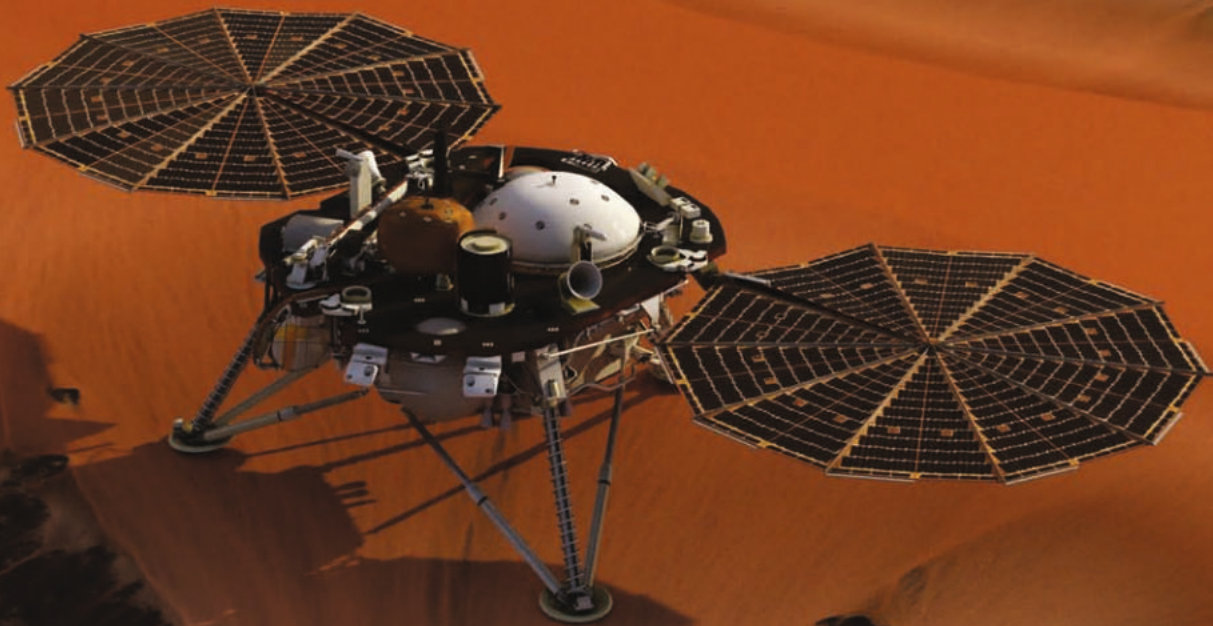


DREAM 2047

R.N. 70269/98 ISSN : 0972-169X
Postal Reg. No.: DL-SW-1/4082/18-20
Date of posting: 26-27 of advance month
Date of publication: 24 of advance month

January 2019 • Vol. 21 • No. 4 • Rs. 5.00

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New Year, New Horizons



Nakul Parashar

Heartiest greetings for the New Year! Let us begin the new year by taking a new step forward towards the goals we have set upon ourselves for the past few years. Let a renewed vision guide us in this pursuit that has been inspiring our thoughts.

Many attempts have been made to take science and technology to the masses in a language they understand, relating to the milieu they identify with and through the mediums most accessible to them. It is a matter of great satisfaction that these endeavours have not ceased to exist. The contribution of Vigyan Prasar is noteworthy in this regard. It has been matching up to its responsibilities through different programs and projects. The credit lies with the vast family of Vigyan Prasar working relentlessly under the capable guidance of the nation's scientists and science writers. We extend our gratitude and salute to them all!

We need a new perspective to make our national mission of popularising science more comprehensive, contemporary and effective. Therefore, we should make every possible use of the expertise accumulated through our initiatives and their implementation so far. This experience can become the foundation for making our task more encompassing. Based on the experience gained, the ever-evolving technologies and new modes of communication can be used to expand the scope of science popularisation many folds. There can be no two opinions about this!

The nation's agriculture sector has progressed in leaps and bounds in the past. Many projects of agricultural research have successfully percolated to the farmers. The statistics bear testimony to the consistent

increase in per hectare yield over the years. However, considering India's size and the growing population, whatever efforts we make to widen the spread of agricultural science will be inadequate. Hence, this year Vigyan Prasar will strive to add this dimension to its programs to enable us to fulfil our commitment towards the rural and agricultural community.

Like agricultural science, medical science has also seen rapid developments. Many programs and projects are currently running to bring these developments to the masses. Vigyan Prasar is committed to play an active role in this nationwide task. During the year, we shall endeavour to include medical science in our science popularisation activities.

Vigyan Prasar has recently implemented a significant project of creating daily content for television and the internet. Under the project, programs produced by Vigyan Prasar are to be broadcast daily on Doordarshan's (DD) Science Channel.

A dedicated internet portal has also been launched to apprise the world of advancements in India's science and technology sector. The India Science, Technology and Innovation Portal (ISTI) is a one-stop window for the latest information about developments in India in science, technology, and innovation.

It is no secret that the world faces an environmental crisis. As both the Paris Climate Agreement as well as the recently concluded COP 24 conference in Poland infer, a change in our lifestyles can go a long way in preserving our planet. We shall try to take this message to the widest possible audience during the year.

This year's National Science Film Festival will be organised in Chandigarh from 27 to 31 January. More than 300 films have been rigorously evaluated to be shortlisted for this festival. Some of the country's finest filmmakers will now judge the best among these during the festival. Vigyan Prasar will lend its full support to all such festivals throughout the country.

Last year, we celebrated the 125th birth anniversary of Prof. Meghnad Saha. This year marks the 125th birth anniversary of Prof. Satyendra Nath Bose. It is planned to organise nationwide programs during the year to take the achievements of the two legendary theoretical physicists to all corners of the country through films, symposiums and publications.

The Union Ministry of Science and Technology has started a new initiative to spread general awareness about artificial intelligence. Vigyan Prasar will make every effort to inform and educate the public about the related innovations in simple language.

Much more is in the offing. The first step into the new year with a new vigour and optimism is only the beginning.

Once again, best wishes for the New Year.

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(Transted by Shri Deepak Sharma) ■

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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.

NSG-No Entry?



M.S.S. Murthy

In 1974 a group of countries joined together to form the Nuclear Suppliers Group (NSG) with the purpose of overseeing that the export of nuclear materials and technology are not used to foster nuclear weapons development by the recipient states. Today the Group consists of 48 countries, controlling most of the international nuclear trade under two sets of guidelines developed in association with the International Atomic Energy Agency (IAEA).

In the recent past India has been spending much of its diplomatic might to get into an exclusive club of nations known as “Nuclear Suppliers Group”. What is this Group and why does Indian need the membership of this Group?

Way back in 1974 India conducted a “peaceful nuclear explosion” nicknamed the ‘Smiling Buddha’. Many countries saw this as a disguised nuclear weapons program, which may lead to proliferation of nuclear weapons, particularly among the Asian countries. The plutonium used for the explosion was allegedly obtained through reprocessing the spent fuel from the Canada-India reactor at Trombay, Mumbai. Canada considered this as a deviation of nuclear technology transferred for peaceful purposes and along with the USA withheld any further collaboration.

Following these developments, in 1974 a group of countries joined together to form the Nuclear Suppliers Group (NSG) with the purpose of overseeing that the export of nuclear materials and technology are not used to foster nuclear weapons development by the recipient states. Today the Group consists of 48 countries, controlling most of the international nuclear trade under two sets of guidelines developed in association with the International Atomic Energy Agency (IAEA). The first guideline covers the export of nuclear materials

and technology, which include nuclear reactors and equipment thereof, plants and equipment for fabrication of nuclear fuel, plants and equipment for reprocessing the spent fuel, plants and equipment for heavy-water production, etc. The second guideline covers the export of nuclear-related (dual use) materials and technology like isotope separation and other industrial equipment which can be used for both nuclear and non-nuclear operations. Nuclear trade can happen only among the member countries.

Who can become members of this elite club? One of the guidelines for seeking membership is that the country must be a signatory for the Nuclear Non-proliferation



Treaty (NPT) of the IAEA or to treaties which aim to preserve certain geographical areas such as Latin America, Africa, South pacific, South-east and Central Asia as nuclear-free zones. The NPT, which is in force since 1970, is specifically designed to prevent the proliferation of nuclear weapons. Though India supported the principles of nuclear

non-proliferation, it is not a signatory to the NPT since it considers the Treaty as discriminatory. Hence India has been excluded from the membership of NSG right from the beginning.

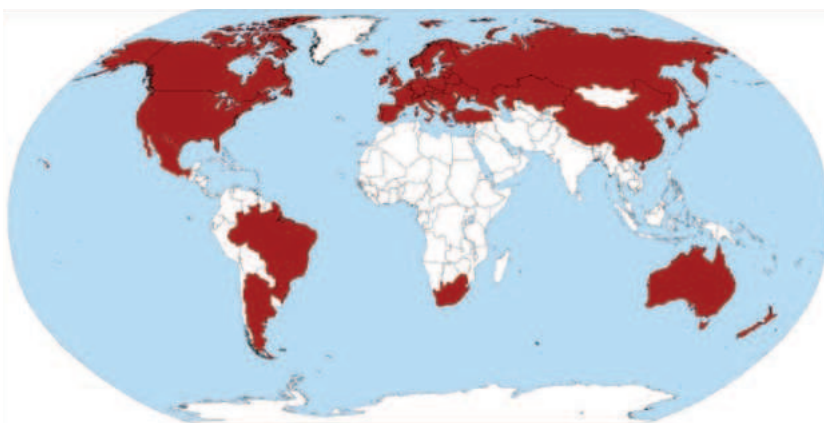
Notwithstanding such efforts by the international community to exclude India

from further nuclear cooperation, India carried out five full-fledged nuclear weapons tests, including a thermonuclear device and declared itself as a nuclear weapon state in 1998. Furthermore, the country went ahead to develop peaceful applications of nuclear technology based on its earlier experience. Today there are 22 reactors in operation in 8 nuclear power plants across the country generating about 5 gigawatts of electricity.

