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VISION INDIA

CLEAN AND GREEN STRATEGIES TO RESTORE OUR ENVIRONMENT

HYDROGEN: A PROMISING ENERGY HERO FOR GLOBAL APPETITE

HUMAN VIROME: A NOVEL CANOPY AMONG PLANETARY BIOME

Azadi Ka Amrit Mahotsav

VIGYAN PRASAR

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NAKUL PARASHAR

Only One Earth

'ENEMIES AT your gate' is the name of a short film made by my friend and an accomplished media personality, Rizwan Ahmad of MANUU, Hyderabad (https://youtu.be/Ch32IruQXoI). I found this one to be very time-relevant. It's about the environment and, thus, something that all of us are concerned about and eagerly looking forward to some concrete and permanent solution. For us in India, as soon as the summers set in, we feel the consequences of our past wrongdoings when the mercury starts to hit the roof. This year, we've all witnessed an early onset of the summers, and as days pass by, the heatwave is felt unabated and increasing. We are all aware of it, but on the ground, where are we, and what are we doing to ensure that no further artificial destruction to the environment is allowed! The paths to the destruction of the environment have to be blocked or dug up so that we can shun away the enemy knocking on our doors.

June 5th is celebrated as the World Environment Day. This year, the host country is Sweden, with the campaign slogan as **only one earth** aimed at living sustainably in harmony with nature. Interestingly, this year's World Environment Day went back to Sweden, from where it all started 50 years ago, as the famous 1972 Stockholm Conference. **Only one earth** was also the campaign slogan from the 1972 conference, and UNEP has been managing it. From the UN Sustainable Development Goal standpoint, relevant goals for the World Environment day are goals 1, 2, 6, 7, 12, 13, 14, 15, and 17, which emphasise the importance of this day.

Pundits of the domain have been warning about the perils of ignoring the early warnings about the environment and thus have constantly been suggesting ways to do our bit. Reduce, reuse, and recycle tops the list of things we should do. Lessening what we trash can undoubtedly assist us in maintaining natural resources. So, why wait for others to join in their endeavour to clean up the localities! Creating awareness and educating people are equally critical. Water, we all know, is highly important, and thus, conserving it is equally important. When choosing sustainability, we should look for food and clothing that adhere to related parameters. From Rizwan's movie, one strong message about plastics that cuts across all is that they should avoid plastic bags while going out for shopping. Reducing greenhouse gas emissions by using long-lasting light bulbs is also essential. Our age-old tradition of planting a tree is indeed an important one in this list of things to do. We should ensure that chemicals are not thrown into the waterways. Indeed, still, a lot more to do.

Amidst all this, I have seen that many discussions and decisions have been arrived at, and a lot more has happened during the past two decades. Yet, for reasons galore, the damage so far has been irreversible. This thus puts a big question mark on the efficacy of the steps taken so far. For this World Environment Day in 2022, I guess we need to put our heads down and continue relentlessly to fight the growing environmental issue.

Wishing all of you a very happy Environment Day 2022.

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SUSHEELA

VISION INDIA:

CLEAN AND GREEN STRATEGIES TO RESTORE OUR ENVIRONMENT

Images source: NASA

Melt streams on the Greenland Ice Sheet on 19 July 2015. NASA photo by Maria-José Viñas.

From the microorganisms to the most complex creatures, all beings come to this world with an innate responsibility to respect an unwritten pact: to preserve the bounties of nature and sustain the cycle of life harmoniously. This plan prompts us to take what is necessary to live and thrive and also calls upon us to tread carefully and be mindful of our actions not to topple the delicate balance so that the grand scheme of life on Earth flourishes.

Sadly, humans–the most evolved and intelligent creatures–deviate from this pact grossly. Human greed has left the planet bruised and depleted in resources. Earth is seriously in need of healing.

CLARION CALLS

Many concerns plague us today due to our insensitive ways: carbon emissions, greenhouse gases, pollution, consumerism, plastics, and climate change. Reportedly, there has been a 40% increase in the global collective emission of carbon dioxide and greenhouse gases since 1990. India contributes a significant chunk to this rise and ranks second globally, with over three billion tonnes of emissions annually.

Pollution is everywhere. According to the World Air Quality report, 35 out of 50 cities with the worst air quality are in India. Given India's growing vehicular woes and traditional agricultural practices, poor air quality and increased levels of particulate matter are rampant.

Consumerism, too, is at a record high. *National Geographic* reports that nearly 1.7 billion people worldwide belong to the 'consumer class' with particular demands and a lifestyle devoted to accumulating non-essential goods. The result is the depletion of natural resources like water and minerals drastically. Single-use plastic is used indiscriminately, leading to toxic waste and pollution of the land, waters, and air.

Rapid urbanisation, industrialisation, and population explosion have led to anthropogenic activities that fast snuff out biodiversity and ecology. The list of threatening dangers is a long one. We are in a desperate position, and the call is for extreme mitigating measures, without which the planet will soon become a lifeless one.

Awareness of the situation is a starting point. Hence, we have many commemorative days that focus on the existing pain point: Earth Day, Oceans Day, Biodiversity Day, and others dedicated to dying plant and animal species.

To this end, every year on June 5th, the world observes World Environment Day (WED) to spread awareness and commit to positive changes to restore a healthier environment.

ON A RESTORATION PATH

India realises the urgency of addressing the climate and environmental issues looming upon us and has laid out aggressive restoration plans. Various policies that will be beneficial in the long run will unfurl, aimed to put India on

a clean, green, reliable, and sustainable path. Hon'ble Prime Minister Narendra Modi revealed a restoration roadmap for the next 25 years at the COP26 summit in Glasgow last November.

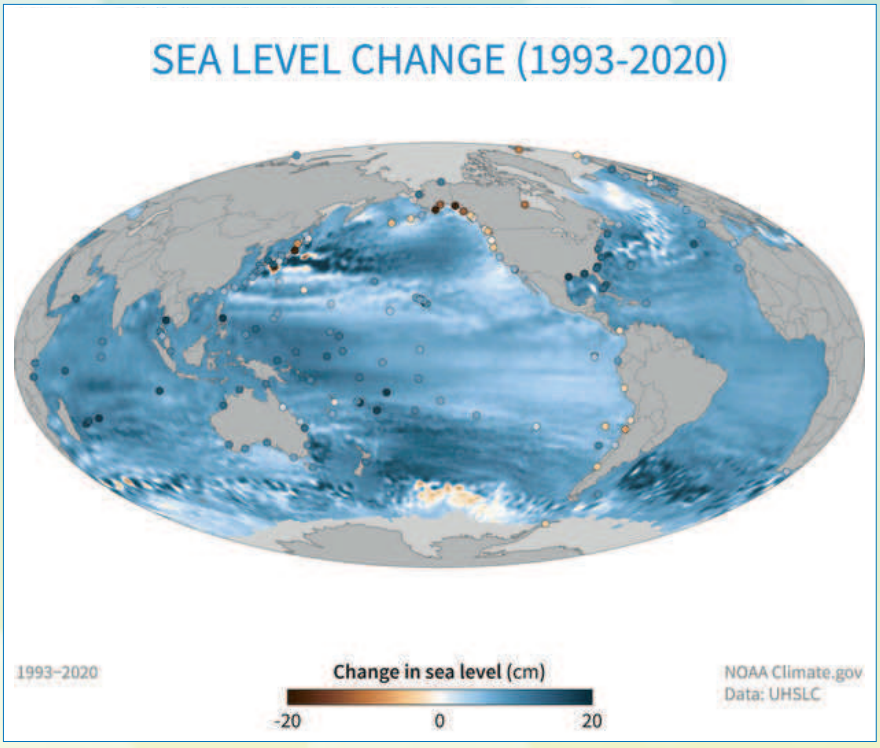
EMISSIONS CONTROL

Farmers in Delhi's neighbouring states burn crop residue and stubble as a quick fix to clear the fields for sowing winter crops. Unfortunately, this decades-old practice pollutes the surrounding areas severely.

