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

Postal Registration No.: DL-SW-1/4082/18-20
Date of posting: 26-27 of advance month
Date of publication: 24 of advance month

DREAM 2047

March 2018 Vol. 20 No. 6 Rs. 5.00

A Silent Revolution: Six Decades of Metric System in India

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

EDITORIAL

Empowering Women

Chander Mohan

Women are not just one half of the world's population but an equal partner in progress as well. They are now widely recognised as a critical section of the workforce and it is as relevant, and perhaps more, particularly in the science and technology (S&T) domain. However, a large number of well-qualified women get left out of the S&T activities due to various circumstances, which are usually typical to the gender. Familial responsibilities are by and large the major reason for them to take a so called 'back seat' even though they could easily be in the driver's seat. The challenges faced by them are several and these have been highlighted often, though many of these perhaps never even get addressed.

Despite the emphasis laid down by the government on compulsory education for all and free education for the girl child, a majority of them end up gradually, and sometimes even abruptly, terminating their quest for higher education. We in the Department of Science and Technology (DST) had acknowledged this lacuna and initiated several programmes and schemes to address this vital issue. Interactions at various levels made us realise that a large percentage of even those who had done rather well at higher secondary and college level in the realm of S&T, got 'left out' from the mainstream. And, most often, this "break in career" arose out of marriage, motherhood and other family responsibilities like taking care of the children and the elderly.

To address such issues, DST launched "Women Scientists Scheme (WOS)" during 2002-03. This initiative primarily aimed at providing opportunities to women scientists and technologists between the age group of 27-57 years, who had a break in their career but desired to return to mainstream, to apply for a research grant that also encompassed a fellowship. Then in 2014-15, this as well as all other initiatives undertaken by DST for furthering the career of women in S&T were brought under one umbrella called KIRAN (Knowledge Involvement Research Advancement through Nurturing). KIRAN provides a bouquet of opportunities to career women scientists & technologists. It is primarily aimed at gender parity in S&T sector by inducting more women talent in research and development (R&D) and also creating an enabling eco-system.

Various programs in the KIRAN kitty include Women Scientist Scheme-A (WOS-A) for pursuing basic research in many disciplines of S&T, Women Scientist Scheme-B (WOS-B) for R&D aimed at addressing some well identified societal challenge and Women Scientist Scheme-C (WOS-C) that enables them to pursue a career in Intellectual Property (IP) regime. Over 4,000 women who 'dared to dream' have been nurtured through WOS alone and we are counting. Institutional support through Consolidation of University Research through Innovation and Excellence in Women Universities (CURIE) program, wherein R&D facilities are augmented in women-only universities, and Women Technology Parks (WTPs), which offer single-window opportunities to women at grassroots level, are other pillars of KIRAN platform. Recently, DST also launched a new program 'Indo-US Fellowship for Women in STEMM' to provide international exposure to women scientists. Thus, DST has made concerted and focussed efforts to provide a launch pad for further forays in S&T, a level playing field and a stronger foothold. So with this background, it is time to once again observe International Women's Day on the coming 8th of March. Several programmes are in the offing to celebrate the growing status of our women and we look forward to our readers to send us feedback on how this day was commemorated by them.

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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.

Juice Blending –
A promising way to improve quality and storage of nutritive fruit and vegetable juices


Shashi Meena and Ravi Kumar Meena

Formulation of mixed fruit, vegetable, and spice juice beverage is extremely useful for satisfying consumer tastes and preferences. Blended juices have a longer shelf-life (3-6 months) without having any microbial infestations of juices. There is a great potential for utilisation and commercialisation of mixed fruit, vegetable, and spice juice beverage as a natural health drink from major and underexploited fruits not only in the domestic market but also at the export front.

During the last few years, the demand for beverages made from fruit and vegetable juices have been increasing, which may be attributed to change in dietary habits, increase in health awareness, taste preferences, and the lifestyle. But the utilisation of some of the fruits and vegetables for consumption becomes limited due to having high acidity, astringency, bitterness, and such other factors, despite possessing high nutritional qualities. Therefore, blending of two or more fruit and vegetable juices for the preparation of ready-to-serve beverage may be a preferable and economic alternative for the utilisation of such fruits and vegetables. The formulation of blended mixed fruit, vegetable, and spice juice beverage is extremely useful for satisfying consumer preferences and possess a longer shelf-life (3-6 months) without having any microbial infestations in comparison to pure juices. There exists a great potential for utilisation and commercialisation of blended juice beverages from major and underexploited fruits as a natural health drink by overcoming few limitations.

India has a wide range of agro-climatic regions, on which a large number of horticultural crops such as fruits, vegetables, spices, medicinal and aromatic plants can be grown successfully. Fruits and vegetables are important constituents of diet and provide significant quantities of nutrients, especially vitamins, sugars, minerals, and fibre. Daily consumption of fruits and vegetables reduce risk of cancer, heart disease, premature aging, stress, and fatigue, primarily due to the integrated action of oxygen radical scavengers such as β-carotene and ascorbic acid. The post-harvest shelf life of most fruits and vegetables is very limited due to their perishable nature. In India more than 20-25 percent of fruits and vegetables are spoiled before utilisation. Despite being world's second largest producer of fruits and vegetables after China, only about 1.5 percent of the total fruits and vegetables produced are processed.

Merits of blending fruit and vegetable juices

- Maintaining a single juice's uniformity within and between seasons by blending

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multiple cultivars to insure a consistent availability of product in the market.

- Overcoming the high cost of some juices (exotic fruits) by blending with other fruit juices.
- Overcoming scarcity and/or seasonal availability of certain juice components.
- Balancing out excessively strong flavours, primarily high acidity, astringency or bitterness.
- Correcting low-soluble solids level.
- Balancing juices with weak or bland flavour, but possessing other nutritive positive attributes.
- Helping improve colour or colour stability of otherwise desirable juices attributes.
- Overcoming undesirable single-strength juice consistency.

Effect of juice blending on important qualitative parameters

Storability of juice

Storability of fruit and vegetable juices depends upon factors like presence of acids, time of sterilisation, method of preservation and the storage temperature. All these factors are complementary in nature, which are responsible for extending shelf life and storage stability of fruit beverages. Some fruits and spices have natural antioxidant and antimicrobial properties, and these juices can be stored effectively for long periods of time without any chemical changes. Blending of different fruit, vegetable, and spiced juices improve storability and inhibit microbial growth in juice.