However, it is not enough. India, with its total annual electricity generation of about 307 gigawatts as of October 2016, is among the countries with lowest per capita electricity consumption in the world. Hence the government has charted out an ambitious plan of increasing the electricity generation from the present 307 gigawatts per annum to 800 gigawatts in the next few decades for sustained growth and prosperity. Right now nearly 70 percent of this energy is coming from burning fossil fuel like coal, oil and gas. In view of its impact on global warming, this proportion has to definitely come down. For this, the country has to heavily rely on greener energy sources of which nuclear energy is a major part. Consequently, it is planned to take nuclear share from the present 1.9 percent to a whopping 25 percent by 2050.

However, there are problems. The country does not have enough uranium resources to build and operate the required number of nuclear reactors to reach this target. Though India has an abundant source of thorium, it is not fissionable, but can be converted to nuclear fuel in special types of reactors known as fast breeder reactors which require plutonium as the fuel. Plutonium does not occur in nature but has to be extracted only from spent uranium fuels. Considering all these factors the only alternative available for the country is to import nuclear reactors and associated technology. For that, membership of NSG is essential.

Admission of new members to the Group is based on consensus. All current members have to vote in favour of the new



Current members of Nuclear Suppliers Group (Shaded)

applicant. Though majority of the members are in favour of admitting India, China and a few other countries are not. They argue that since India is not a signatory to the NPT, no exemption should be made for a single country, but a uniform policy has to be evolved. It may be noted that Pakistan, which is also not a signatory to the NPT has also applied for membership of NSG.

However, falling short of being an actual signatory, India has voluntarily chosen to abide by the principles of nuclear non-proliferation. Following the nuclear tests in 1988, the then Prime Minister Atal Bihari Vajpayee declared a moratorium on further nuclear tests and 'no first use' of nuclear weapons during an armed conflict with any country. In September 2008, the then Minister for External Affairs Pranab Mukherjee made a statement highlighting India's nuclear policy and the steps taken towards the goal of nuclear non-proliferation. Based on these declarations and a proposal from the USA, in 2008 the NSG gave India waiver from its guidelines, facilitating the member countries to engage in nuclear trade with India. Following this significant liberalisation, India entered into a civil nuclear agreement with the USA for the import of nuclear materials and technology. As a requirement of this agreement, India also placed its civil nuclear facilities under the IAEA Safeguards. Soon other countries—France, Russia, UK, Kazakhstan, Australia and Japan followed suit.

What then is the problem, one may ask. NSG Waiver has a catch. It does not cover transfer of sensitive equipment and technology including enrichment and fuel reprocessing, even under the IAEA Safeguards, limiting its scope. Hence

India is looking for full membership, which will also enable it to enter export market for nuclear materials and technology, particularly when it develops the thorium utilisation technology in the coming years.

It may appear odd that India is seeking membership of a club, which was born as a protest response to its testing a nuclear explosive device in 1974. But since then the scenario has changed. In a significant development in

December 2017, the elite export control regime Wassenaar Arrangement (WA) decided to admit India as its new member, which is expected to raise New Delhi's stature in the field of non-proliferation besides helping it acquire critical technologies. The decision was taken at the two-day plenary meeting of the grouping in Vienna.

India's entry into the export control regime would enhance its credentials in the field of non-proliferation despite not being a signatory to the NPT and is also expected to build up a strong case for India's entry into the 48-member Nuclear Suppliers Group (NSG). ■

VP website



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Beware of Plastic Containers for Food and Water!



Dr. Felix Bast

The government should urgently intervene and take the first, baby step, by banning bisphenol-A (BPA) – the most obvious and rational step to take. There should be a mechanism to periodically check the plastic goods for harmful chemicals and take appropriate actions against the defaulters. Unfortunately, such a system is non-existent in India. Labels such as ‘food-grade plastic’ are deceptive and make no sense, as none of the plastics is safe. We should gear our posterity towards a new lifestyle prioritising their health and environment, rather than senseless Vanity Fair. For, we have only one life, and one earth.

We live in a world where we tend to follow the current trend be it in food habits, use of materials, or fashion. Consider, for example, school lunch boxes. In my school days two decades ago I used to bring my lunch in those inconspicuous round steel containers, that we called ‘chottupathram’ (rice container). Since then, these containers have become old-fashioned and obsolete; the trending fashion in schools these days is one of those chic and colourful lunch boxes with images of famous cartoon characters and animals. Society dictates us to purchase those trendy, colourful lunchboxes for my daughters to affirm my position as a virtuous parent. Those are irresistible to the kids; if I insist that she carry her food in steel lunch boxes, she would be ridiculed at her school and branded as old-fashioned! She will be disappointed and will soon demand to ‘upgrade’ her lunchbox to more trendy! However, in reality, it would be no upgrading. Almost all of these plastic school lunch boxes are made with a plastic subtype called polycarbonate. Polycarbonate plastics (and anything else that contains ‘epoxy’ resins) invariably leach out a synthetic chemical called bisphenol-A (BPA). This chemical structurally resembles female reproductive hormone oestrogen and if it gets inside our body may lead to a host of health issues including chromosome damage in ovaries, decreased fertility in males, cardiovascular system damage, increased risk of breast and prostate cancer, and so on. Increased public

awareness and legal intervention has led to a reduction in use of BPA-containing plastics in developed countries. BPA is banned or restricted in several countries including USA, Canada, EU, Japan, Australia, New Zealand, and even in many developing countries including Brazil, Argentina, Philippines, Taiwan, China and Malaysia.

To bypass these enforcements, the plastic manufacturers increasingly replace the BPA with BPS (bisphenol-S) and BPF (bisphenol-F) for the sake of getting “BPA-Free” certification, although newer research has revealed that BPS and BPF are as dangerous as BPA and therefore its consumption should be completely avoided. In India, regrettably indeed, BPA is not banned, nor are there any restrictions on its sale are in force, which is an utter disappointment to scientifically conscious citizens. In 2013, a draft was prepared by the Bureau of Indian Standards to restrict BPA in feeding bottles, but due to peer pressure from plastic industry, the government stayed away from enforcing these draft guidelines. The question of whether industrial growth or the health of its citizens— especially the vulnerable citizens, including pregnant women, infants, and children— is more important to a government is arguably an ethical question. To penetrate the customer niche of informed citizens, many companies voluntarily mark their products with ‘BPA-Free’ logo. A study in 2014 concluded that a vast majority of these proclaimed ‘BPA Free’

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products that included infant feeding bottles from well-known brands tested positive for BPA.

How will you know whether the plastic that you buy is BPA/BPS/BPF-free? One easy way is to look for the “fine print.” Most of the plastic products have a tiny triangular (with three arrows) recycle symbol, usually underneath the containers (Fig. 1). Look out for the number inside this symbol. The number would be 7 for polycarbonate (sometimes code “PC” can also be found)—that would mean you should avoid this product, as polycarbonate leaches out BPS or its analogues. Another test uses a standard chemical, iron (III) chloride (FeCl_3) that can be found in chemistry labs. First make an ‘indicator’ solution by mixing a quarter teaspoon of FeCl_3 in a cup of water. Place the plastic to be tested in just-boiled water for 5 minutes. Subsequently, take the plastic out and use a cotton swab soaked in alcohol to rub the surface of the plastic. Let the cotton swab dry to evaporate the alcohol in it. On a white surface (such as a tile), place a drop of the FeCl_3 indicator solution and dip the cotton swab in it to allow it to soak up the indicator liquid. The cotton swab will turn purple, blue or green if BPA is present in the plastic. Repeat the same experiment with a swab that is rubbed on a steel or glass container (our negative control), to make sure no colour appears for this swab.

The numbers engraved on plasticware is technically called Resin Identification Code (RIC). These codes are universal valid throughout the world. There are seven numbers 1 through 7 and these numbers are mere labels for categories of plastic resins used for the manufacturing; they are not ordered in any sensible manner. In other words, as the number increases you cannot conclude that these are safer or vice versa. As a rule of thumb, never reuse a container made of PET and never consume the food in it if the container is exposed to high temperatures—like inside a car parked in the scorching sun for several hours. Oily food stored inside PET bottles is very dangerous,

so avoid purchasing oils, pickles, and sweet dishes that are packed in PET containers. In my modest survey of all known curd brands available in Punjab and Delhi, I found all of them came in PET containers, as no law exists in India preventing its use (while in developed countries rules do exist that dairy products should be packed in RIC No. 5). I have come across many environmentally conscious people who keep on recycling PET bottles as water bottles and fridge bottles. While recycling is good for the environment, recycling PET bottles is a dangerous practice for your health, and the chances are high that you might develop a chronic disease in the long run. As a general rule of thumb, storing solid items (like cereals, grains, etc.) in plastic containers is safer than storing

A (BPA), dioxins, phthalates, cadmium, lead, mercury and so on, and therefore it is very dangerous. Phthalates are well-known ‘gender-benders’; its consumption makes males more feminine. Phthalates also cause attention deficit hyperactivity disorder (ADHD) in school children.