The Commission for Air Quality Management has mandated a framework to control or eliminate stubble burning. Under an upcoming project called SAMARTH, farmers will receive help to convert the stubble into biomass pellets and sell them to coal-fired power plants.

Half of India's colossal electricity demand is met by 285 coal-fired thermal power plants. Under this new strategy announced by the Union Power Ministry, three categories of power plants are mandated to use a 5% blend of biomass pellets with coal as fuel. The scheme is to be enforced from October 2022 to contain pollution from stubble-burning. Two years hence, two categories of power plants will increase the blend to 7%.

Under the Ethanol Blend Petroleum Project (EBP), ethanol-blended fuel will reduce vehicular emissions. The program will roll out in a phased manner. According to NITI Aayog's report, 20% blending in petrol (E20) is achievable by 2030. Currently, E10 is underway (9.9% blend achieved so far) with 10% ethanol blend-tuned vehicles to roll out by 2023 and E20-tuned vehicles by 2025.



Climate Dashboard (Global sea levels image)

The EBP also promotes ethanol production from maize and other food grains apart from the conventional sugarcane-based raw material.

It is estimated that the E20 blend will reduce carbon monoxide emissions in two-wheelers by 50% and 30% in four-wheelers, apart from lowering hydrocarbon emissions compared to unblended motor fuel. In addition, ethanol blending will cut petroleum consumption and its cost, significantly reducing import costs.

WHAT IS ETHANOL BLENDING AND HOW IS IT BENEFICIAL?

- Ethanol or ethyl alcohol (commonly found in alcoholic beverages) is obtained by fermenting sugars by yeast metabolism. It can also be made by ethylene hydration.
- Ethanol is a plant-derived biofuel and hence a renewable resource.
- A 99% pure ethyl alcohol is blended with petrol to obtain ethanol-blend motor fuel. This is high in oxygen content, so vehicle engines burn it thoroughly, reducing emissions.

CARBON CAPTURE AND STORAGE (CCS)

Heavy industries, chemical factories, and coal-fired power plants release large amounts of carbon dioxide (CO_2) as flue gas, causing pollution. The excess carbon dioxide gives rise to the greenhouse effect, causing climate changes. The ripples of rising temperatures are felt up to the polar regions and are melting the glaciers rapidly. India is the fourth biggest emitter of CO_2.

In nature, forests and trees are natural inhibitors of CO_2 accumulation and sequester (store) carbon in the soil. So, one way to improve carbon sequestration is to increase the green cover.

Another plan is to arrest carbon at the source, stopping the release of industrial flue gases into the atmosphere. The CO_2 generated from the industries and power plants is collected, purified, transported to remote regions and stored deep below the ground. However, such a system poses several safety challenges which must be met with innovative ideas.

DST and DBT launched a joint venture called The Mission Innovation project to tackle the above challenges. The initiative's primary goal is to develop new technologies for carbon capture. This Mission will facilitate R&D and innovation to create safe

and cost-effective CO_2 capture, and utilisation and storage (CCUS) technologies. In addition, India is collaborating with the western nations on technologies to achieve net-zero levels by 2070. Net-zero means not adding additional greenhouse gases to the atmosphere.

STRIDES IN INNOVATIVE CCUS TECHNOLOGIES

A PIB press release says, "Professor Rahul Banerjee's group at IISER-Kolkata has demonstrated a strategy to synthesise novel solid adsorbents, especially for CO_2 capture and CO_2 utilisation. They discovered special types of nanoparticles or microparticles which can capture CO_2 in their micro and mesoporous voids.

CLEAN, GREEN ENERGY

At the COP26 summit, the Prime Minister announced that by 2030 India would generate 50% of its energy from clean sources and 500 GW from renewable energy. Power and New & Renewable Energy (PMNRE) Minister R.K. Singh told the media that 40% of the target is already achieved. India will have around 450 GW of solar and wind power, while 70-100 GW will be from hydropower plants.

A PIB statement dated 24 March states that the government is implementing a scheme to set up 50 Solar Parks with a total capacity of 40,000 MW. These parks will provide developed infrastructure to install solar power projects.

Moreover, the MNRE ministry is drafting an Approved List of Models and Manufacturers (ALMM of eligible solar module manufacturers who comply with the BIS Standards), allowing only those listed to sell electricity. The MNRE ministry will also supp ort R&D activities in academic institutions and industry under its Renewable Energy Research and Technology Development (RE-RTD) programme. This will enable indigenous solutions like new types of batteries and renewable energy technologies that are cost-effective and efficient.

Besides, the Ministry will be prompting rooftop solar schemes, solarisation of agriculture pumps (connected to the grid or run on diesel), solar street lights, solar study lamps, solar-powered livelihood applications, and many more innovative ideas.

SOLID WASTE MANAGEMENT

India generates enormous solid waste; lifestyle changes and increasing consumerism have led to massive dump yards filled with mountains of garbage which give off putrid fumes and volatile gases, adding to the pollution woes. The toxic fumes jeopardise the well-being of the people living in the surroundings and pose a severe threat to the ecology.

On 6 December 2021, NITI Aayog brought out a comprehensive knowledge repository called 'Waste-Wise Cities: Best Practices in Municipal Solid Waste Management', which documents the best practices from 28 cities across 15 states of India. The five-month research initiated in July 2021 examines ten different aspects that explain a sustainable value chain: source segregation, material recovery, and technological innovations, to manage waste such as biodegradables, plastics, e-waste, C&D waste, and landfills. According to the country-wide survey study report, India's solid waste management sector has witnessed unparalleled growth in the last few years, spurring the Swachh Bharat Mission Phase 2 to strengthen the efforts for a clean India further.

These are some of the schemes underway at a national level. However, one must always be mindful that amidst all policies, individual contributions to choosing nature-friendly practices and lifestyles are vital to a successful environmental restoration strategy.

It is said, tiny droplets make the mighty ocean; on a similar note, we are conservationists in our own right in ways small or big. We must join hands to save our planet, for we have only one Earth.