Vitamin C

Ascorbic acid (Vitamin C) is natural antioxidant and also *co-factor* in many *enzymatic* reactions including several **collagen** synthesis reactions. Ascorbic acid is sensitive to heat and is oxidised quickly in the presence of oxygen. There are many fruits and vegetables which are source of ascorbic acid. Blending other juices with ascorbic acid-rich fruits such as *amla*, acid lime, etc., could help in maintaining balance of vitamin C levels in fruit juices.

Vitamin A

The carotenoids are one of the major sources of colour and human nutrition in food as some of them convert into vitamin A. Blending with carotene-rich fruit and vegetable juices such as papaya, mango, and carrot can significantly improve the carotenoid content in beverage.

Acidity

Acidity in juice is an important factor and its maintenance in juice assumes special significance during storage. The decrease in acidity observed during storage is attributed to the chemical interaction between the organic constituents of the juice induced by temperature and action of enzymes. The acidity levels can be increased to optimum level by juice blending with natural antioxidants (spice extracts) which reduce conversion of acids to sugars and salt by enzymes and oxidation during storage.

pH

The pH of fruit juice plays an important role in the preparation of beverages. The pH of juice is increases during storage of juice, may be due to the decrease in acidity, which in turn may be due to the chemical reaction between organic constituents. It is a measure of the acidity, which not only influences the flavour or palatability of a product but also the shelf life. The blending of juices with low-pH fruit or vegetable juices allows increase in pH and hence the shelf life of juice.

Microbial Population

Fruit juice is the best medium for multiplication of microbes hence there is an increase in microbial (bacteria, yeast, and mould) population during storage. The microorganisms use food materials for their growth. They utilise nutrients and cause enzymatic changes, contributing to creating off-flavour by breakdown or synthesis of new compounds and hence spoil the food. These organisms are either present in fruit or get incorporated into the product during processing and multiply fast during processing and during storage. Minimum increase in the microbial population was recorded when juice was blended with spices like ginger, mint, and black pepper. This might be due to their inhibitory effect onmicro-organisms.

Sensory Evaluation of Juice

Marketability of juice depends on the flavour, colour, and the taste of fruit juice. Qualities like colour, flavour, and nutritive value of fruit products generally decrease with increase in storage period. The colour, flavour, taste, and appearance, as well as the nutrient component of the blends, were found to be superior as compared to juice prepared from individual fruits.

Since many factors affect the composition and quality of the juice, blending provides the great opportunity to adjust sugar/acid ratios and compensate for other imbalances in juice. These differences can be dramatic and complicate the task of a manufacturer committed to a uniform product with established standards. Fortunately, by blending several batches of juice with complementary compositions a uniform the standard juice is practical. Adjusting 100 percent juices is much more of a challenge than manipulating acid and sugar in juice beverage blends.

Deficiencies in nutritional attributes and quality of the juices can be overcome by proper combination of juices. Further adjustments may call for additional ingredients. Extremely acidic and/or strong flavoured juices completely mask more subtle juices. In that case, the flavour of the juices can be greatly extended by non-juice sweeteners, although labelling regulations must be precisely followed.

Storage life of juices is related to acidity and it was found that when pH is between 4.0 and4.2 or lower, the germination of surviving spores is inhibited and comparatively low-temperature process– 100°C or under may be used safely. The blending of less acidic vegetable juices with highly acidic fruit juices can be used to increase the acidity of less acidic juices thereby increase storage life.

Continued on page 29

Human Urine as an Organic Alternative to Chemical Fertilisers

B.B.Jana

The safe and proper use of human urine would be a sustainable alternative to chemical fertilisers for the benefit of poverty-ridden farmers in the country. This fulfils the philosophy of wastes into wealth. Human urine is not a waste but a valuable resource. Urine is an ultra filtrate of blood plasma acting as a feedback mechanism to maintain ionic balance of our body.

Human urine is not a waste but a valuable resource. It is said that waste is a resource out of place. Urine is an ultra filtrate of blood plasma acting as a feedback mechanism to maintain ionic balance of our body. Average person urinates seven times a day, voiding around 2 litres of urine per day. It creates pollution when discharged into the sewer system and costs more to remediate. On the other hand, there is immense potential of its profitable uses in many economic driven activities. According to a NASA study, one person's urine could be same person's refreshing glass of water and generating electricity using leftover solid waste. The International Space Station (ISS) has been using a similar urine converting system since 2008. Col. Chris Hadfield who has spent a total of six months in space, demonstrated the process in one of his incredible YouTube videos.

Human urine is an aqueous solution. Though the composition of human urine may vary depending on meal habits, on an average there is15-19% nitrogen (N), 2.5 - 5% phosphorous (P_2O_5), 3.0 - 4.5% potassium (K_2O), 11 - 17% carbon (C), 4.5 - 6% calcium (Ca) in the dry matter content of urine. Each person, on an average, contributes about 4.6 kg of phosphorus and 1.1 kg of potassium in a year besides some growth promoting agents such as amino acids, glucose and vitamins. Its contribution in total domestic waste water is mostly in the form of major plant nutrients (94% of N, P and K in direct toilet water and 80% of N, 50% of P and 60% of K in wastewater). It is surprising that more that Rs. 61 million could be recovered from the country's domestic sewage daily in the form of NPK fertilisers, while we obtain new fertilisers from the environment at significant cost from non-renewable mineral sources.

Ecological sanitation

Around the world, more than 2.4 billion people still live in unsanitary conditions. Nearly 60% of the Indian population do not have access to proper sanitation and go for open defecation or have not developed the habits of using toilet. This causes a high risk of life-threatening sanitation-related diseases. The United Nations has set a target of providing sanitation facilities to at least 50% of the population by the end of the year 2050. Accordingly, Government of India has taken appropriate measures to provide sanitation facilities to the country's entire population by 2050.

With a view to conserve water, efforts are being made to install waterless urinals and a source separating flush toilets. Bill Gates Foundation is funding the development of the nano membrane toilet, which will be able to treat human waste on-site without external energy or water. It

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will enable those without plumbing to have access to safe and hygienic facilities. Indian Institute of Technology, Delhi has recently developed waterless toilet. Terminal-2 of Mumbai International Airport has been using waterless toilet in which green bacteria are used to make the urinals odour-free. Likewise, technology is being developed to fabricate waterless urinals for women. The urine diverted from toilet will facilitate collection in a holding tank where it will be treated and eventually be used to create safe fertilisers that will substitute synthetic chemical fertilisers.