PVC is used in most household plastic materials in India, for example, containers, buckets, mugs, food wraps, toys, and so on. The tradition of using plastic buckets for drinking water distribution (in communal feasts, marriage feasts, etc.) should be avoided. We should stay away from using PVC pipes for potable water supply plumbing. In summary, distance yourself from PVC at all costs. RIC No. 6 is polystyrene (PS). PS leaches styrene—a dangerous carcinogen

when hot or oily food items are stored in it. PS is also commonly used in disposable cups and food containers (for example, teacups in railways). This is especially alarming, as when hot tea or coffee is poured, PS readily releases styrene which is harmful to the users. Styrene is known to cause cancers, especially pancreatic cancers. We should refrain from using any food or water that has come in contact with PS surface by all means. RIC No. 7 is polycarbonate (PC). As already explained, PC is perhaps the most dangerous (along with

PVC) plastics available in the market as of this writing, and we should eschew it doubtlessly. Strictly speaking, No. 7 encompasses “all the rest” that not only includes PC but mixtures of various plastics (all are harmful); but almost the entire range of consumer plastics with RIC No. 7 are PC type, leaching BPA. In summary, watch out for “1367”- Types 1, 3, 6 and 7 are the most dangerous plastics in the market!

Now, let’s turn our attention towards the second group of plastics that are less dangerous than the earlier types, although they pose significant health risks when reused for long. RIC No. 2 is high-density polyethylene (HDPE) that leach nonylphenol, a dangerous endocrine disrupter like BPA. HDPE is commonly

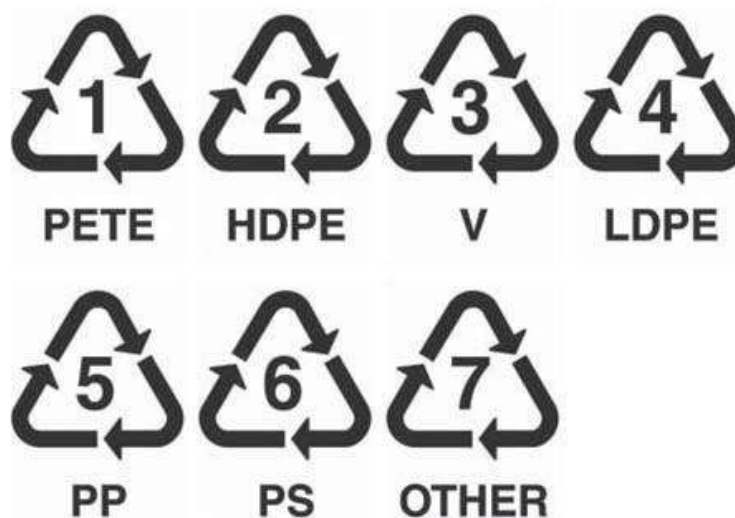


Fig. 1. Resin Identification Codes (RIC) of plastics

powdered items, which in turn is safer than storing liquid items (as area of contact with plastic surface progressively gets larger, allowing more dangerous chemicals to leach into the food).

Most restaurants in India pack the food for home delivery in plastic containers and that is a dangerous practice, especially given that the food is very hot, oily and semi-solid; we should desist from placing orders with such restaurants. PET bottles are undeniably ‘use and throw’ commodity, a huge burden for our planet (like the rest of plastics, these are non-biodegradable). PET – RIC No. 1—should be avoided whenever it is possible; never reuse it for the sake of your health! RIC No. 3 is polyvinyl chloride (PVC). PVC is known to leach bisphenol

found in grocery plastic bags, milk and juice cartons and so on. This plastic is relatively safe for limited uses provided food is not hot or oily. RIC No. 4 is low-density polyethylene (LDPE). Like HDPE, it can release nonylphenol. LDPE is commonly used in toys, food wraps, Tetrapack cartons, disposable cups, and storage containers. RIC No. 5 is polypropylene (PP), commonly found in many household food containers that tend to be more expensive than the rest. PP has been shown to be releasing plastic-stabilising substance oleamide into the food. Heated PP also releases chemicals that could induce asthma. RIC Nos 4 (LDPE) and 5 (PP) are relatively safer plastics for limited use when used with no hot or oily substances. About the safety of plastics, unfortunately, we have nothing that can be called 'safe'; all kinds of plastics are significantly dangerous than alternatives. Perhaps if you are left with no choice and have to buy a food storage container or water bottle, remember "245"; Types 2, 4 and 5 are relatively less dangerous than all other types of plastics.

We have yet another type of plastics – the cheap Chinese ones that usually floods your house if you have little children. By the way, in countries where BPA is banned, ban is not applicable for the goods that are manufactured for export to other countries! As deceptive as it seems, these plastics comes with no standard numbers, so it is not possible to find out the type of plastic used. My suggestion is to distrust such sly manufacturers and avoid any plastics that come with no identifier numbers, no matter how appealing they may seem. Even if the RIC numbers are printed, the trust is still a major decision factor. What if a firm that embosses RIC No. 5 (PP) on a product that is, in reality, made of RIC No. 7 (PC), and swindle its customers? As no legal enforcement exists in India regarding the safety of plastics, consumer worry in this angle is positively warranted.

An ingenious way to check the quality of plastic bottle is to pour water into it halfway through and let it sit at room temperature for one day. When you open the bottle and take a deep sniff after one day, you could smell leached phthalates and other synthetics if the plastic is dangerous. This is because most of the resins used in plastic manufacturing are aromatic, and we can trust our sense of smell if it gets leached. If you could smell the plastic in the bottle,

you should discard it immediately for the sake of your and your family's health!

Fortunately, we do have healthy alternatives for all of these. For example, my family and I use steel water bottles. Steel bottles, especially the insulated ones tend to be a little heavier and expensive, but this is immensely helping our environment (by reducing the non-biodegradable pollutants), and our health. One good stainless steel bottle can last a lifetime. Deciding never to buy a mineral water bottle and instead to carry a reusable and safe water bottle also reduce our carbon footprints tremendously. Mineral water bottles are often bottled at plants situated far away, and it travels hundreds of kilometres, burning hundreds of litres of fossil fuels before it reaches our stores. I also carry a steel travel mug for hot drinks and use it in place of disposable cups (for example, in long train journeys, or in office parties). Steel lunchboxes are still the best choice for both school and office. It might not be trendy for the kids, but nothing matters more than their health. Finally, my ingenious solution worked for my daughter's lunchbox preference; all I did was to order colourful stickers of her favourite animation characters so that she can have her (steel) lunchboxes with different trendy plastic stickers every month! At least, those plastic stickers do not come in contact with her food, to get into her body, for my peace of mind. In my opinion, the school authorities should intervene to ban the irresistible plastic lunchboxes, for the sake of our posterity! I have lived in Japan for many years, and I can vouch that school lunch boxes in Japan, the so-called *O'Bento*, are mostly bamboo boxes. *O'Bento* is so much part of the Japanese tradition, and they have whole academic programs about these packed lunches, and programs on how to pack a healthy lunch for the pupil regularly appear on their TV channels. Japanese kids have that luxury of eating in bamboo lunch boxes; it is a pity we do not have! I have been using leak-proof glass lunch boxes (Borosil) to my office, as it lets me microwave it before consumption.

In the supermarket, I exercise my volition as well. Instead of jams, pickles and so on that comes in plastic containers; I always choose the ones in glass containers. Instead of cooking oils that come in plastic containers, one can buy those that come in metal containers. Commodities that are marketed in sealed plastic bags possess a

substantial health hazard. This is because while sealing, plastic materials readily release dioxins, phthalates, BPA and other insidious chemicals, which instantaneously get into the food items that it contains. In many parts of India (especially in Chennai during summers), it is a common practice to sell drinking water in these transparent plastic pouches. Instead of milk bags that come in plastic PET bags in India that no one talks or cares about (these bags too possess similar health hazards like that of drinking water pouches), one can buy milk in vending machines at stores (for example, Mother Dairy throughout Delhi-NCR allows one to pour milk into their containers). In places where these vending machines are not available, one can choose to buy milk from the local dairy, or buy milk in cartons instead of bags. However, beware that most of these 'Tetrapack' juice or milk cartons contain 'soak proof shield' – a market gimmick for plastic lining, which consists of RIC No. 3 or 7 resins with epoxy groups readily releasing BPA. Paper plates, albeit such an innocuous name, are not merely paper but contain layers of plastic coating to make it soak-proof. The similar plastic lining can also be found on the surface of 'paper plantain sheet' – as a substitute for the real plantain (banana) leaves to serve South Indian meals. Most of us do not realise that these plastic lining can readily release dioxins, phthalates and BPA when hot or oily food items are poured on it. Cans – tin containers for packed food items and drinks – too have plastic linings. While canned food does not constitute a sizeable fraction of Indian food market, canned drinks like soft drinks and beers are ubiquitous. Instead of plastic food containers to store the leftover food in the fridge, we have invested in glass containers – a decision I will never regret even though many of our containers have fallen and broken!

Of late, there has been a lot of public sensitisation and civil enforcement against plastics. However, most of these enforcements have been against a minority subtype of plastics, namely the plastic shopping bags. While something is better than nothing and this indeed is a welcome step, a vast majority of plastics – especially those that pose the highest health hazard to the population like food containers, water

Continued on page 27

India's Space Prowess



Sankhadip Sen and Soumadip Sen

From the day of its formation, ISRO has been continuing to harness space technology for national interest. The vision of this organisation is to “harness space technology for national development” and to pursue research for space and planetary exploration. ISRO is striving to upgrade and develop new technology so that it can be effectively used for the betterment of the nation.