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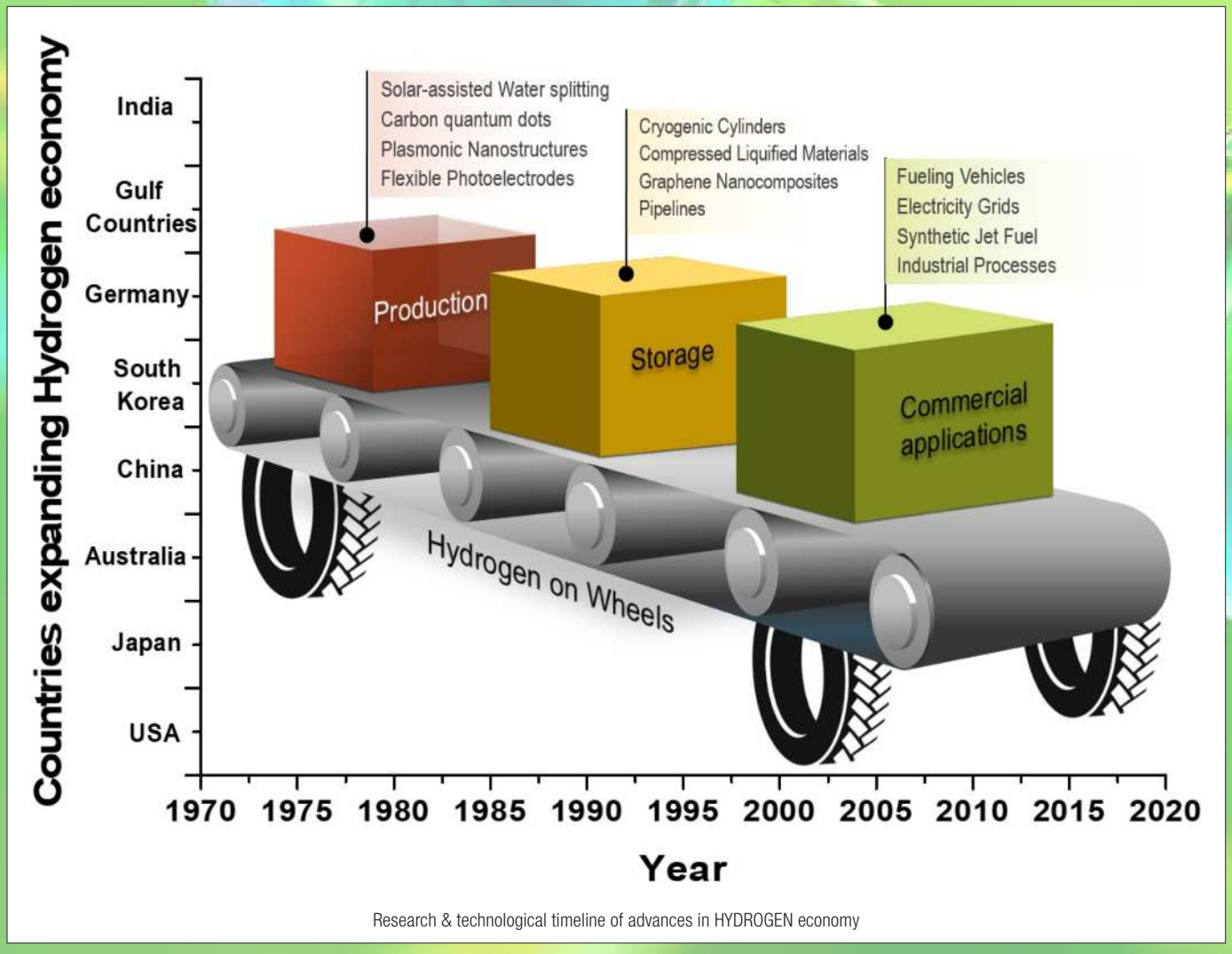
POOJA DEVI

HYDROGEN: A Promising Energy Hero for Global Appetite

As a child you must have done the experiment of putting two pencils in water, connecting their end with a battery, and observe lots of gas coming out. Have you pondered upon what is the Sun made of? Why it shines so bright and why it's so hot? It is none other than "Hydrogen". This lightest and most abundant element of the universe holds the potential to change our future, lifestyle, energy economy, and reduce our dependency on coal/diesel/petrol/LPG!

Hydrogen is our "Clean Energy Hero". As an element it is a colourless, odourless, and tasteless gas (H_2) and the first member (element) of the Periodic table. Hydrogen gas on burning (combustion) with oxygen (air) generates a humongous amount of energy. Generally, the combustion reaction releases around 286,000 joules of energy per mole of hydrogen gas burned, which is a multitude higher over fuels being used in present. Some other excellent features, which makes it stand out from the existing crowd of fuels are



Research & technological timeline of advances in HYDROGEN economy

(i) its high energy density/mass (120-142 MJ/kg, while for gasoline it is 44.5 MJ/kg); (ii) low ignition temperature; (iii) high combustion energy (2.86 x 10^5 J/mol H_2); (iv) no toxic combustion by-products etc.

Increased release of carbon dioxide with combustion of fossil fuels affects our Mother Earth heavily. Climate change is one of the major concerns, which is making our planet hotter and affecting the air quality with increased airborne solid and liquid particulates, oxides of nitrogen, sulphur, and carbon. As per worldometers data India alone contributes to the ~7% of global CO_2 production and air quality index for several of its cities is very poor. Hydrogen as an alternative to fossil fuel will not only prevent all these damages but will also provide the equivalent amount of energy in a sustainable manner.

Currently, hydrogen is being largely produced from conventional fuels through processes like steam-methane reforming, coal gasification, etc., which is known as Blue Hydrogen. But these technologies also produce CO_2. According to a study, the Blue Hydrogen production is responsible for the emission of around 830 million tons of CO_2 per year. On the other hand, the water electrolysis process produces hydrogen known as Green Hydrogen and it contributes to only 4% Hydrogen generation and energy demand for the process and cost associated are quite high. We thus need alternative methods for Green Hydrogen production, which are cost-effective, sustainable, and efficient. Among the renewables sources, solar energy is readily available to us in abundance (1,73,000 TW). Currently, solar energy is being stored in the form of electrical energy, i.e., through solar panels into batteries. But this technology has concern related to toxic electronic waste product generation, poor efficiency, high cost, etc. Hence the scientists are trying to tap solar energy storage in the form of chemical bonds, i.e., Solar energy to Hydrogen energy. This method of hydrogen production from water using solar energy is known as Solar Water Splitting or Photo Catalytic Water Splitting. However, if some electrical energy is used along with photo (solar) energy, then it is known as Photo electrocatalytic (PEC) water splitting. The latter method is better, because, it gives us the advantage to produce hydrogen and oxygen in separate chambers. The capacity of a PEC system to produce hydrogen from water highly depends upon the type of the electrodes in the system. The major challenges for Green Hydrogen production through the PEC system are (i) How efficiently the electrodes respond to light leading to exciton or e/h pair generation?; (ii) How much these electrodes can absorb the spectrum of solar energy falling on Earth? (iii) How efficiently the excited charge generated gets separated and participate in water splitting? (iv) How stable are the electrodes in electrolyte? (v) How long can the electrodes produce hydrogen? (vi) What is the source of the production of these electrodes (supply-chain)? Another suitable approach is to integrate electrocatalysis (EC) with solar photovoltaic.

We at CSIR-Central Scientific Instruments Organisation (CSIR-CSIO) are addressing the issues of EC and PEC as a material scientist to design the suitable electrode materials meeting the commercial benchmark. We are investigating several 2D materials (including MXenes), oxides, transition metal sulphides, flexible electrodes, etc., for efficient Green Hydrogen production from water (including wastewater). To extend these electrodes' capability to respond to a wide range of light from the solar spectrum, we have developed several visible light sensitizers (carbon quantum dots, plasmonic materials, etc.) using naturally available precursors and demonstrated them for efficient hydrogen production Our research group is also extensively investigating wastewater as a feedstock for hydrogen production instead of potabale water. This could solve both the problem of wastewater management as well as clean hydrogen generation. However, more investigations and design challenges are required to be overcome to commercially realise this technology for large-scale Hydrogen production and usage.

As a research community, our next step will be to develop solutions to strengthen its production keeping the production of CO_2 low. Hydrogen has found a good place in transportation (cars, buses, trains, aviation, space, etc.) sector, Chemical Industries, Power Generation, Stationary Applications, etc. Also, not to forget, it could even replace the LPG being currently used in cooking. To obtain electricity/energy from hydrogen, the hydrogen is reacted under a controlled rate with oxygen, giving out energy/electricity and water as output. Generally, it is done in a device known as Fuel Cell. Hydrogen Fuel Cells have been successfully shown in space vehicles to drive electricity as well as generate water to drink for the astronauts.