Eco-sanitation has emerged as important tool to solve water and sanitation problems in the society. Eco-sanitation and organic farming are interlinked with each other as the former is crucial in closing the loop between the nutrients and agriculture or aquaculture.

Eco-sanitation restores a remarkable natural balance between quantity of nutrients excreted by one person in one year and that required to produce his/her food for a year, and therefore can help in saving limited freshwater and mineral resource.A

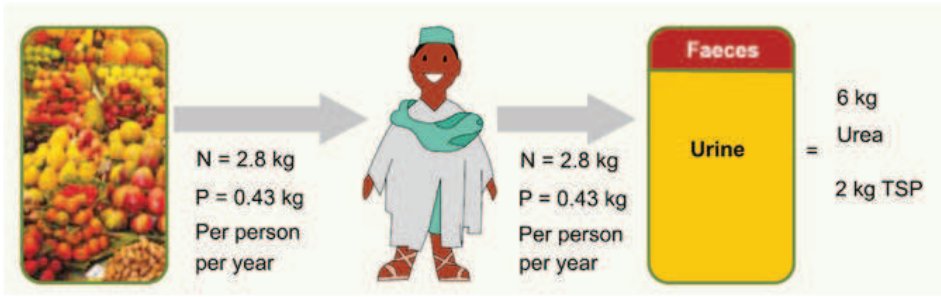

Fig. 1. Balance of nutrients between food and urine and faeces

remarkable natural balance (Fig.1) exists between quantity of nutrients excreted by one person in one year and that required to produce his/her food– 250 kg of grain (7.5 kg nitrate, phosphorus and potassium).

In India, farmers often face the loss of agricultural profits due to high cost of chemical fertilisers used in agricultural production, but we have not implemented the concept 'wastes into wealth' by turning human wastes into organic fertilisers. We essentially make new fertiliser for each use. Nitrogen fertiliser is produced via an energy-intensive process using natural gas, while phosphorus and potassium are derived from non-renewable mined ore which are projected to be exhausted soon.

Urine is less hazardous

One of the advantages of using human urine is that the hazardous chemical compounds or heavy metals are generally absent or low in human urine whereas chemical phosphate fertiliser contains a high level of heavy metal depending on the type rock phosphate used for the manufacture. As a result, agricultural bulk fertilisers may have cadmium concentrations of up to 36 g per kilogram phosphate which is several magnitudes higher than that of typical human urine. This implies that human urine is safer than chemical phosphate fertiliser. Moreover, it is estimated that phosphorus reserve in earth (rock phosphate) will be exhausted within the next 60-130 years.

The benefits of urine

Because the composition of human urine reflects the average requirement of essential nutrients in available form for plant growth, human urine is a well-balanced nitrogen-rich and cost-effective fertiliser that gives the same yields as chemical fertiliser in crop production. Urine-derived fertiliser can play an important role in food security, mitigation of poverty and malnutrition. Recycling of municipal wastewater for biological production is an age-old practice in many countries of Asia. This practice now in a more scientific way is rapidly spreading in many countries, especially in Mexico, USA, West Africa, Germany, Sweden, Norway, and Finland.

Human urine is used as balanced fertiliser for the cultivation of high N-demand vegetables such as cabbage, barley, cucumber in temperate climate. Trials conducted in Finland have fairly proved the fertiliser value of urine as compared to chemical fertiliser in cabbage production

Fig. 2. Cabbage grown with human urine in Finland as well as in West Africa

(Fig. 2) when both were applied at a dose of 180 kg N/ha. Growth, biomass, and levels of chloride were slightly higher in urine-fertilised cabbage than inchemical-fertilised cabbage. Insect damage was lower in urine-fertilised than in chemical-fertilised plots. Microbiological quality of urine-fertilised cabbage and sauerkraut (shredded cabbage fermented in brine) was similar to that in the other fertilised cabbages. Further, the level of glucosinolates (natural components of many pungent plants such as mustard, cabbage, and horse radish) and the taste of sauerkrauts did not differ between the two fertiliser treatments.

Tomato (*Lycopersiconsp*) was cultivated using human urine as fertilizer in green house and produced 1.3 kg of tomato from eight plants after 114 days of cultivation. Applying stored human urine at the rate of 145 kg of N/ha in arable soil, wheat yield was enhanced by 94% compared to reference yield. Banana cultivation in Bengaluru with 10% solution of fresh human urine revealed surprisingly high production, each weighing as much as 500 g a piece. Spinach (Fig. 3), French beans (Fig.4), pole beans and pumpkins also grow well with human urine. Applying 25% diluted human urine as fertiliser once in four days, yield of green amaranth (*Amaranthus sp*.) was significantly

Fig. 3. Spinach grown with human urine

Fig. 4. French bean grown with chemical fertilizer French bean grown with human urine

higher in urine-fertilised treatment compared to unfertilised ones.

It is evident that yields from field research in Burkina Faso (West Africa), where yields of urine-fertilised crops did not differ from mineral fertilised crops (Table 1). The urine procured from one person in a year is sufficient to fertilize 300-400 m^2 of crop to a level of about 50-100 kg N/ha.

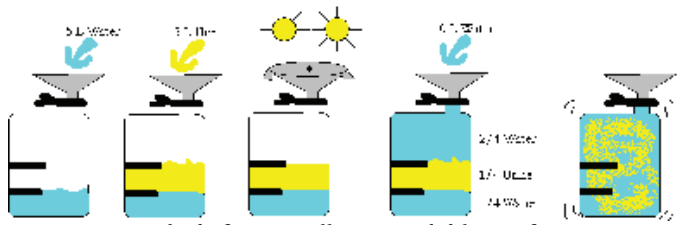

Fig. 5. Method of urine collection and dilution for use in crops

Table 1.Yield of vegetables as an average of three years of field trials in Burkino Faso (West Africa). There was no statistical difference in the yield between urine and mineral fertiliser

Treatments	Eggplant (ton/ha)	Gombo (ton/ha)	Tomato (ton/ha)
Unfertilised control	2.8	1.7	2.1
Mineral fertiliser	17.8	2.7	5.7
Stored urine	17.7	2.4	5.2

Other vegetables such as lettuce, carrots or maize, etc.,have been grown at a research plot in New England, USA.