Wednesday, 15 February 2017, the world witnessed the prowess of India in the domain of space technology when ISRO successfully placed 104 satellites in a single flight. This was the largest number of satellites ever launched in a single mission. This 39th flight of ISRO's Polar Satellite Launch Vehicle (PSLV-C37), which successfully placed the Earth Observation Satellite *Cartosat-2D* along with other 103 co-passenger satellites in orbit, was launched from Satish Dhawan Space Centre, Sriharikota. This was the 38th consecutively successful flights of the PSLV. The total

Sensing Satellite Programme, is similar to the earlier 4 satellites of *Cartosat-2* series namely *Cartosat-2*, 2A, 2B and 2C. According to ISRO, “the imageries from *Cartosat-2* series satellite will be highly useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications.”

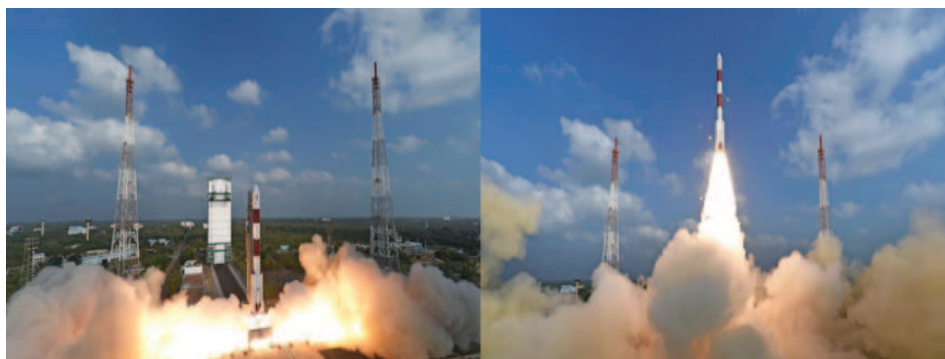


Fig.1. Lift off view (Left) and view (Right) of PSLV-C37 at SDSC-SHAR, Sriharikota (Credit: ISRO)

weight of all the 104 satellites including the 714-kg *Cartosat-2D* was 1,378 kg.

The *Cartosat-2D* of the *Cartosat-2* series, which is part of the Indian Remote

Besides the *Cartosat-2D*, the 103 satellites carried by PSLV-C37 included two modular Indian satellites – the ISRO Nano Satellites (*INS*) named *INS-1A*

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Fig.2. Cartosat-2 Series Satellite undergoing Panel Deployment Test (Credit: ISRO)

and INS-1B weighing 8.4 kg and 9.7 kg respectively. The ISRO Nano Satellites are envisioned for future science and experimental researches. The primary objectives of the INS system are to provide an opportunity for ISRO technology demonstration, and more specifically to carry innovative payloads for universities and R&D laboratories.

The remaining 101 co-passenger satellites were nano satellites from international customers including 96 (88 *Dove* satellites and 8 *LEMUR* satellites) of the US, and one satellite each of the Netherlands (*PEASSS*), Switzerland (*DIDO-2*), of Israel (*BGUSat*), Kazakhstan (*Al-*

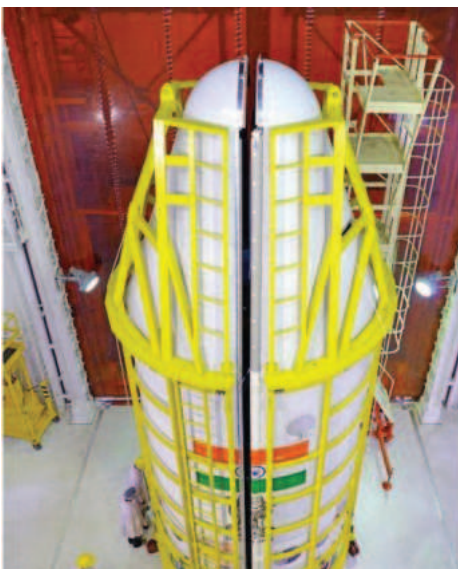


Fig.3. PSLV-C37 Heat-shield is being closed with all the 104 satellites inside. Picture (ISRO)

Farabi-1), and UAE (*Nayif-1*). These 101 foreign satellites were launched as part of the commercial agreement between the international customers and the commercial wing of ISRO named Antrix Corporation Limited.

ISRO's Polar Satellite Launch Vehicle (PSLV) for launching satellites into polar orbits is amongst the most popular launch vehicles which have attracted foreign customers. Built in three versions—PSLV-G (Standard), PSLV-CA (Core Alone), and PSLV-XL (Extended)—PSLV is the third generation launch vehicle of India and is the first Indian launch vehicle to be equipped with liquid stages. It remains a favourite among various organisations as a launch service provider and has successfully launched 48 Indian satellites and 209 foreign satellites for customers from abroad during the years 1994 to 2017. Moreover, the vehicle has successfully launched the two major Indian spacecraft i.e., *Chandrayaan-1*, India's first lunar probe (that was placed in Moon orbit) was launched by PSLV-C11 on 22 October 2008 and Mars Orbiter Spacecraft—*Mangalyaan* (that was placed in Mars orbit) was launched by PSLV-C25 on 5 November 2013. The latest mission, PSLV-C38 lifted off on 23 June 2017 and successfully launched *Cartosat-2E* along with 30 co-passenger satellites making this the thirty-ninth consecutively successful mission of PSLV, which has earned it the title 'Workhorse of ISRO'.

Since the formation of ISRO in 1969, ISRO has come a long way. The remarkable

success of the *Chandrayaan-1* mission, which for the first time detected water on Moon, and India's first interplanetary mission—the *Mars Orbiter Mission*, which made India the first nation to succeed on its first attempt to reach Mars, and ISRO the fourth space agency to reach Mars, after NASA, Soviet Union, and the European Space Agency.

Apart from the successful Moon and Mars missions, ISRO has also been playing a leading role in improving telecommunication, remote sensing, and satellite navigation.

The Indian National Satellite programme, popularly known as INSAT is one of the largest domestic communication satellite systems in the Asia-Pacific region. The INSAT system provides services to television broadcasting, telecommunications, weather forecasting, telemedicine, disaster warning

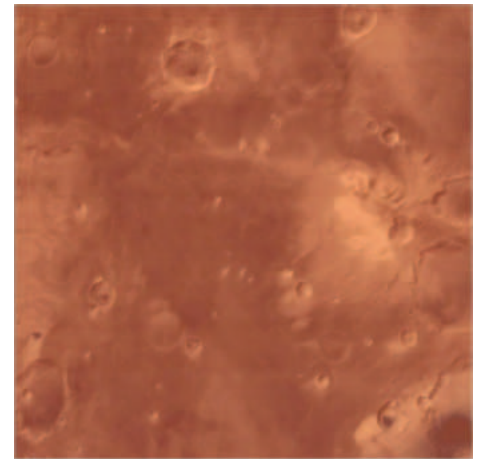


Fig.4. Image of the Martian terrain captured by Mars Colour Camera (MCC) of MOM on 14 July 2014 at an altitude of 2,555 km with a resolution of 132.8 m. (Credit: ISRO)

and management along with search-and-rescue operations.

The Indian Regional Navigation Satellite System (IRNSS) programme, with its operational name NAVIC, which stands for Navigation with Indian Constellation, is an autonomous regional navigation satellite system being developed by India. It is designed to provide accurate real-time positioning services. The IRNSS service will cover the entire Indian subcontinent and a region extending up to 1,500 km around it, with future plans for extension. The system works with a constellation of seven geosynchronous satellites, three of which are placed in the geostationary orbit 36,000 km above the equator. According to ISRO, the

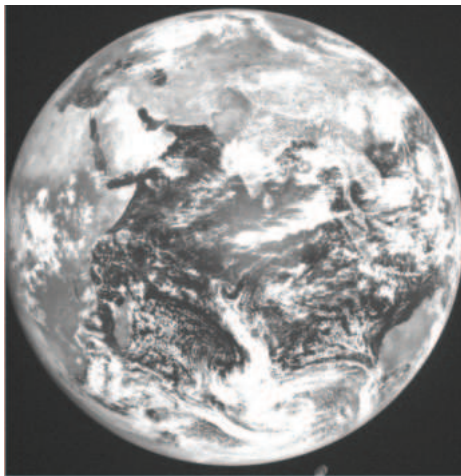


Fig.5. First Images of Earth from INSAT-3DR Imager taken on 5th Sep. 2016. The tiny white object at the bottom of the image is the Moon. (Credit: ISRO)

system will provide services and applications in the area of terrestrial, aerial and marine navigation, disaster management, vehicle tracking and fleet management, visual and voice navigation for drivers, along with mapping and geodetic data capture facilities.

The Indian remote sensing programme is one of the most enthusiastic and highly essential projects launched by ISRO. Remote sensing is the branch of science that deals with the collection or acquisition of information about resources, objects, events, areas or phenomenon occurring on Earth from a distance, typically from aircrafts or satellites. The Indian Remote Sensing Satellites (IRS)

observe the Earth from space and provide systematic information in a periodic manner pertaining to land, water, atmosphere and several aspects of environment. This information is used for land and resource survey and has immense applications in the field of military, intelligence, socio-economic planning, along with commercial and humanitarian applications. Apart from these stated applications, the information obtained through remote sensing is extremely valuable for monitoring and management of natural resources, detection of disasters, monitoring of soil and agricultural activities, planning and monitoring of developmental activities, weather and climate monitoring/forecasting, cartography, rural & urban development, ocean and meteorology. Various departments of Central and State Governments along with some academic, private and Non-Governmental Organisations play a major role in utilising the technology for developmental activities and better governance. The major satellite series in Indian Remote Sensing programme are *OceanSat* (for ocean and atmospheric studies), *CartoSat* (for cartographic applications), *ResourceSat* (for resource monitoring applications), etc.