Several countries have tested and adopted hydrogen driven buses for public transport; to name a few are Gulf countries, the United States, Japan, South Korea, China, India, and Germany. These countries are focusing on the hydrogen-fuelled energy economy. These countries are making investments towards cleaner production technology and expanding the network of hydrogen. A hydrogen fuel cell bus has been launched in India by Tata Motors in collaboration with the Indian Space Research Organization (ISRO) and Indian Oil (IOCL). Further, one private manufacturer also seeks to launch its first fuel cell SUV in India soon and plans on building the required infrastructure for it in and around Delhi-NCR area. These small blueprints in our country thus strengthen the presence of Hydrogen as future Coal. More recently, our Hon'ble Prime Minister launched Hydrogen Mission for India on 75th Independence Day to make India a green hydrogen hub as well as meet its climate targets. Ministry of Power, GoI released Green Hydrogen Policy for the country on 17 February 2022. India has envisioned to be a global leader to develop hydrogen generation, storage, and utilisation technologies for the benefit of humankind and the environment.

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MUSKAN PANDEY, BARKHA SINGHAL

HUMAN VIROME: A NOVEL CANOPY AMONG PLANETARY BIOME

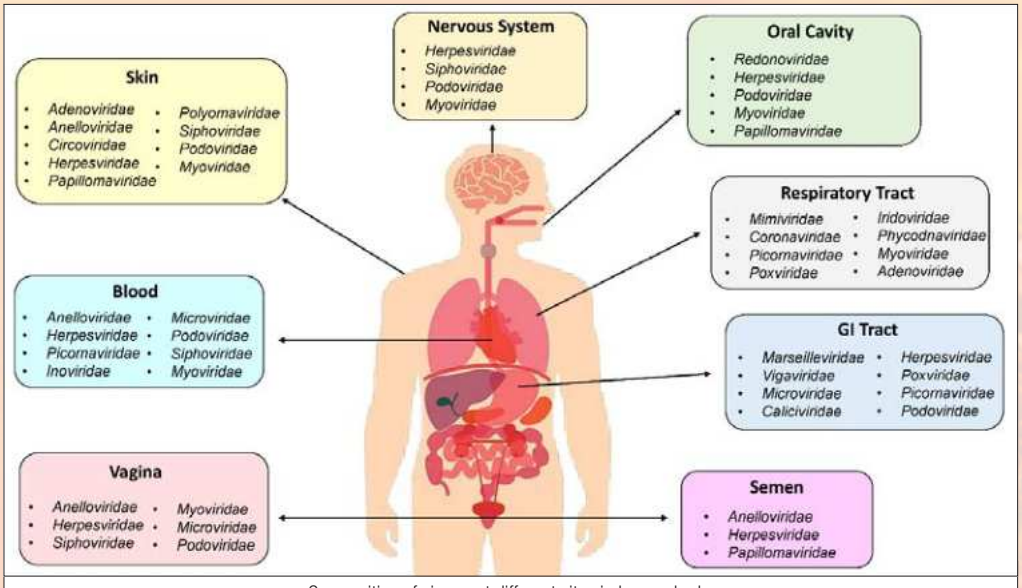
Nature creates wonderful serendipities which keep astonishing us as we dive deeper. Similarly, mammals being colonized with numerous microbes which is collectively known as microbiota is also a blessing in disguise. The symbiotic relationship established between host and the microbiota provides tremendous health benefits. Our gut is a rich and diversified niche of microbiome. Till date, the most explored gut microbiome consists of bacterial species but little is explicit about virome.

Human virome

For several decades, viruses were linked with specific characteristic diseases. Due to non-availability of sequences of many novel viruses in the databases, scientists considered studying virome as exploring dark matter. Improved metagenomics approaches have changed the way of looking toward this less explored area of virome and have given hope to be able to dive deeper. Scientists now believe that just like gut microbiomes, gut virome has also co-evolved with their hosts. Many studies have established that the DNA and RNA viruses present in the intestinal virome are somewhat found equivalent to bacterial cells in terms of number. However, while talking about the mucus layer and gut mucosal surfaces more viruses than bacterial cells are being observed. Each gram of human gut content is estimated to have 108-109 Virus-like particles (VLPs). Eukaryotic viruses like *Picobirnaviridae, Adenoviridae, Anelloviridae, Astroviridae* etc. are found in healthy people; while presence of Human Immunodeficiency Virus (HIV), Hepatitis B virus, Herpes virus, Polyomavirus etc. are detected in infected people. Bacteriophages present in the gut help in modulation of their bacterial hosts directly affecting their mortality by horizontal gene transfer and in many ways by re-programming the metabolism of the host. There are approximately 10^{15} bacteriophages in gastrointestinal tracts of humans. Among them cross assembly phages (CrAssphages) are most abundant. Several eukaryotic viruses like Cytomegalovirus (CMV), Enterovirus, Epstein-Bars virus, etc. are found in amniotic fluid of healthy mother who gave birth to healthy babies. On the contrary, several viruses like HIV, Hepatitis, Influenza, Rubella, etc. were detected in placenta and vagina of infected mothers. It has been found that phages are dispersed across the whole human body representing differing composition of phages at different sites. In the same way eukaryotic viruses also differ in their colonizing behaviour depending upon the site of the body.

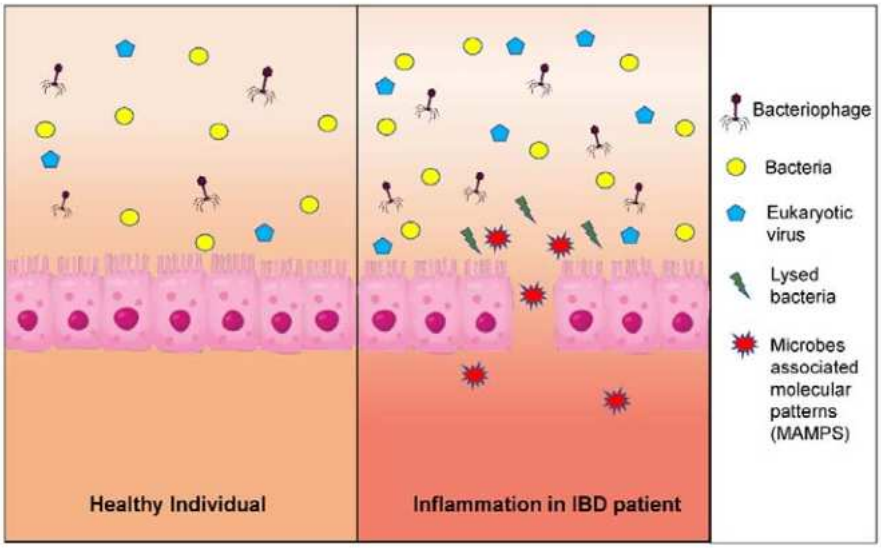
Crosstalk between virome with gut bacteria and their host

The studies on correlating the presence of virome and their diversity is pursued from various directions. Scientists are still working on establishing the relationship between human virome and



Composition of virome at different sites in human body

health of the host. Besides the studies associated with healthy human intestinal bacteriome also indicate towards the "healthy gut phageomes". Studies found out that the major way of virome affecting the host is by "transkingdom interaction". The interaction between viruses and bacteria can influence the host health. It has been observed that phages act as a vehicle for the horizontal gene transfer in their prokaryotic host and it is believed that they can influence the evolution of bacteria, their diversity, and their metabolism. Due to emergence of more drug-resistant bacteria scientists are inclining toward a new technique known as "phage therapy" to treat several bacterial infections.