Urine (Fig. 5) is collected and turned into fertiliser by a simple process. Urine is collected in modified jugs or 20L jerry cans and diluted with water in a ratio ranging from 1 to 10 depending upon the crop (direct application on plants will cause burning of leaves and roots). The jerry cans are to be kept air-tight using a piece of rubber chord in order to avoid the loss of nitrogen that may escape the jug into air as ammonia. Finally, the jerry can is filled with water and mixed well, making a mixture of 5 litres of urine and 15 litres of water, which is now ready for use in agricultural crops.

Protocol for aquaculture

Stored urine, which has been kept under closed condition at least for six months, is safe for aquaculture. Using human urine several experiments were performed to evaluate its fertiliser value on the production of algae, zooplankton and fish in experimental tanks. The results were highly successful implying that human urine is either superior or almost similar to conventional fertilisers. In terms of production cost, it is very cheap and highly cost effective.

Microalgae production

Excellent growth of the microalgae (*Scenedesmusacuminatus*) was observed in culture with 2% solution of fresh human urine within three days of culture. Using nitrified stored human urine as medium, good growth of blue green *Spirulina platensis* was observed. While comparing the efficacy of fresh and stored urine, it was observed that primary productivity of phytoplankton was distinctly higher in stored urine than in fresh urine treated tanks.

Zooplankton production

Zooplankton is indispensable as primary natural food in rearing of larval fish. It is of immense use in the culture of ornamental fish in aquarium fish by minimising the use of artificial feed that causes deterioration of water quality. Likewise, *Moina*, an important zooplankton, grew and reproduced well in 0.5% solution of fresh human urine. This work was highlighted in the Nature News (www.nature.com/news/2007/070629/full/news070625-13.html)

Fish production

Production cost of fish using the conventional fertilisers is very high and fish culture is a common method of livelihood for millions of poor people. Human urine has been proved to be effective alternative chemical fertiliser for fish culture. Our studies have shown significantly higher fish yield in stored urine treatments compared to that of fresh urine. The load of pathogenic bacteria *E. coli* did not differ from urine treated tanks to control.

Methods of disinfection

The researchers have been exploring the ways to remove bacteria, viruses and residual pharmaceuticals from urine to make it a viable and safe fertiliser. In fresh urine, greater part of the nitrogen appears as urea [$CO(NH_2)_2$] which, on storage, is hydrolysed microbiologically into ammonia causing pH augmentation from about 6 to 9 accompanied with ammonium (NH_4^+) and bicarbonate ions. The evolution of ammonia

Table 2. Effect of urine on different crops

Bad effect on	Little effect on	Best effect on	Great effect on
Carrots, because it will grow big leaves and small roots	Legumes, beans, and peanuts, because they fix nitrogen	Corn, millet; sorghum, salads, spinach, and other greens because urine fertiliser is great for growing bigger leaves and lots of seeds.	Onions, tomatoes, potatoes, eggplant, bananas,peppers, garlic, cucumber, melons, squash, sweet potatoes, cassava.

Fig. 6, Application of human urine in agriculture fields in Norway

gas can be reduced by preventing ventilation. It is claimed that if the urine is stored at 20°C for at least 6 months, the urine may be considered safe for using as fertilizer for any crop. Moreover, pH of stored urine below 4 seems to further reduce the number of pathogens. It is also reported that at pH from 2-7.5, about 25% of urea of stored urine could be hydrolysed within 30 days. Almost similar to SODIS method, storage of urine in closed transparent bottle under sunlight for 30 days is enough for removal of almost all bacteria.

Our studies have shown that human urine undergoes microbiological and chemical changes during the storage period and becomes highly alkaline resulting in death of pathogenic bacteria. Storage for 253 days under closed conditions is the period when the coliform counts remained within the safe limit.

Challenges

For safe use of excreta in agriculture, World Health Organization has suggested a flexible multi-barrier approach for managing

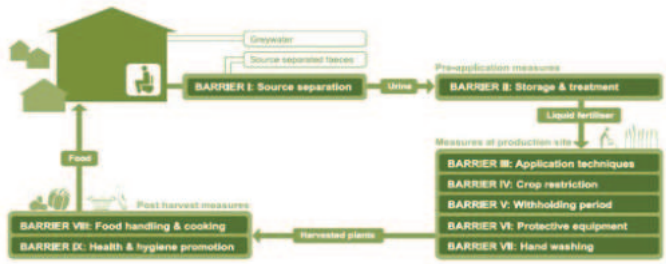

Fig. 7. Barrier concept for safe use of urine as fertilizer

the healthrisks associated with the use of excreta. This concept comprises of a series of measures/barriers from 'toilet totable'. Barriers include storage, crop restrictions, withholding periods and reduced contact, correct handling and cooking of the food crop (Fig 7). Each of the barriers has a potential to reducehealth risks associated with the excreta use.

Conclusion

The safe and proper use of human urine would be a sustainable alternative to chemical fertilisers for the benefit of poverty-ridden farmers in the country. This fulfils the philosophy of wastes into wealth. It is easy to collect from community toilets, airport, railway stations, market places, schools, colleges, universities, etc. Mobile toilets may be used in rural festival places where a large number of people throng.

Awareness campaigns involving NGOs with audio-visual aids should be encouraged to promote open defecation-free 'clean village' for which facilities for eco-sanitation will be extended for collecting the urine and faeces separately and will be processed for their safe uses in economy-driven activities. ■

Juice Blending –A promising way to improve quality and storage ..... *(Continued from page 33)*

Limitations in juice blending

a) Identification of proper blending ratios of different fruit and vegetable juices

Identification of suitable blending ratios of juice needs several experimentations. Perfect blend would be a mixture of different fruit and vegetable juices,to satisfy consumers' need both in nutritional levels and sensory values.

b) Loss of original flavour

There is a chance where the original flavour of the base juice may be lost while blending with different fruit and vegetable juices.

c) Variation in processing methods for original juices and in blended juices

This is the major problem while preparing juice blends as processing methods for different fruits and vegetables are different from each other. While preparing juice blend one must have knowledge of the difference in processing methods, as this factor may damage the quality of the product.