In a significant development, ISRO successfully launched the 3,136-kg *GSAT-19* with its most powerful rocket *GSLV-Mark III* on 13 June 2017. The rocket used an indigenous cryogenic engine for its upper stage. In future, the *GSLV-Mark III* will be used to launch the country's own

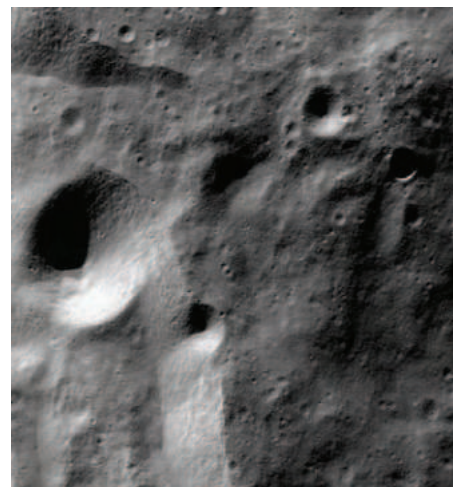


Fig.6. Picture of the Moon's surface, captured by Terrain Mapping Camera (TMC) of Chandrayaan-1. (Credit: ISRO)

communication satellites which were till recently launched by foreign agencies, as ISRO didn't have the capability to launch heavy satellites. The success of *GSLV-Mark III* is a significant toward removing this handicap.

From the day of its formation, ISRO has been continuing to harness space technology for national interest. The vision of this organisation is to "harness space technology for national development" and to pursue research for space and planetary exploration. ISRO is striving to upgrade and develop new technology so that it can be effectively used for the betterment of the nation. ■

Beware of Plastic Containers for Food and Water! *(continued from page 30)*

bottles, soft drink bottles, milk bags, baby feeding bottles, etc.— remain out of this enforcement and that is a pity. It seems like almost everyone believes plastics are bad for the environment. However, most of us fail to understand that we are very much part of this environment and what is not good for the environment is also not good for us.

Another subtype of plastics that completely escaped the attention from sensitised citizens is microplastic, which is commonly found in a number of cosmetic products and consumer plastics like foam mattresses and bean bags. Once released in the environment, microplastics get accumulated in marine organisms such as

tiny zooplankton, ultimately leading to its death. It gets concentrated in higher trophic levels progressively with each higher-level predator. Some of which goes in our seafood too, ultimately impairing our health. Microplastics are now found everywhere from the Arctic herring to the Antarctic krill and pose the greatest challenge to the marine biodiversity yet.

The government should urgently intervene and take the first, baby step, by banning BPA—the most obvious and rational step to take. There should be a mechanism for the government to periodically check the plastic goods for harmful chemicals and take appropriate actions against the defaulters.

Unfortunately, such a system is non-existent in India. Labels such as 'food-grade plastic' are deceptive and make no sense, as none of the plastics is safe. After all, the ball is in our court and we have to decide ourselves if we would like to make a self-goal; all we should do is to discern good from bad and exercise our conscious volition to avoid plastics altogether and instead go with biodegradable and healthy alternatives like glass, steel, ceramics, wood, cloth and so on. We should gear our posterity towards a new lifestyle prioritising their health and environment, rather than senseless Vanity Fair. For, we have only one life, and one earth. ■

Harlow Shapley

A Key Figure of 20th Century Astronomy



Dr Subodh Mahanty



*Harlow Shapley
(1875-1972)*

Harlow Shapley's greatest single contribution to science was the discovery of the dimensions of our Galaxy and of the location of its centre. His observations of stars and globular clusters led him to propose that the Milky Way, our own Galaxy, was much larger than previously thought.

“Not the least of Shapley’s achievements was his development of the Harvard Observatory into one of the major research institutions of the world. He introduced a graduate program and attracted a distinguished and much increased staff. During this time his interest turned to ‘galaxies’, as he called them, or ‘extragalactic nebulae’ in Hubble’s terminology. Northern and southern skies were surveyed for galaxies and tens of thousands were recorded.”

— *A Dictionary of Scientists*, Oxford University Press, 1999

“The son of a farmer, Shapley was a teenage crime reporter on two newspapers before entering the University of Missouri, intending to study journalism; he soon changed to astronomy. In 1915, using Leavitt’s ‘Cepheid variable’ method of estimating stellar distances, Shapley was able to provide the first reasonable picture of the structure and size of our own galaxy.”

— *The Cambridge Dictionary of Scientists* (2nd edition), 2003

“Harlow Shapley was an outstanding man of his time—astronomer, educator, author, orator, as well as man of affairs. Some of his gifts, displayed prominently in the course of his life, may gradually fall into oblivion as those of us who knew him in his prime may no longer be here to remember; and dust may settle on some of his work, or as many awards bestowed upon him by his contemporaries. But one title to fame will never tarnish—Shapley’s discovery of the centre of our Galaxy, and our position within it.”

— Z. Kopel, ‘Great Debate’: Obituary of Harlow Shapley, *Nature*, Vol.240, pp.429-430, 1972.

Harlow Shapley’s greatest single contribution to science was the discovery of the dimensions of our Galaxy and of the location of its centre. His observations of stars and globular clusters led him to propose that the Milky Way, our own Galaxy, was much larger than previously thought. As the

great Polish astronomer Nicolaus Copernicus (1473-1543) had earlier observed that the Earth was not at the centre of the solar system, Shapley observed that the Sun was not at the centre of the Galaxy. He estimated that the Sun was some 50,000 light years away from the centre of the Galaxy and the

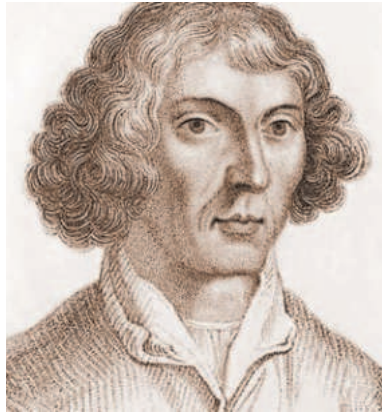
diameter of the galactic disc was about 300,000 light years. However, later it was found that these figures were over estimated. The figures were revised to 30,000 light years and 100,000 light years respectively.

Shapley believed that the galactic universe made a single, enormous, all-inclusive unit. While proposing the galactic model of the universe, Shapley argued against the existence of other galaxies. He believed that even the most remote globular cluster should be inside our Galaxy, the Milky Way. He defended his galactic model in the so-called 'Great Debate' organised by the National Academy of Sciences, USA on 26 April 1920.

It was the American astronomer Edwin Hubble (1889-1953) who demonstrated conclusively that globular clusters were independent entities and far beyond the boundary of our own galaxy. Hubble in a letter, which he wrote on 19 February 1924, informed Shapley that he had discovered a Cepheid in the

Andromeda Nebula, which was about a million light years away (he calculated the distance by the period-distance relationship), far beyond the limit of our Galaxy assumed by Shapley. After reading Hubble's letter Shapley was supposed to have commented to a colleague, who happened to be present in Shapley's office at that time, that "Here is the letter that has destroyed my universe."

Shapley jointly with his assistant Adelaide Ames (1900-1932), produced a catalogue of galaxies in 1932, which revealed the irregular distribution of galaxies and existence of clusters of galaxies. The catalogue described 1,249 galaxies including over a thousand galaxies brighter than 13th magnitude. In 1937, he published a survey of 36,000 southern galaxies. While studying the Magellanic Clouds (the Large



Nicolaus Copernicus
(1473-1543)

Magellanic Cloud and Small Magellanic Cloud—the two minor satellite galaxies of the Milky Way visible in the Southern Hemisphere), he identified the first two dwarf galaxies, the Fornax, an ellipsoidally-shaped galaxy in the constellation of Fornax and Sculptor, also known as the Silver Coin or Silver Dollar Galaxy, an intermediate spiral galaxy in the constellation

of Sculptor. These two star systems are members of the Local Group of galaxies.

One important aspect of Shapley's contribution towards the development of astronomical studies was his role in establishing the Harvard College Observatory as an important research centre of world-class. In addition to astronomy, Shapley displayed his life-long interest in myrmecology, the study of ants.

Shapley in his time was well known as a humanitarian and an internationalist. Thus while writing about Shapley in *Biographical Memoirs* of the National Academy of Sciences, USA, Bart J. Bock wrote:

"Historians of the future should not only take note of Harlow Shapley's great scientific achievements, but I hope that they will also remember him as a fine human being, as an independent, bold human spirit with a healthy distrust of all authority. Harlow Shapley loved to push beyond frontiers, scientific and human. He thought of our world as one large place, with unnatural national boundaries, populated by hundreds of millions of basically kind and worthy people. He was a great American who will

be remembered for centuries to come. His name deserves to be carved in the marble walls of the National Academy of Sciences. He was the Copernicus of the first half of the twentieth century."