Comparison of virome distribution of healthy and IBD-affected individual

Human virome and disease correlation

Several alterations are being observed in gut virome during different childhood diseases like Inflammatory Bowel disease (IBD), Crohn's disease (CD), and ulcerative colitis (UC). *Caudovirales* was found to be associated with CD. Reduced richness of Microviridae strains in CD was observed than healthy controls while high ratio of *Caudovirales* to *Microviridae* in IBD was also detected. There was also increase in Anelloviridae etc. Several studies have correlated viral infection as one of the possible causes of Type 1 diabetes (T1D). It was found that Enterovirus infection and T1D onset were correlated in many patients. Several patients showed correlation with *Circoviridae*-related viruses. In many diseases like diarrheal diseases and celiac diseases shift in the virome composition in the patients was also observed. Patients suffering from AIDS showed increased enteric adenovirus and colorectal cancer patients showed increased viral diversity.

Factors affecting virome colonization

Numerous factors are reported to influence the human virome and affect the health of the host. Diet being a very prominent part of life plays a crucial role in the establishment of human virome. In addition to diet and genetic factors, geographical factors, age, and heath status of an individuals also play significant role in the colonization of virome. The overwhelming utilization of antibiotics also affect the human virome indirectly as it kills the prokaryotic host of the virus. For example, study on a cohort was done who were treated with antibiotics against Staphylococcus infection and found out that oral virome were affected more than faecal virome, and enhanced population of papillomavirus in antibiotic-treated individuals was also seen.

Human virome and its relation with COVID-19

It has been observed that many patients of COVID-19 show various symptoms related to gastrointestinal tract, in which vomiting and diarrhoea are the main symptoms. In addition to this SARS-CoV-2 were also detected in the faecal samples of the patients indicating that GI tract being a site other than lungs where the virus can replicate. Several research studies were performed on COVID-19 patients to know the effect of this disease on the human virome. This led to a result that COVID-19 patients showed reduction in the population of Pepper mild mottle virus (RNA virus) and some bacteriophages while some environmentally derived eukaryotic DNA virus were increased in faecal sample. While changes in gut virome with the severity of COVID-19 were observed, age of the patients gave an idea of the fact that older patients are more prone to severe COVID-19.

Challenges and future prospects

Despite increasing techniques for metagenomic analysis and advanced DNA sequencing techniques, characterizing and annotating virome is still a challenging task because of several limitations. It is being observed in various studies that while aligning different sequences obtained from the samples of interest with the known sequences in the databases there is still sceptical outcome of the results. There is still lack of standard annotating methods to annotate virome dark matter. Annotation and characterisation of novel viruses present in the human virome populations still remain quite challenging. Studying RNA viruses is also challenging and limited due to their less stability in samples which are used for metagenomic studies. These factors have confined our studies which need more advanced and improved techniques to characterize these human virome and exploit this serendipity of nature for our betterment.

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DEVI PRASAD MOHAPATRA

THE EMPEROR'S NEW CLOTHES: Restoring Human Skin

The human skin is a sophisticated and complex organ that covers the body. It is the largest organ of the body and has been entrusted by nature with many functions. The first and foremost function of the human skin is defence. The human skin defends the body against physical and biological influences. The physical influences include heat, cold, water, etc. The biological influences include infection by bacteria, viruses, fungi, and numerous other microorganisms. The other functions of skin include temperature regulation, touch and heat sensation, vitamin D metabolism, immunity, and contouring the human body. Needless to say, damage to this natural sophisticated cloak could en-danger the underlying body.

How could the body lose its cloak?

A break in the skin leading to exposure of the underlying tissues is known as a wound or ulcer. Injury to the skin following trivial or severe accidents, exposure to harsh chemicals like acids and alkalis, exposure to thermal and electrical energy leading to burn or elec-trical injuries would all lead to damage to the skin. Skin infections from microbes like *Staphylococcus aureus* lead to pus formation and in severe cases, destruction of skin and deeper tissues. Extensive damage of the skin is seen following severe allergic reac-tions to drugs like antibiotics which cause blisters and subsequent breakdown of large portions of the skin. This condition is known as Stevens Johnsons syndrome.

When the human body loses its natural cover, it becomes exposed to the influences of nature. Notably, the bio-organisms which normally colonise the skin, start invading the defenceless body. In absence of a physical barrier, the body's defence mechanism gets overwhelmed by the onslaught of bacteria, viruses, fungi and numerous other microor-ganisms. This subsequently leads to sepsis, failure of bodily functions, and in extreme cases, death.

Ever wondered, how the skin is restored if lost? In many situations when the breach in the skin is small and superficial as in knife-cuts on finger or shaving-cuts on the cheek, the body heals itself. However, when the loss of skin is extensive, the body fails to re-place it. Doctors since time immemorial have attempted to replace this crucial cloak, ei-ther temporarily for a short time till the body heals itself or permanently using natural skin or even artificial constructs when the skin loss is extensive.

A Humby2s skin grafting knife with its blade

Jacques-Louis Reverdin Source; (https://commons.wikimedia.org/)

The earliest descriptions of covering a wound by external substances can be found in *Sushruta Samhita*, a treatise on surgery by the great Indian Sage Sushruta, who is also known as the father of plastic surgery. Sushruta describes the use of banana leaf and natural ointments derived from honey or tulsi plant (Ocimum sanctum) to cover the wound and protect it from external influences till the healthy surrounding skin regrows.

The process of covering a wound with skin is known as skin transplantation. Maratha surgeons of ancient India are believed to be pioneers in this technique when they took skin from the person's buttocks and used it to cover wounds on their nose. The piece of skin transferred to cover a wound is known as skin graft. When the skin graft is taken from the same person, it is known as an autograft. When the skin graft is taken from a different individual and transplanted on a wound, it is called an allograft. Occasionally, skin of different animals may be used to cover wounds after proper processing. These are known as xenografts.

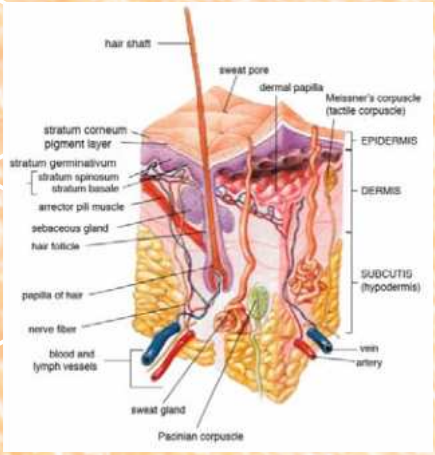
The first scientific description of the process of skin grafting comes from a book titled *Degli Innesti Animali* (On Grafting in Animals) written by Italian Physician Giusseppe Baronio in 1804. Carl Bunger, a German physician first documented the use of skin grafts in humans in 1823. He used a piece of skin from the thigh of a patient and used it to cover a wound on his nose. Swiss surgeon Jaques-Louis Reverdin introduced the concept of small split-thickness skin grafts, also known as pinch grafts. He pinched a bit of skin in his fingers and used a sharp knife to cut off the pinched skin, leaving a cir-cular defect on the body and a piece of skin on the fingers. This could be repeated many times and multiple circular grafts could be collected to cover a given wound.

Depth control while raising skin grafts

was essential because thin grafts were more likely to survive on the wound. Graham Humby, a British surgeon and a trained plastic sur-geon, first developed a blade in 1934 where thickness of the skin could be adjusted by a calibrating mechanism. This blade known as Humby's knife is still being used today.

In 1939, Earl Padgett and his co-worker engineer George Hood developed the derma-tome, an instrument that could accurately help in harvesting of skin grafts of necessary thickness and width. Several modifications later, this Padgett and Hood dermatome is still being used worldwide.