For example, while preparing a blend using pomegranate juice one must keep in mind that the phenolic constituents of pomegranates give colour, astringency, and bitterness to the juice. These compounds are also responsible for the formation of the cloudy appearance of fruit juices during concentration and storage. Although pomegranate juice contains only trace amounts of pectin, clarification is necessary to prevent the formation of haze in the juice during process and storage. Phenolic compounds can form complexes with proteins. These complexes increase the turbidity of fruit juices.

d) Complexity in license acquirement procedure for blended juices manufacture

Specific standards are not yet made for juice blends which in turn create complexity in license acquirement procedure.

Conclusion

It may be concluded that the formulation of mixed fruit, vegetable, and spice juice beverage is extremely useful for satisfying consumer tastes and preferences. Blended juices have a longer shelf-life (3-6 months) without having any microbial infestations of juices. There is a great potential for utilisation and commercialisation of mixed fruit, vegetable, and spice juice beverage as a natural health drink from major and underexploited fruits not only in the domestic market but also at the export front. ■

India's Biggest Planetarium Reopens with a Bang

Shakunt Pandey

A planetarium makes learning astronomy a fun and a pleasant experience. It fosters scientific temper among the general public. It sets the layman, amateurs and students on a quest to unravel the mysteries of the cosmic world. It serves as an educational facility and the varied educational programmes held at the planetarium inspire students to pursue astronomy and space science as a career.

What is the best way to learn astronomy? Scientists believe this can be done by regular visits to a planetarium. Simply put, a planetarium is a theatre in the domed structure of a building, where a special projector creates the simulated motions of the stars and planets in the night sky as seen from any location on Earth.

A planetarium makes learning astronomy a fun and a pleasant experience. It fosters scientific temper among the general public. It sets the layman, amateurs and students on a quest to unravel the mysteries of the cosmic world. It serves as an educational facility and the varied educational programmes held at the planetarium inspire students to pursue astronomy and space science as a career.

M.P. Birla Planetarium, Kolkata

India's planetarium journey is quite unique in the sense that it all began in the cradle of learning itself, a school. The first planetarium of the country took birth in the year 1954 at the historical New English School in Pune (Maharashtra) which was run by the famous Deccan Education Society (DES). The then Head Master of the school P.N. Veerkar had commissioned the simple planetarium at the top of the school building in a 63-square-metrearea. The 9-m dome housed a Spitz A1 projector which was imported from Philadelphia, US. It was christened Kusumbai Motichand Planetarium and became operational on 18 September 1954. The old projector worked tirelessly till 2004 and was out of order for seven years. It was restored and made operational again in 2011. Apart from its own students and students from nearby schools, the planetarium also welcomes general visitors to the astronomical shows held on Independence Day and other select holidays.

Professor R. Subramanian, a pioneer in the field of planetariums, had himself installed a simple table model planetarium at the Madras Museum during 1950-51, without any formal training. He was also instrumental in setting up a relatively bigger planetarium at National Physical Laboratory (NPL) in New Delhi during 1956.The UNESCO had a General Conference in 1956 in Delhi when an 'India and Science'

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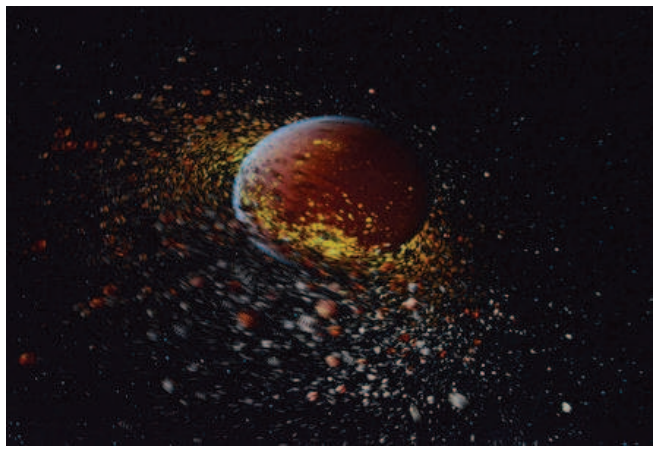
exhibition was set up to coincide with the conference. Leading planetarium manufacturer Carl Zeiss also participated in it. They gifted the planetarium instruments to Jawaharlal Nehru who in turn gifted it to NPL. Renowned physicist Sir K.S. Krishnan, who was the first director of NPL handed it over to Prof. Subramanian who set it up at NPL in a small planetarium for demonstration before invited school groups. It could accommodate forty persons at a time.



The astronomical show at the planetarium

Professor Subramanian was also instrumental in setting up the first major public planetarium in India, the M. P. Birla Planetarium at Kolkata in 1961, which was the largest in Asia at that time. Counted among Asia's oldest planetariums, this 55-year-old planetarium is modelled on one of the famous Buddhist icons, the Sanchi Stupa of Madhya Pradesh. It was a result of a joint vision of philanthropist and entrepreneur Madhav Prasad Birla, the then chief minister of West Bengal Dr. Bidhan Chandra Roy, and the brilliance of Professor R. Subramanian. It began its operations on 29 September 1962.The news of its opening, which came out in the then leading English daily of Kolkata *The Statesman*, had inquisitive hordes of people queuing up to have a glimpse of the stars and the moon in broad daylight!

The Planetarium was formally inaugurated on 2 July 1963 by the first Prime Minister of India Pandit Jawaharlal Nehru, who dedicated it to the nation. Initially the planetarium was called the Nehru Planetarium, but in due course of time it was renamed M.P. Birla Planetarium.

-India has around 40 planetariums ranging from the simple to the state–of-the-art ones spread across the length and breadth of the country. Some new small facilities are coming up under the aegis of National Council of Science Museums. The projection system at these planetariums consists of Spitz, Zeiss, Evans and Sutherland and Hybrid. The rapid transition from optomechanical to digital and now in some cases hybrid projection system is being seen.

Along with M. P. Birla Planetarium in Kolkata, the Nehru Planetariums of Mumbai and New Delhi, B. M. Birla Planetariums of Hyderabad and Jaipur and Jawaharlal Nehru Planetarium of Bengaluru are considered the major planetariums of the country due to fact that they play a lead role in terms of show production, astronomy activities, and astronomy courses and have excellent exhibition galleries. Other planetariums are also catching up with renovation and modernisation programmes.

