthmatic airways and identifies how cells in the lung communicate with each other. Knowing the types of cells in asthmatic lungs and how they

communicate, could help researchers seek new drug targets that could prevent the cells from responding to the inflammatory signals and help restore normal lung function, the researchers say.

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