Harlow Shapley was born on 2 November 1885 in a farmhouse about 7 km away from Nashville, Missouri, USA. His father, Willis Shapely was a farmer and his mother Sarah Stowell Shapley was a schoolteacher. In his early years he worked in his family's farm. He attended a rural school, built on a land given by his family. The school held its sessions for only three or four months of the year. Shapley acquired education from this rural school, which would be equivalent to today's fifth-grade education. After his schooling he started working in the family's farm. It seems Shapley did not enjoy working in his family's farm and so he took up job of a reporter in Chanute, Kansas. Later he worked as a police reporter in Joplin, Missouri where he worked for the *Daily Sun*. At the time of starting his career as a crime reporter he was 16 years old. While working as a reporter he realised the shortcomings of his education and he decided to upgrade it. He applied for admission to Carthage High School, a prestigious school located in the nearest city to Nashville. However, the school did not find his preparations adequate and he was denied admission. But he could manage to get admission in the Carthage Collegiate Institute, run by the Presbyterian Church and he completed its six-year school education programme in only two years. In 1907 he decided to join the University of Missouri to study in its School of Journalism. However, he found that the School of Journalism would not be opened for another year. Instead of waiting for

another year he decided to take up another subject. He had no idea what to study. It is said that he picked up the university's course directory intending to study the first subject listed there. The first subject listed there happened to be 'art and archaeology' but as later mentioned by him, he could not pronounce the word 'archaeology' and moreover he had very vague idea about its



Edwin Hubble
(1889-1953)



Henry Norris Russell
(1877-1957)

meaning and so he ended up in taking up the next subject listed there. The next entry happened to be astronomy. Thus he became an astronomer by accident and not by choice. As we know, the rest was history.

He received the A.B. degree in astronomy from the University of Missouri in 1910 and the A.M. degree in 1911. He won the Thaw Fellowship at Princeton University Observatory. He went to Princeton in 1911 and started working for his Ph.D. degree under the supervision of Henry Norris Russell (1877-1957), who then headed the Department of Astronomy at Princeton and he was

one of the prominent and well-known astronomers of the day. At Princeton, Shapley also came in contact with Raymond Smith Dugan (1878-1940), who by sheer hard work established himself as a competent observer of variable stars. At Princeton, Shapley chose eclipsing binary stars as the topic of his doctoral dissertation. He was greatly influenced by his collaborators, Russell and Dugan. Commenting on their collaboration

Bart J. Bock wrote: "Together they worked out the theory for analysis of light curves of eclipsing binaries, a theory that even today dominates analysis in this area. Through his close collaboration efforts with Russell and Dugan, Shapley became impressed with potentials for research presented by the double stars, especially eclipsing binaries, which reveal secrets about stars and their physical properties through analysis of their light and related spectrographic data."

Shapley obtained



Raymond Smith Dugan
(1878-1940)



Arthur Stanley Eddington
(1882-1944)



Henrietta Swan Leavitt
(1868-1921)

Practical Astronomy (1922-56).

Shapley's work under Russell at Princeton proved that the group of stars known as Cepheids, were not binary stars as they used to be believed. They were single stars that changed their brightness as they changed their size. In fact Cepheids, named after the prototype, Delta Cephei, were the first 'pulsating variables' to be discovered. It was Arthur Stanley Eddington (1882-1944), a British astrophysicist and mathematician, who had worked out the theoretical basis for the pulsation. Shapley

subsequently discovered Cepheids in globular clusters and he measured their distances and distribution by using the period-luminosity law discovered by Henrietta Swan Leavitt (1868-1921), an American astronomer, and a statistical method developed by Shapley himself.

Shapley was an important science populariser and an accomplished writer. He wrote several books including *Star Clusters* (1930), *Flights from Chaos* (1930), *Galactic and Extragalactic Studies* (1948), *Climatic Change* (1953), *Of Stars and Men*

his Ph.D. in 1913. His thesis, which was on properties of binary eclipses, became a classic in the field. In 1914, Shapley joined the staff of the Mount Wilson Observatory in California and worked there till 1921, when he was appointed Director of the Harvard College Observatory, where he remained until 1952. At Harvard he also served as Paine Professor of

(1958), *A Census of Northern Galaxies in an Area of 3600 Square Degrees* (1958), *Source Book in Astronomy 1900-1950* (1960), *The View from a Distant Star: Man's Future in the Universe* (1964), *Beyond Observatory* (1967), and *Galaxies: The Harvard Books on Astronomy* (1972). In *Through Rugged Ways to the Stars* (1969), he gave an account of his scientific life.

Shapley received many awards which included *Henry Draper Medal* of the National Academy of Sciences, USA (1926), *Jules Janssen Prize* of the French Astronomical Society (1933), *Rumford Prize* of the American Academy of Arts and Sciences (1933), *Gold Medal* of the Astronomical Society of the Pacific (1939), *Janssen Medal* from the French Academy of Sciences (1940), *Pius XI Medal* (1941), *Franklin Medal* (1945) and *Henry Norris Russell Lectureship* of the American Astronomical Society (1950). Shapley served as the President of the American Association for the Advancement of Science (1947). In 1940s Shapley helped establish government funded scientific associations in USA including the National Academy of Sciences. He was responsible for the incorporation of 'S' in UNESCO—United Nations Educational, Scientific and Cultural Organisation. In fact he played an important role in the establishment of UNESCO.

Shapley died on 20 October 1972 at Boulder, Colorado, USA. He was buried at the local cemetery and the epitaph on his grave reads "And we by his triumph are lifted level with the skies", a quotation from Lucretius.

A crater on the Moon (Shapley crater), an asteroid (Asteroid 1123), and a supercluster of galaxies (Shapley supercluster) are named after Shapley. The American Astronomical Society has established Harlow Shapley Visiting Lectureship in Astronomy.

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

Top science stories of 2018

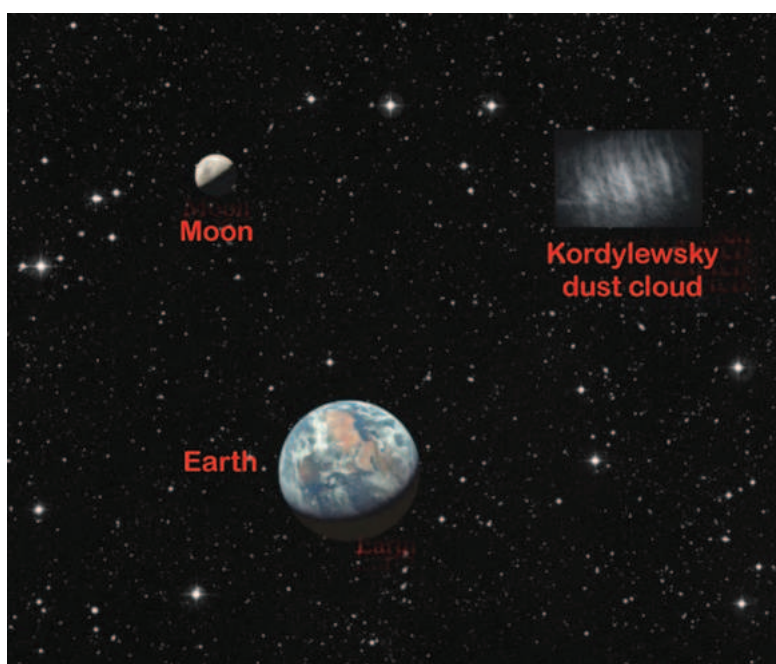


Biman Basu

Extra, hidden 'moons' of Earth discovered

Hungarian astronomer Judit Slíz-Balogh and physicist Gábor Horváth have made a startling disclosure that the Moon is not our planet's sole natural satellite and claimed that they have confirmed the existence of two Earth-orbiting objects entirely made of dust. They have even managed to capture snapshots of the mysterious clouds located just 4,02,336 kilometres away, roughly the same distance as the Moon. Their work was published in the journal *Monthly Notices of the Royal Astronomical Society* on 25 October 2018.

The dusty clouds have been named Kordylewski clouds after Polish astronomer Kazimierz Kordylewski, who first got a glimpse of the clouds in 1961. According to the new findings, each Kordylewski cloud is about $15^\circ \times 10^\circ$ wide as seen from Earth, compared to our Moon's angular size of 0.5° . This means they appear as large as 30×20 lunar disks in the night sky. But despite being large they have remained hidden in the darkness of space until now simply because they are extremely faint. According to the Royal Astronomical Society, given their stability, the Lagrange points L4 and L5 points are potential sites for the location of the orbiting Kordylewski



Earth's hidden moon

clouds. In other words, the dust clouds orbit approximately in the Moon's orbit, moving ahead of and behind the Moon in orbit.

Decay of Higgs boson observed

Six years after discovering the Higgs boson, physicists have observed how the particle decays. This is considered as a monumental contribution to our understanding of the Standard Model of particle physics and the universe at large. Higgs boson is an elementary particle predicted by the Standard Model of particle physics that relates to how objects have mass.

The discovery, however, was not the end of the Higgs boson story, because in addition to predicting the existence of Higgs boson particles, the Standard Model also predicted that 60 percent of the time, a Higgs boson will decay into smaller fundamental particles called bottom quarks (b quarks), which has now been observed. The results were presented at CERN on 28 August 2018 by the ATLAS and CMS collaborations at the LHC. According to physicists, the finding provides major support for the Standard Model, which has many implications for how we understand the world and the universe.

In confirming that the Higgs boson does, in fact, decay into b quarks, the physicists have shown that the Higgs field, the field behind Higgs boson particles – the “invisible jelly that permeates all of space” – gives b quarks mass. The Higgs field uses the Higgs boson to interact with other particles, like the b quark, and give them mass.