The Nehru Planetarium of Mumbai, which began its journey in 1977, inspires students with science quizzes and astropainting, astropoetry and science elocution contests. Special arrangements are made to study and photograph solar and lunar eclipses and other celestial events. Telescopes are installed outside the planetarium to enable eager visitors to watch these phenomena. The Nehru Planetarium of New Delhi, which was set up in 1964, also has similar programmes for schools and colleges and amateur astronomers. It conducts workshops and interactive programmes throughout the year.

The B.M. Birla Planetarium of Hyderabad, which was inaugurated in 1985 by the then chief minister of Andhra Pradesh N. T. Rama Rao, also conducts a popular course on astronomy and astrophysics. The cosmic presentations here have been given a better rating than those in Japan, US, Europe and elsewhere.

The B. M. Birla Planetarium of Jaipur organises interactive sessions, right after the sky shows. A special live session has been designed and being regularly presented to higher classes to supplement their science syllabi. The planetarium coordinates the activities of the Amateur Astronomers Association, which include telescope fabrication, astrophotography and organising evening sky watch sessions.

In 1989, the Bangalore City Corporation established the Jawaharlal Nehru Planetarium Bangalore (now Bengaluru). It is administered by Bangalore Association for Science Education (BASE), which was formed in 1992. It has established a science centre in the planetarium which has become a nucleus for non-formal science education at all levels. A Science Park, Sky theatre shows, monthly astronomy lectures and monthly science movies are some of its prime attractions.

The world's second largest and India's biggest planetarium –the M.P. Birla Planetarium of Kolkata has reopened its doors to quench the thirst of budding astronomers, space scientists, students and the common public at large after remaining out of bounds for almost eighteen months.

The M.P. Birla Planetarium popularly known among the masses as the 'Taramandal' was closed down in March 2015 for thorough renovation and modernisation. It reopened again after a massive makeover on the 22 July 2017.

New Features

The M.P. Birla Planetarium is a popular destination for popularisation of science among the layman. Before its closure for renovation, the Planetarium attracted a footfall to the tune of 6.5 to 7 lakh per year. This is expected to increase with a host of attractive features added to the redone planetarium.

Let's take a look at some of these attractive features.

State of the art projection system

There was a general feeling doing the rounds in some quarters that the invasion of digital media in the common man's house and the easy availability of digital material was turning out to be a bane for the astronomical shows which was being carried on with the old optomechanical projector at the M.P. Birla Planetarium.

The centre of attraction of the planetarium was and forever remains the daily astronomical shows, which are held in English, Hindi and Bengali seven days a week. The seven shows held daily from Monday to Saturday and nine shows held

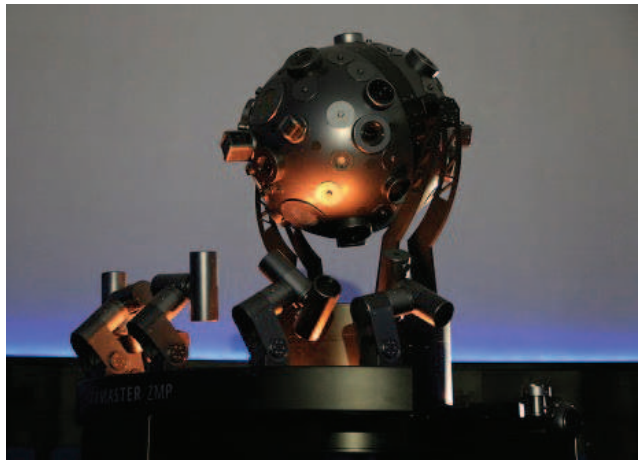
on Sunday are an eye opener to the enigma of cosmic world. The English voiceover is by Hollywood star Robert Redford which makes it all the more exciting and enjoyable.

The planetarium has replaced the 54-year-old optomechanical projection system with a state-of-the-art Hybrid Projection System from Carl Zeiss. It comprises of an optical-mechanical planetarium projector called "Star Master", also known as "starball", which is placed in the middle of the dome and nine smaller hybrid resolution digital projectors placed on the walls of the dome. The output from all these are merged by software to create the final image on the 23-metre-diameter dome. In total, more than 20,000,000 pixels are generated 60 times per second.

The starball presents the most realistic star field in the dome with superimposed images of constellation outlines, space objects like nebula and galaxies, planets and moons by the digital video system called full dome projection.

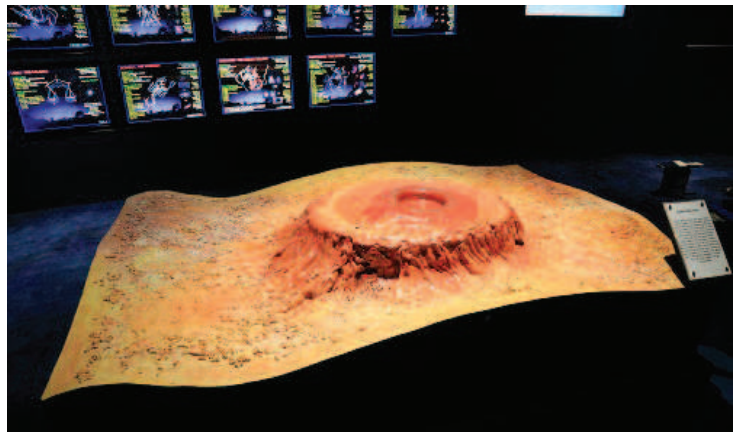
The new projection system has opened the doors to totally new and exciting possibilities of presentation. It is now possible to bring to life spell-binding flights to the planets of the solar system and other faraway constellations in high resolution, and cosmic collisions are just as possible as a vivid demonstration of the laws of astronomy. However, the most noteworthy innovation offered by the star master planetarium projector is the star-lit sky. The stars are now point shaped, making them shine in exactly the same way as in the real sky.

The new seating arrangement is an icing on the cake. Viewers can now enjoy the astronomical shows sitting on the 600 ergonomically designed seats.



The new projection system

The old projection system that did its duty for past 54 years, now a part of the display



The model of Olympus Mons on Mars the solar system's largest known volcano

Know your weight on celestial bodies

If you weigh 60 kg (the average weight of an Indian male) on our planet Earth, do you know how much will you weigh on the other planets of our solar system? Well, you don't have to rake up your mind or get immersed in complicated calculations to know the answer. A new section at the planetarium has this very interesting section 'Your weight on celestial bodies' where one can get their weight on different celestial bodies. There is a scale on the ground fixed with a computer chip that will easily show how much you will weigh on the different planets as well as on the Sun, the Moon and even on Ceres, the largest object in the asteroid belt between the orbits of Mars and Jupiter. The new exhibition gallery is also very interesting where one can see celestial projections on huge LED screens and watch videos of the night sky in various seasons. There are six small domes to show the Kolkata night sky in different seasons.