Skin consists of two layers: a superficial layer of epidermis and a deeper layer of dermis which contains the hair follicles and sweat glands. The process of collecting skin grafts is known as 'harvesting'. Depending on the requirements of the wound, skin grafts may be full-thickness or partial-thickness. Full-thickness grafts are harvested in such a way that the epidermis as well as the full thickness of dermis is included in the graft; where-as, split-thickness or partial-thickness grafts are those which contain epidermis and var-iable thickness of dermis. Full-thickness grafts are used where appearance is of im-portance, like eyelids, face, and nose. Split-thickness grafts are useful where a large area has to be covered. The areas from where full thickness grafts are harvested are closed with sutures while areas from where split thickness grafts are raised, heal on their own in two weeks' time.



The layers of the human skin and specialised systems within it

There are situations where skin grafts of the same person may not be available or the wound may not be suitable to apply a skin graft, for example, deep extensive burns of the body where most of the skin may be damaged and hence unavailable to be harvested as a graft. Sometimes, patients may be so sick that an operation may not be possible for them and a temporary skin cover is needed to conceal the wounds and prevent further infection. Sometimes, wounds may be loaded with harmful bacteria and therefore may be unsuitable for cover with autografts. In such situations, allografts and xenografts are used as skin substitutes.

Tissue engineered skin, as these skin substitutes are technically called, are made in la-boratories and are composed of cells and an external supporting matrix on which these cells rest. *Biobrane* is a temporary skin substitute containing an inner layer of silicone and an outer layer of nylon mesh which is held together with collagen derived from pig skin. Dermagraft is a bioabsorbable mesh of polygalactin seeded with neonatal fibro-blasts. These are temporarily placed on a wound and when the patient is ready for sur-gery, removed from the wound and replaced with skin graft. Integra is a similar substi-tute made of bovine collagen, chondroitin sulphate and a silastic membrane on top. The bovine collagen remains in contact of the wound and integrates with the patient's cells while the silastic membrane peels off allowing the dermis to regenerate and wound to heal slowly. A thin skin graft can then be applied on the regenerated dermis to allow faster healing. Dermal substitutes composed of autologous cultured fibroblasts seeded into a hyaluronic acid matrix, have been used to provide strength to wound by providing a dermal matrix on which autologous skin can be grafted.

ReCell ⍰spray on⍰ skin. Courtesy: Avita medical (http://avitamedical.com)

A child with a wound after burn injury covered with split skin graft.

The human skin can also be grown in the laboratory. A small piece of the patient's skin is taken and cultured in the laboratory to obtain a large sheet of skin. This cultured skin known as Cultured Epithelial Autograft (CEA) can be applied on the patient's wounds. J.G. Rhinewald and H. Green in 1975 first suggested the technique of obtaining CEA. However, the cultured skin is not as durable as the natural skin as it lacks a dermis. Cul-tured skin cells can also be made into a suspension and sprayed over small areas of wounds to form new skin. This is popularly known as 'Spray-on Skin' and available commercially as ReCell.

Skin Banking is a process in which skin is obtained from a live or dead donor, processed and stored properly to be reused as a graft when the need arises. This is particularly use-ful when the skin of a person is completely damaged and no native skin is available to cover their wounds, as in cases of extensive burns. In such situations, skin is collected from donors and cleaned and tested for diseases and then applied on the wounds. Do-nors can be live, for example a parent can donate skin for their child if required. Dead donors are those individuals who have died recently and their skin in collected and stored in tissue refrigerators to be used when needed. In such situations, permission is obtained from the relatives of the dead person to obtain their skin.

Replacement of human skin is a very important part of medical science research. Re-searchers are looking for the best skin substitute, which can resist infection, is readily available, durable, permanent, inexpensive and matches the person's existing skin.

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K. VENKATARAMAN

Biological Weathering

Did you ever wonder where the soil beneath your feet comes from? The answer is rocks. Rocks become disintegrated and broken into smaller particles by a process called weathering. The elements from the weathered rocks provide nutrients for plants and animals. Biological weathering may take place either by physical or by chemicals means.

Biological weathering by physical means occurs when a force or pressure is applied to break rocks or degrade the minerals in them. Plants can grow anywhere and can biologically weather rocks by growing into the cracks.

Burrowing animals like shrews, moles, earthworms, and ants contribute to biological weathering. They make holes in the ground and move the rock fragments to the surface. Birds, while foraging for seeds and worms create holes and erode the upper surface of the soil, thus contributing to weathering. Humans can also indirectly contribute to biological weathering by merely walking and running, thus making the soil particles crushed into smaller pieces. Tree plantation and road construction can also contribute to biological weathering.

Biological weathering by chemical means is also carried out by living organisms. This is also called organic weathering. Despite their minute size, some microorganisms can break down the largest rocks and the hardest soil. Such ativities are carried out by lichens and fungi. Fungi are well suited as weathering agents since they can be highly resistant to extreme environmental conditions such as metal toxicity, UV radiation, and desiccation. Many fungi can scavenge nutrients from the air and rain water which enables them to grow on rock surfaces. In limestone, fungi and lichens are considered to be important agents of mineral deterioration. The bacteria Actinomycetes, through acid production, mineral solubilisation, and metal leaching have successfully degraded rocks. Actinomycetes inhabiting granite rocks at St. Catherine in Egypt were investigated for their bio-weathering potential. Actinomycetes counts ranged between 174 and 360 colony-forming units per gram.

Rock borers occur in a broad range of taxonomic groups including bivalves, gastropods, polychaetes, sipunculids, crustaceans, sea urchins, and sponges. A new anatomically and morphologically divergent species of shipworm by name Lithoredo abatanica (Bivalvia) is found in Abatan River of the Philippines, that bores in carbonate limestone rather than woody substrates. It bores by ingesting the limestone which accumulates in the guts of the animal and is expelled from the siphon as fine-grained particles. Elemental analysis was performed to determine the mineralogical composition of both bored and ingested rock. Analysis of the intestinal content matched the mineralogical profiles of the rock samples into which the animals were boring, namely carbon, silicon, aluminium, magnesium, calcium and iron in similar proportion. It is true that the nutritional value of rocks remains zero. Why does this little rock borer go through the trouble of eating rocks? Wood-borers are known to keep a small symbiotic bacteria around their gills to help them digest the wood. But scientists have to determine what kind of bacteria a rock eater needs to get its food. These

organisms can turn rocks into sand and have the potential to redirect rivers, with potentially disastrous results.

Murex sp. belonging to Gastropoda, are active predators and have radula (an anatomical structure used by molluscs for feeding) adapted for tearing flesh and capable of drilling. In borers an accessory boring organ secretes a calcium chelating compound that softens a shell during drilling process. Drilling is carried out by the radula.

The direction of boring in living corals is to the outside, the borers keeping pace with the growing coral layer, to maintain their burrows open. The burrows are mostly much larger than their inhabitants. Generally, it is due to abrasive action of the shell which moves straight and without any rotation.

Polydora is a genus of ringed worms or segmented worms that live in mud, holes bored in rocks and shells, etc. into which they burrow. They are a major economic issue for parts of the shellfish industry. Pseudopotamulla reniformis and Perkinsiana rubra have irregular winding burrows, which penetrate to a distance of about 5 cm into the hard limestone and are probably formed mostly by chemical means.

Phascolosoma, a rock-boring sipunculid worm, is commonly known as peanut worm. The head bears a retractile introvert with the mouth at its end. These worms prefer to find shelter in shells of gastropods or scaphopods bored by predatory molluscs. After occupying the shell the worm exudes a sticky substance, gluing the entrance of the shell with cemented mud, sand or silt, thus making a hard cover with a little opening in the centre for the introvert. Some species of Phascolosoma are semi-mobile worms which shelter in cracks and cavities in hard surface beneath the soil. To some extent they are able to bore hard rocks such as limestone.