A galaxy without dark matter detected

Dark matter is an enigmatic entity that has mass but is invisible because it does not interact with light. The primary evidence

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for dark matter came from calculations which showed that many galaxies would fly apart instead of rotating or would not have formed or move as they do, if they did not contain a large amount of unseen matter. In fact, till recently it was believed that galaxies and dark matter go together and that there cannot be one without the other. Without dark matter, theoretical models of our universe simply wouldn't add up. But the idea that dark matter is an essential ingredient for galaxies to form is being challenged by



NGC1052-DF2, a galaxy without dark matter

the discovery of a distant galaxy that seems to contain no – or almost no – dark matter.

The discovery of the sparse, see-thru galaxy called NGC1052-DF2 in the constellation of Cetus was made by astronomers using the Dragonfly Telephoto Array – a New Mexico-based telescope built of camera parts that is designed to detect very faint galactic structures. The astronomers then followed up the analysis, collecting more data using the Hubble Space Telescope as well as the Gemini North and Keck Observatories in Hawaii. Their findings were reported in the journal *Nature* on 29 March 2018. NGC1052-DF2 is the first galaxy detected to contain little or no dark matter.

The ghostly galaxy, 61.97 million light-years away, doesn't have a noticeable central region, or even spiral arms and a disk – typical features of a spiral galaxy. But it doesn't look like an elliptical galaxy, either. The galaxy also shows no evidence that it houses a central black hole. Based on the colours of its globular clusters, astronomers estimate NGC1052-DF2 to be about 10 billion years old.

The kilogram redefined

Kilogram, the familiar unit we use for weighing things, was originally defined as equivalent to the mass of 1 litre of water at 4°C. It is currently defined as equivalent to the mass of an International Prototype Kilogram made of platinum-iridium alloy, also known as 'Le Grand K', manufactured in 1889 and carefully stored in an

environmentally monitored safe in a lower vault in the basement of the International Bureau of Weights and Measures (BIPM) in Sèvres near Paris in France. Several identical copies are stored safely in countries around the world, including one at National Physical Laboratory in New Delhi. All kilogram weights used around the world must match the international prototype.

The change in definition of the kilogram became necessary because it was found that, despite best efforts to maintain them, the international prototype kilograms have gained up to 50 micrograms of mass from surface contamination since their



The International Prototype Kilogram

manufacture late in the 19th century. As a result, each country that has one of these standard masses has a slightly different definition of the kilogram. This led to efforts to develop a system precise enough to allow replacing the physical lump of metal with a definition based directly on a fundamental law of nature which is invariant,

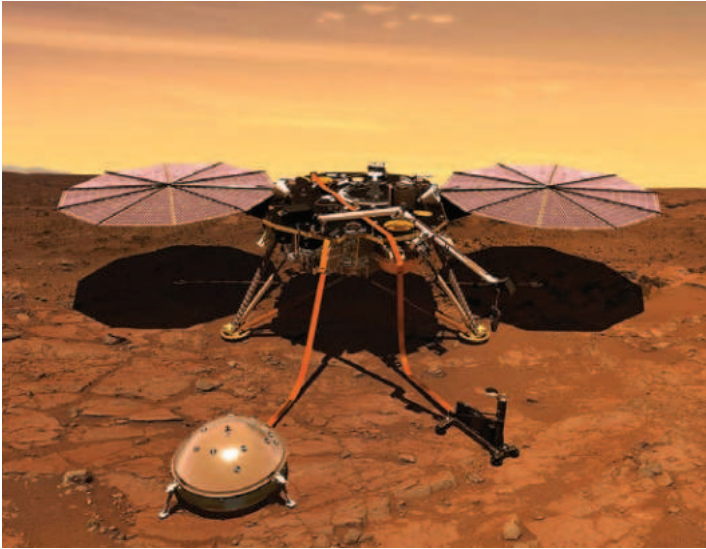
After decades of ground-breaking laboratory work, the world's scientific and technical community, representing 60 countries, came together at a session of the 26th General Conference on Weights and Measures in Versailles, France,

on 16 November 2018, to redefine four of the seven base units of measurement for the International System of Units (SI). They include the kilogram (the unit of mass), the ampere (the unit of electric current), the kelvin (the unit of temperature) and the mole (the unit for amount of substance). The new definitions will come into effect from World Metrology Day, which falls on 20 May 2019. The new definition of the kilogram is based on the fundamental unit Planck's constant, which has a value of $6.626070150 \times 10^{-34}$ joule-seconds.

NASA's InSight lands, to look inside Mars

NASA's latest Mars probe *InSight* landed on Mars on 26 November 2018, to become the first outer space robotic explorer to study in-depth the "inner space" of Mars – its crust, mantle, and core. *InSight*, short for 'Interior exploration using Seismic Investigations, Geodesy and Heat Transport', is a Mars lander designed to give the Red Planet its "first thorough check-up since it formed some 4.5 billion years ago".

According to NASA, studying the interior structure of Mars could answer key questions about the early formation of rocky planets in our inner solar system – Mercury, Venus, Earth, and Mars – more than 4 billion years ago, as well as rocky exoplanets discovered in the past couple of decades. *InSight* would also measure tectonic activity and meteorite impacts happening on Mars today. This mission is part of NASA's Discovery Program which is a series of



InSight lander on Mars

lower-cost, highly focussed scientific space missions aimed at exploring the solar system.

InSight will study the Red Planet's insides using two main instruments. The craft's seismometer will be deployed shortly after landing – the first seismometer to be placed directly on the surface of Mars. For two years (one Martian year), *InSight* will stay perfectly still while the domed instrument listens to the seismic waves travelling through Mars. This is not just any seismometer, like those measuring earthquakes on Earth; this instrument is so sensitive that it can measure the movement of the ground by the distance of single atoms. If Mars shakes even an atom's distance-worth, *InSight* will catch it. It is known that Mars no longer hosts tectonic or volcanic activity, but it is still cooling and shrinking, a process scientist believe causes quakes. In addition to marsquakes, *InSight's* 'Seismic Experiment for Interior Structure' or SEIS will listen for the seismic reverberations triggered by meteorite impacts. In addition, *InSight* has sensors to provide information on the weather and any changes in the local magnetic field nearby the lander. The lander's robotic arm features a camera that will take "colour 3D views of the landing site, instrument placement, and activities", according to NASA.

After landing the 'Heat Flow and Physical Properties Probe', or HP3 instrument was deployed, which was driven up to 5 metres into ground. The HP3 is essentially a large thermometer that will stay in the soil for a full Martian year, or two Earth

years. As Mars orbits the Sun, the HP3 will monitor the interior temperature of Mars.

Liquid water found on Mars

The journal *Science* reported on 25 July 2018 the discovery of a large reservoir of liquid water under Planum Australe – the southern polar plain on Mars. Till now, presence of water ice in the polar caps of

Mars has been known and there have been speculations about the presence of liquid water on the Red Planet, but without any confirmation. A lake of liquid water has been discovered some 1.5 kilometres below the polar ice cap. The discovery was made by a team of Italian scientists using three years' worth of data from the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) instrument on the European Space Agency's *Mars Express* orbiter. For the past 12 years the MARSIS instrument on-board the orbiting *Mars Express* has mapped the Martian underground using beams of low-frequency radar pulses, which can penetrate up to several kilometres beneath the surface.

According to the scientists who did the study, the potential lake is at least a few metres deep, and might be a fixed, steady feature of the subsurface. If confirmed, this would be the first-known reservoir of liquid water on present-day Mars which may provide a vital clue in the search for past or even present life on the Red Planet.

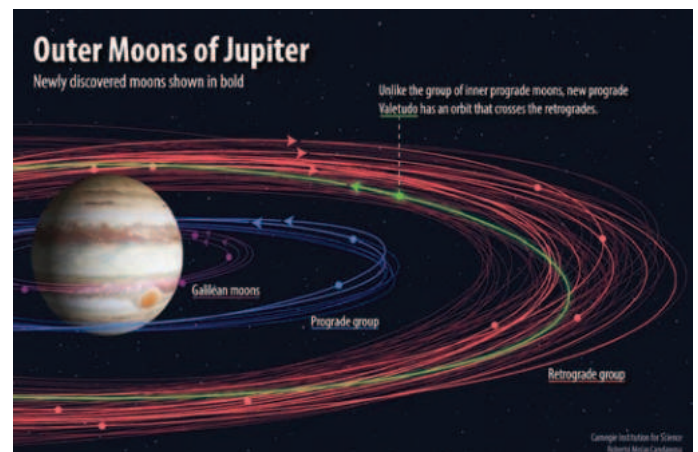
Bright spots beneath Mars's southern ice cap were first detected in 2007. The Italian team reprogrammed MARSIS to employ a more intensive scanning mode and then

surveyed Planum Australe 29 times with the instrument between 2012 and 2015. Every time the new MARSIS readings revealed a consistent 20-kilometre-wide bright spot nestled in a bowl-like depression beneath the ice cap in Planum Australe. The team then spent almost a year analysing the data, and another two years writing their paper and attempting to rule out non-aqueous explanations for what they had seen.

Scientists have found evidence that billions of years ago, Mars was much wetter and a more Earth-like place where water pooled in seas, carved enormous canyons and bubbled from hot springs. Mars-orbiting spacecraft have also glimpsed what might be rivulets of water flowing down sun-bathed crater walls at the height of Martian summer. Still, the water that once flowed across the Martian land had to go somewhere. Some of it was likely lost to space due to Mars's weak gravitational field, but scientists believe a significant fraction of the planet's aqueous inventory never really left and may have just frozen below ground. Now it appears not all of that buried watery wealth is frozen after all; rather a large part may be in the form of liquid water.