The gallery also has models of the surface of Mars and the Moon. A model of Olympus Mons on Mars, the largest of all known volcanoes in the solar system is a centre of attraction. One can even test one's knowledge of astronomy by taking a quiz on the computer screen or increase one's knowledge about the planets and other celestial bodies by simply going through the wealth of information that has been put up on display.

The new Astro corner is interesting too, with memorabilia, books and CDs on the cosmic world available to be picked up. The telescopes on sale are a centre of attraction for the budding astronomers and space enthusiasts.

The astronomy gallery that has a huge collection of paintings and statues of renowned astronomers continues to be as popular as before.

Though M.P. Birla planetarium is popular as a planetarium, it also happens to be a national-level research centre and have classrooms and laboratories. With these welcome changes the planetarium will continue its journey to bewitch many a child and introduce them to the ever-exciting cosmic world. It would provide that moment of inspiration when a rookie to the subject decides to fly to Mars or Moon or any other celestial body. ■

A Silent Revolution: Six Decades of Metric System in India

Bhupati Chakrabarti

The introduction of metric system in India is considered to be very successful one as the entire work could be done virtually in a single go and its acceptance was total. This approach in this field is known as "big bang" approach and the Indian model has been appreciated by different nations. We should be thankful to the Indian Decimal Society for its initiative for metrication; otherwise this possibly would have been delayed.

To bring about a widespread change of a measurement system that a common man uses and comes across in his everyday life is a delicate as well as a challenging task. Particularly the change over from one system to another can offer several problematic situations that one may not be able to visualise beforehand. Same was the case with the metric system that was introduced in India replacing what is known as the Imperial or the British System. In 2017 we were in the sixtieth year of metrication in India along with the seventieth year of our independence. This is an opportunity to look back to those eventful days before and after independence and see how such a huge revolutionary change could be brought about silently, yet decisively.

The metric system was introduced in India officially from 1 April 1957, but first it was only for the coinage. The rupee retained the name but under the metric system was equal to 100 '*nayepaise*' instead of 64 of the old paisa, although the '*anna*' ($^1/_{16}$th of the rupee) continued to be used. In this connection we must remember that when we talk about metrication, the coinage is only a part of it. There are two more equally important aspects of it, namely weights and measures, as they are also the parts of everyday activities involving measurements. This implied introduction of new metric units for all types of length, area and volume measurements, along with the suitable metric units for the measurement of weights of various types. There was also need for a system of units that could take care of the weight of small gold ornaments as well as that of a loaded boat or an elephant. In India the metrication of weights and measures was officially introduced from 1 October 1958 and the entire system then became a comprehensive one.

The introduction of the metric system could not take away the influence of the Imperial System immediately. People tried to retain the concept of *anna* that is essentially one sixteenth of a rupee making one *anna* roughly equal to 6 *nayepaise*. However that would make 96 *nayepaise* equal to one rupee. So one *nayapaisa* was added to the every *fourthanna*, which made 4 annas equal to 25 paise rather than 24 *nayepaise*.

The metric system is a product of French revolution in late eighteenth century, and France is the first country to adopt metric system completely way back in 1795. One of the major reasons of the French Revolution, according to historians, was the deprivation of ordinary people of their actual dues in different situations by the affluent and aristocrat section of the society through the practice of using non-standard measuring systems. That possibly prompted the French people to take a very strong approach in converting the whole system into a metric one. So immediately after the French Revolution when the monarchy fell, people could adopt it in 1795. Among the physicists and mathematicians who helped this to happen one can find familiar names like Joseph-Louis Lagrange and Pierre Simon Laplace. The countries from continental Europe began to take interest in the system albeit slowly and their initial hesitation is well understood. Most of these countries

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in Europe had their own systems and it was not quite easy to transform to a new system however convenient that may be from the points of view of conversion, uniformity and ease of use because of cultural barrier, national pride and of course, the long habit.

Naturally, when it came to metrication, the European countries were less enthusiastic. Yet the convenience of the metric system ultimately own over. The easy convertibility of the units of similar type through multiplication or division by 10 or by fixing what is now known as SI prefix was a big attraction. And a metre becomes 1,000 times just by using 'kilo' before it. The next few countries after France that adopted metric system were Portugal, Belgium and the Netherlands. And by the time the metric system made a transcontinental journey from Europe to Chile in South America more than 50 years had passed.

But in India the movement for metrication drew its spirit from a nationalistic inspiration as the official system immediately before the independence was introduced by the British Government and was essentially the Imperial system. The introduction of metric system in India is considered to be very successful one as the entire work could be done virtually in a single go and its acceptance was total. This approach in this field is known as "big bang" approach and the Indian model has been appreciated by different nations. Some interesting reasons are attributed to this success. First, India had barely 30% literacy during the early 1950s. Not many people were even bothered about the official system, i.e., the Imperial system introduced by the British in 1870 in the form of Indian Weights and Measures Act. This in a way tells us that before 1870 the country did not have a single set of measuring system acceptable to all but things were apparently going without much of a problem. Owing to the lack of physical movement of people from one region of the country to another, one could use a wide variety of systems without much of a difficulty. In fact, the year 1870 should be seen in the context of the spreading of railway network in India that began in a significant scale from 1860s. Now the movement of the people increased manifold, people were literally moving through, say distances of 1,000 kilometres or so, and it was something people could not dream of before the introduction of the railways. With distance, a large number of things including the measurement systems turned out to be alien for the people. And that gave the colonial rulers an opportunity to initiate an effort for standardisation.

However, once the official system was in place all the official transactions were done with the help of the system, but the local measurement systems were very much in vogue along with these. And these units apparently had no connection with the Imperial system. For example, we used to purchase rice, pulses or sugar in units called 'seer' which is different from pound of the Imperial system (1 seer = 2.057 lbs = 0.9331 kg). The stress on the division and multiplication by two or 4 was evident from the use of mound (= 40 seers = 37.324 kg),or use of 'pao' as 1/4thof a seer. The use of seer and mound and not pound or ton continued well after independence until the metric system took over. We also used to have units like 'ratti', 'tola' for the measurement of small masses associated with gold and silver ornaments. Liquids like milk or edible oil were being sold by weight and not by volume so there was no widely used unit for volume. In fact some of the old timers may remember that doctors used to prescribe a 'mixture' in case of fever or diarrhoea and a pharmacist used to prepare the 'mixture' with markings pasted on the external wall of the bottle indicating dose.