The crustacean Alpheus saxidomus, has a hammer-shaped dactylus (the tip region of the tentacular club of cephalopods and of the leg of some crustaceans) on the first right pereopod (one of the walking limbs of a crustacean) of male and female that shows tracks of abrasion at the hammer-head. Structural analysis of this hammer-dactylus proved that it is suited for the mechanical treatment of rocks. The very thick and calcified cuticle of the hammer is mostly formed by the sclerotinized hard exocuticle, which has abundant pore canals. Sclerotization involves the molecular stabilisation of the protein chains of the cuticles by establishment of cross-links. Sclerotin, the product of sclerotinization, is a kind of natural plastic. The pores may be used to feed on algae and other growth around the sieve plate.

Echinometra, a species of sea urchin is a rock-boring animal. For feeding, it removes a large portion of coral calcium carbonate in addition to the algal growing on the dead coral. They use their round set of teeth to gnaw into limestone or volcanic rock and thus create their own shelters. They also use their bottom and side spines to scrape. They excavate tunnels with open ceilings of various widths. They are vegetarians and come and go from caverns to graze on algae. In areas of heavy fishing, rock-boring urchins cause far more damage to reefs than they would normally.

Cliona celata is a species of rock-boring sponge. They have the ability to drill holes in limestone and molluscan shells. The sponge uses acid to form tunnels in the calcium material. The only function of these holes is to create a place for the sponge to live. With the effects of ocean acidification, the impact from boring-sponges will be increased.

Thus, burrowers and borers are ecosystem engineers that alter their physical environment through bioturbation (the reworking of soils and sediments by animals or plants); bioirrigation (the process of deep-water organisms flushing their burrows with overlying water); and bioerosion (the breakdown of hard ocean substrates by living organisms). The mechanisms of moving through solid substrate by burrowing or boring depend on the mechanical properties of the medium and the size and morphology of the organism.

Formation of nutrient-rich soil, creation of sediments, and contribution to land formation are the advantages of biological weathering. Soil erosion and mass wasting, that is, huge masses of rocks fallen off by an avalanche are some disadvantages of weathering. If weathering never occurred, the Earth would have a surface of the bare rocks and no plant or animal life could exist.

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VIKAS UPADHYAY

Science journalism and science writing in Gujarat

The history of science journalism in India is very old, but in proportion to that the development in this field had been quite limited. The worship of knowledge was important in ancient India and people wished to attain knowledge from every possible ways. On 27 January 1780, James Augustus Hickey started printing the 'Bengal Gazette' in Calcutta (now Kolkata), which is considered the starting point of journalism in India. In 1818, the monthly magazine 'Digdarshan' was published in Hindi, Bangla, and English from Shrirampur in Hooghly, West Bengal.

Since then modern science writing and journalism has been flourishing in India. Gujarati journalism started in the country with the introduction of a newspaper 'Bombay Samachar' (now Mumbai Samachar) on 1 July 1822 in Bombay (now Mumbai). If we look at the scientific writings in the Gujarati, we find that in 1855, a weekly named 'Parsi Mitra' was launched in Mumbai. It was published every Saturday. In this, preference was given to science, technology, and historical writings. In the famous compilation 'History of Gujarati Journalism', the researcher Dr Ratan Marshall has mentioned about this.

The newspapers and contemporary articles of that period, for example, 'Vasant' by Anandshankar Dhruva (1902); 'Vismi Sadi' by Haji Mohammad Allarkhia Shivaji (1916); 'Kumar' by Ravi Shankar Rawal (1922); etc. had a reformist and progressive approach. In 1937, Dr Harinarayan Acharya established 'Prakriti Mandal' for the study and dissemination of wildlife and geology of Gujarat. He had also started a quarterly called 'Prakriti' in 1942, which continued publishing for about 14 years bringing out 56 issues. In this more than 500 articles, illustrations, and accounts of 90 authors were published. Therefore, 'Prakriti' can be rightfully considered to be the first periodical of Gnostic science in Gujarati. All the texts of 'Prakriti' have also been digitized.

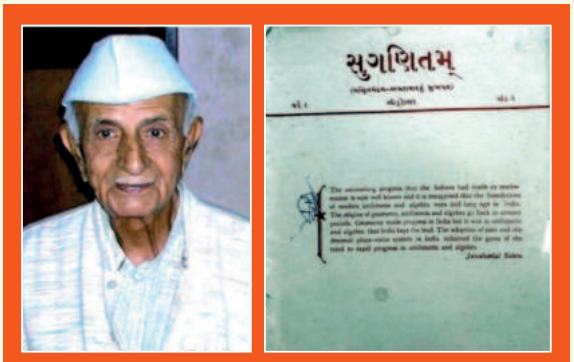
Dr Chotubhai Suthar, founder of the first astronomical magazine of India, Aakash Ganga

In 1945, Dr Chotubhai Suthar, a famous astronomer from Gujarat, established an organization called 'Tarak Mandal' in Anand and started an illustrated periodical on astronomy called 'Aakash Ganga' in 1946. This was not only in Gujarat, but the first special periodical of astronomy in the whole of India and a matter of great pride for Gujarat.

Under the guidance of the famous mathematician Dr P.C. Vaidya, a periodical titled 'Suganitam' on mathematics- was started in 1961. This is the only magazine from Gujarat to be published continuously for 58 years and hence has special importance at the national as well.

Another popular and purely on science periodical in Gujarat is 'Vigyan Darshan' and has a unique and historical importance. The first issue of 'Vigyan Darshan' was published in October 1971 but was closed after the January 2016 issue. This was the only science magazine from Gujarat to be published for 45 years continuously. It is quite disheartening that this periodical could not be continued.

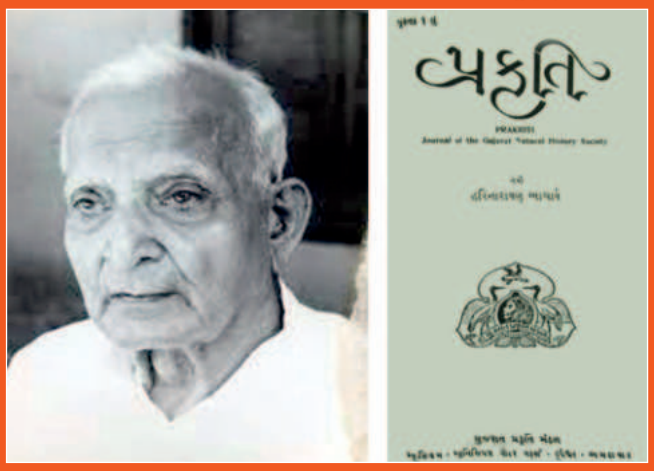
Nagendra Vijay did commendable job of publishing scientific write-ups through his magazines 'Scope' and 'Safari'. Since the very first issue of 'Scope', published in November 1977, this periodical earned huge popularity. Moreover, the magazine had not a single advertisement. 'Scope' was published till 1992, but in the meantime, Vijay also started 'Safari' in 1980, which is still being published. Its digital versions are also available. In 1988, Mahendra Desai added a new sparkle to the science journalism in Gujarati by publishing the colourful science magazine 'Wavelength'. Similarly, the Bird Conservation Society of Gujarat started the journal on ornithology in Gujarati and English named 'Vihang' and 'Flamingo', respectively in 1997-98.