Jupiter gets 12 new moons

Jupiter is the largest planet of the solar system and it has the largest number of moons. Till recently, the total number of moons of Jupiter was taken to be 67. On 17 July 2018, the International Astronomical Union (IAU) announced the discovery of 10 new moons orbiting Jupiter. These along with two announced earlier in June 2017 bring the total number of Jupiter's known natural satellites to 79. Saturn, Jupiter's



Jupiter's new moons

closest rival, has a mere 62 moons orbiting around it. The four largest of Jupiter's moons were discovered by the Italian astronomer Galileo Galilei using a small home-made telescope more than 400 years ago, in 1610. Later, over the years, dozens of moons were discovered using more powerful telescopes and space probes.

The discovery of the new moons came by chance. Astronomer Scott Sheppard of the Carnegie Institution for Science in Washington, DC, USA was looking for Planet Nine, a hypothetical planet many astronomers think should exist in the distant reaches of our solar system beyond Pluto. He and his team have been photographing the skies with some of today's best telescope technology, hoping to catch sight of this mysterious ninth planet. It so happened that around mid-2017, Jupiter happened to be in an area of sky the team wanted to search for Planet Nine.

All the new moons around Jupiter are on average about three kilometres wide, which may be the reason why they had been left undiscovered until now, till scientists found them using incredibly sensitive telescopes. One of new moons named Valetudo turned out to be an oddball. It moves in an unusual way. It is positioned where Jupiter's outer, retrograde moons are, but it orbits Jupiter in the prograde direction. "It's like it's going down the highway in the wrong direction."

According to the researchers, finding how the objects came to be formed and orbit around Jupiter could shed light on the formation of our solar system.

First primates cloned

Dolly, the sheep, created sensation in the scientific world being the first mammal to be cloned. Dolly was created by a technique called somatic cell nuclear transfer (SCNT) in which the nucleus of a body (somatic) cell is transferred to the cytoplasm of an egg (ovum) that has had its own nucleus removed. Once inside the egg, the somatic nucleus is reprogrammed by egg cytoplasmic factors to become a fertilised egg nucleus. The most practical application of SCNT is

in the reproductive cloning of farm animals that have exceptional qualities, such as the ability to produce large quantities of milk. Reproductive cloning is accomplished by implanting an SCNT-derived blastocyst into the uterus of a surrogate mother, in which the embryo develops into a foetus carried to term. Since Dolly, scientists have cloned more than 20 species, including cattle, pigs, dogs, cats, mice and rats, using the same technique.

Now, in a world first, Chinese researchers have successfully cloned a primate, namely macaques, using the SCNT technique. Two new-born macaques, named Zhong Zhong and Hua Hua, were produced at the Chinese Academy of Sciences' Institute of Neuroscience (ION)



Cloned monkeys Zhong Zhong and Hua Hua (Credit: Institute of Neuroscience of Chinese Academy of Sciences)

in Shanghai using SCNT. This achievement, which was announced in January, marks the first time that a primate has ever been cloned in such a manner. The success did not come easily. The birth of Zhong Zhong and Hua Hua was the result of 79 attempts. The researchers say that they want to use this technique to breed macaques for biomedical research. Exact genetic copies of the same animal would reduce the variability in results when testing new drugs or other therapies.

Muming Poo, director of ION and a member of the cloning team, says, "Our research purpose is entirely for producing non-human primate models for human diseases; we absolutely have no intention, and society will not permit, this work to be extended to humans." The achievement

suggests it is now possible to create research populations of identical, customised monkeys, which Poo and his colleagues said would reduce the number of primates used in laboratory experiments.

The scientists say they followed strict international guidelines for animal research, set by the US National Institutes of Health. "We are very aware that future research using non-human primates anywhere in the world depends on scientists following very strict ethical standards," says Poo.

Meghalayan: A new chapter added to Earth's history

The geologic time scale can be termed as the "calendar" of events in Earth's existence. It subdivides all time into slices or units of abstract time called eons, eras, periods, epochs, and ages. Each of these units of time is given a name based on stratigraphy, which is the correlation and classification of rock strata. The fossil forms that occur in the rocks provide the chief means of establishing a geologic time scale. One of the most widely used standard charts showing the relationships between the various intervals of geologic time is the International Chronostratigraphic Chart, which is maintained by the International Commission on Stratigraphy (ICS), the official

keeper of geologic time. The most recent addition to the list is an age named after the north-eastern Indian state of Meghalaya.

According to geologists, around 4,200 years ago, a devastating drought lasting for at least two hundred years caused the collapse of civilisations around the world. It severely disrupted civilisations in Egypt, Greece, Syria, Palestine, Mesopotamia, the Indus Valley, and the Yangtze River Valley. Effects from the drought were felt around the world. Evidence of the prolonged drought has been found in stalagmites (rock formations that form on the floor of a cave due to the accumulation from ceiling drippings) in India, where the lack of monsoon rains is represented by changes in oxygen isotopes in the stalagmites. The



A portion of an Indian stalagmite from Meghalaya that defines the beginning of the Meghalayan Age. (Credit: IUGS website)

clinging evidence came from a stalagmite found in a cave in Meghalaya in the form of chemical signatures, which provided the basis for naming the new geological age.

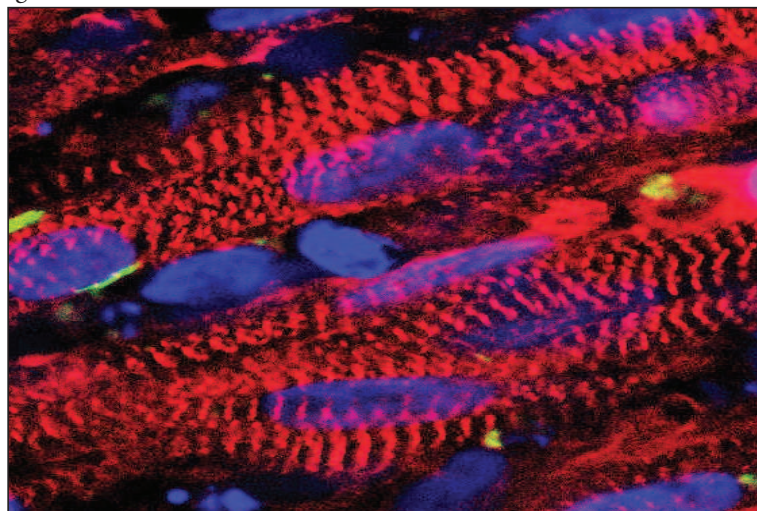
Our current era is the Cenozoic, which is further divided into three periods – Paleogene, Neogene, and Quaternary. We live in the most recent period, the Quaternary, which is again subdivided into two epochs: the current Holocene, and the previous Pleistocene, which ended 11,700 years ago. We currently live in what is called the Holocene. The Meghalayan is the latest age or uppermost stage of the Holocene. The Meghalayan age was officially ratified by the International Union of Geological Sciences (IUGS) on 14 June 2018 along with the two others – the Greenlandian and the Northgrippian. The Meghalayan is unique because it is the first interval in Earth's geological history that has coincided with a major cultural event, as agricultural societies struggled to recover from the shift in climate.

Skin cells turned into muscle cells

For the first time, functioning human muscle has been grown from induced pluripotent stem cells derived from adult skin cells, which holds promise for cellular therapies, drug discovery and studying rare diseases. The research, done by a biomedical engineering team at Duke University in USA was reported in the journal *Nature Communications* on 9 January 2018. The

researchers started with human induced pluripotent stem cells obtained from adult non-muscle tissues, such as skin or blood, and reprogrammed them to revert to a primordial state. The pluripotent stem cells were then grown while being flooded with a molecule called Pax7 – which signals the cells to start becoming muscle. As the cells proliferated,

they became very similar to – but not quite as robust as – adult muscle stem cells. While previous studies had accomplished this feat, till now nobody has been able to



A stained cross-section of the new muscle fibres produced from skin cells. The red cells are muscle cells, the green areas are receptors for neuronal input, and the blue patches are cell nuclei. (Credit: Duke University)

further grow these intermediate cells into functioning skeletal muscle.

In the present study, after two to four weeks of 3-D culture, the resulting muscle cells formed muscle fibres that contracted and reacted to external stimuli such as electrical pulses and biochemical signals mimicking neuronal inputs just like native muscle tissue. According to the researchers, the key to their success was their unique cell culture conditions and 3-D matrix, which allowed cells to grow and develop much faster and longer than the 2-D culture approaches that are more typically used. The researchers also implanted the newly grown muscle fibres into adult mice and showed that they survive and function for at least three weeks while progressively integrating into the native tissue by growing blood vessels.

This success is likely to have far reaching impact on treatment of muscular disorders. In the past, in order to develop cell therapies to correct and treat muscular dystrophies, researchers had to work primarily with animal models. This most recent progress, where muscle is grown from non-muscle, could open the door to much more advanced applications like cell therapies, drug discovery, and the ability to grow larger amounts of muscle, as well as expanding our own understanding of human biology. ■

Articles
invited

Dream 2047

Vigyan Prasar invites original popular science articles for publication in its monthly science magazine *Dream 2047*. At present the magazine has 35,000 subscribers. The article may be limited to 3,000 words and can be written in English or Hindi. Regular columns on i) Health ii) Recent developments in science and technology are also welcome. Honorarium, as per Vigyan Prasar norm, is paid to the author(s) if the article is accepted for publication. For details please log-on to www.vigyanprasar.gov.in or e-mail to dream@vigyanprasar.gov.in