Dr P.C. Vaidya & Suganitam

Today in Gujarat, digital and print newsletters and leaflets are being published from the Lok Vigyan Kendras

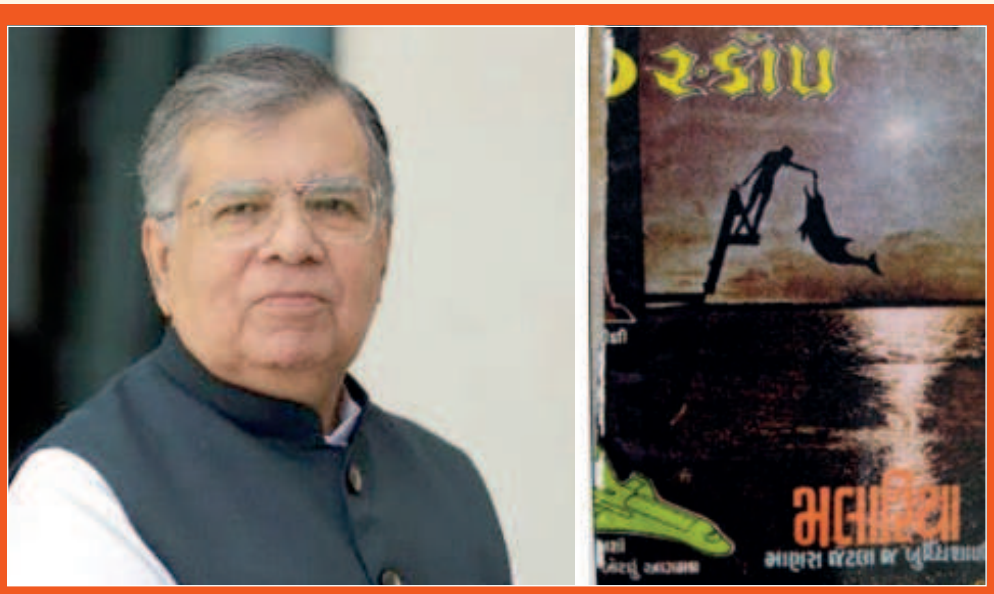
Shri Ishwarbhai Patel & Vigyan Darshan



Shri Harinarayan Acharya & Prakruti

working in different districts, run by the Gujarat Council on Science and Technology, which are proving to be helpful in popularising science among the masses.

Gujarati newspapers and magazines have been instrumental in propagating science and technology among people. In 1986, a separate full-page science supplement was started in 'Gujarat Samachar'. However, after few years it became irregular and later discontinued. But in the present competitive era, science-related material are getting published as supplements in the main-stream newspapers. But still there is a need to improve in terms of quality and frequency.



Shri Nagendra Vijay & SCOPE

Now, when we talk on providing science and technology education in mother tongue, the need for science journalism, science writing, promotion and dissemination of science in Gujarati are immediately felt. It is to be noted that the University Granth Nirman Board of Gujarat has published basic books and definitional dictionaries in Gujarati on different subjects of science.

In the field of science writing in Gujarati, many eminent scholars of science like Kakasaheb Kalelkar, Vijayagupta Maurya, Pradyumna Desai, Niranjan Verma, Jaimal Parmar, Manubhai Mehta, Dr Vihari Chhaya, Dr Sushrut Patel have been actively involved. Some well-known scientists like Dr Pankaj Joshi, Dr J.J. Rawal, Dr P.C. Vaidya, Prof. Hariharbhai Bhatt, and Dr Chhotubhai Suthar have worked relentlessly in writing on science in Gujarati. Banshidhar Shukla tried to prepare a list of more than 2000 science books in Gujarati. It can be made even more comprehensive and authentic. The contribution of Rationalist Associations in developing scientific attitude in Gujarat should not be forgotten.

Several mass media communication channels and now digital platforms are also proving to be very effective in dissemination of science and technological information to the masses. Gujarati journalism has completed 200 years and science writing or journalism is also going to complete 167 years; so, more efforts and participation is needed to strengthen this rich tradition.

Translated by Suman Bajpai

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SCIENTIFIC SOCIAL RESPONSIBILITY

A Game Changer for Science-Society Connect

Government of India has achieved yet another important milestone on 11 May 2022 by promulgating and releasing Scientific Social Responsibility (SSR) Policy guidelines which intend to create a strong science and societal connect. Having a both-way interaction, connection, and impact, it has the potential to bring positive transformational changes in society through the application of Science and Technology (S&T) for improving the quality of life on this planet. Though SSR has been mentioned occasionally globally, our Hon'ble Prime Minister Shri. Narendra Modi was the first political leader to pronounce the importance of SSR on 3 January 2017 held at 104th Indian Science Congress held in Tirupati. Thereafter an extensive national-level consultation was made by the committee appointed by the Ministry of Science and Technology. The author was fortunate to chair this committee. The wide consultation included inter-ministerial meetings including officials from NITI Aayog, HRD, UGC, AICTE, and PSA Office along with regional workshops and round table meetings held in various institutions across the country for getting valuable inputs in formulating the SSR policy guidelines. This was also available on the DST website for a year seeking public and all stakeholders' input.

One may be wondering, what we mean by SSR. It is the obligation of every knowledge worker, particularly in the field of S&T domain, to give back to the society not only through their scientific endeavours, but also to take the scientific outcome to the society as well as aligning their scientific endeavours to societal needs.

Interaction between science and society has to be a two-way transit in which the society would project its needs and requirements and that would be addressed by scientists in the form of tangible and intangible outcomes as a way of giving back to the society. Hence, it becomes a critical obligation of knowledge workers to foster a close link with society and take the knowledge from lab to land and make a difference, particularly among the underprivileged and weaker sections of societies.

There is a broad scope of activities under the purview of SSR which include resource and knowledge sharing with less privileged institutions or individuals in the field of S&T domains; delivering motivational lectures to school children for attracting best brains to S&T streams; creating scientific temper and awareness of technological accomplishments to the masses through media interaction; writing articles in vernacular languages; initiating community video interactions; extending outreach activities; providing support to rural entrepreneurship; capacity building for students in less privileged colleges; assisting in project writing or scientific article preparation, etc. Readers may refer to https://dst.gov.in/document/guidelines/scientific-social-responsibility-ssr-guidelines-2022 for detailed guidelines.

Having a both-way interaction, connection, and impact, SSR has the potential to bring positive transformational changes in society through the application of S&T for improving the quality of life on this planet.

Taking the analogy of Corporate Social Responsibility (CSR) for industries and corporate sector, SSR will be an auditable voluntarism and incentivised endeavour to implement related policy.

There are four major players who would realise the implementation of SSR at national level: Beneficiaries, Implementers, Assessors, and Supporters (BIAS). A national-level portal needs to be created where the beneficiaries from the society may post their current needs which will be implemented by knowledge workers in the laboratories and scientific Institutions and give back the outcome to society. Government of India will create a special purpose vehicle (SPV) or an agency to coordinate, facilitate, and give thrust to implement SSR policy and guidelines. The policy envisages that at least 10 person-days in a year will be spent by all knowledge workers on SSR activities. The performance-based assessment system (PBAS) currently implemented to assess the performance of the knowledge worker can also include a section on SSR contribution.

Research funding agencies can make a separate allocation of budget in sponsored projects to conduct SSR activities along with other project requirements. Even NAAC accreditation, NIRF ranking, and similar agencies can give due weightage to the SSR activities while assessing the contributions of institutions.

While India is celebrating Azadi Ka Amrit Mahotsav, the nation can be proud of climbing the ladder of merit in S&T domain globally. Our Hon'ble PM not only envisioned India to be among the top three countries globally in research & innovation and also India becoming Aatmanirbhar. Perhaps this SSR policy will be a game changer if implemented in the right perspective by all the stakeholders.

It is a clarion call by Hon'ble Prime Minister and the Govt. of India for all the knowledge workers to rise to the occasion stretching themselves, reach out to the society and make a difference through the noble SSR endeavours.

Dr W. Selvamurthy was the chairperson of National Committee of Scientific Social Responsibility appointed by Ministry of Science & Technology and Chancellor of Amity University Chhattisgarh.
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