In a large country like India or elsewhere it has been observed that for quite some time people have ignored the official system and could continue either with the old ones or with some local obscure units not much appreciated beyond a certain area but working fine at the local level. Interestingly, the unit of land measurements is an area where the wide range of units with various names is still in use in unofficial transactions. Some of these terms are common in different regions but the same name may indicate different areas of land in different states even different districts. So if you have one 'bigha' of land in a district in Bihar that may be significantly larger than a 'bigha' of land in West Bengal.

It is not known to many that like France, we also had our own scientists, technologists and mathematicians and statisticians behind a movement that actually initiated in the 1930 the objective of introduction of the metric system. The Indian Decimal Society was founded in 1930 by Sri P. N. Seth of Mumbai with the objective of metrication of all systems in India. The society started campaigning for the metrication through newspaper articles, debates and discussions and organised seminars. It tried to form what we call public opinion in favour of this move. The society approached the then British Government with the request and a road map for metrication in India. The society went on negotiating with the government for bringing in metric system replacing the Indian Weights and Measures Act 1870. But the British Government did not show much interest probably because the Imperial system was something that could be termed as their 'own' and also possibly they were actually reluctant to introduce a system that had its origin in France, the arch rival of Britain in number of fields. This is also evident from the fact that Great Britain is one of the very important nations that finally started metrication only in 1965, well after about 70% of world population has embraced the metric system.

There were other important people associated with this metrication movement led by Indian Decimal Society. One of them was Prof P. C. Mahalanobis the statistician, an FRS, who founded the Indian Statistical Institute in Kolkata. He was instrumental in chalking out the Five-Year Plans after independence. Prof Mahalanobis specially felt that India must use the metric system in science and technology to make the measurements and findings presentable to the international community. For this it was necessary that same system should be the part of everyday life. Same was the opinion of the another physicist Prof S. K. Mitra of University of Calcutta, an FRS and a pioneer in radio communication technology and ionosphere research in India, who stressed the necessity of switching over to metric system both for the teaching of science and for everyday purpose. Another academician Prof H. L. Roy was a Professor of Chemical Engineering and one of the co-founders of the Chemical Engineering Department in Jadavpur University, Kolkata. Prof Roy also stressed upon the need for switching over to metric system from the standpoint of engineering calculations and work and making the life easier for the engineers. The British government did not consider the issue an important one or of immediate interest when the Second World War broke out in 1939. The entire issue was put to the backburner.

However, after the World War was over the Indian Decimal Society approached the interim government and the members of the constituent assembly. At this point the Society could realise, possibly with a bit of surprise, that there was a distinct division among the leaders and the conservative opinion, i.e., to continue with the same old imperial system prevailed, and lots of arguments were provided in its favour. After independence the Society approached the new government under the leadership of *Pandit* Jawaharlal Nehru. The Indian Decimal Society not only put forward these suggestions but in its report published in January 1944 actually explained all the details related to switching over to metric system. It also suggested the details related to its actual mode of implementation. So it was a comprehensive plan with a complete road map for carrying out the transition. The reputation of the people associated with the Indian Decimal Society was immense and Government of India paid attention to these suggestions. There were worries about the problems that this new system might bring, but it was accepted by all that this shift was necessary. Finally the Indian Parliament accepted the scheme submitted by the Indian Decimal Society in 1955 and it was decided that the first stage of metrication would be introduced through the metrication of coinage and that came into force from 1 April 1957.

In this connection we have to remember that most of the erstwhile colonies of Britain took much longer time to shift to metric system leaving behind the legacy of the Imperial or British system. For example, New Zealand did it in 1969, Australia in 1970, and Canada did it in 1973. Our neighbouring countries also did it much later. Pakistan adopted it in 1967, Sri Lanka did it in 1976 and Great Britain took a long time to do away with their own system and possibly there was significant cultural resistance to it.

All of us know that the USA is a very important country that is still using the Imperial system and has not introduced the metric system. Though Great Britain started metrication of their measurements in 1965, it went on taking more and more time for the full metrication. It is interesting to note that that unlike India, Australia, New Zealand or Canada could not do it so easily as those countries possibly considered their emotional and cultural attachment with the Imperial system very strong. This is reflected in mentioning the weight of a person in 'stone' (= 14lbs = 6.35029 kg), the volume of some quantity of beer in 'pints' which is about 475 millilitres, etc.

Some measurements from the old Imperial system are still doing its rounds in our own system, at least in our everyday life. If someone is having a fever we tend to mention it only in degrees Fahrenheit. If we say some one is having a fever of say 103 even without mentioning the unit people understand the gravity of the situation. But if we just mention the same temperature as 39.4°C the impact of the statement looks missing. This is in spite of the fact that the clinical thermometers have calibrations both in °F and in °C. More or less a similar thing happens with our own height or the floor area of an apartment. We like them to be expressed in feet and inches and square feet respectively, as that brings the right kind of feeling. Though officially we need to put our heights in centimetres in the different application forms we actually measure it in feet and inches and then convert it to cm by multiplying it by 2.5. Frankly this may be an easy procedure but it introduces some error as one inch is equal to 2.54 cm and not 2.5 cm. That causes a miscalculation of nearly 3 cm in the height of an average person if that is taken to be 5 ft 7 inches. Similarly, we can easily gauge the floor area of an apartment if it is quoted as 1,200 sqft, but find it difficult if it is mentioned as 111.5 sq metres. After a long struggle we have been able to do away with ratti, etc., in the measurements of the weights of gold ornaments yet one will always come across the term 'bhari' or 'tola'(which is close to 10 grams but not exactly) while mentioning ornaments one has received in marriage.

In cultural sphere and in our language the Imperial system has its own role. Our cricketers touch a 'milestone', height of mountain peaks, or the altitude of a hill station if mentioned in feet provides us with a more understandable feeling. We look for a pound of cake or tea leaves but not of rice or sugar; the metric tonne is different from Imperial ton yet is its namesake. Distances on the sea are mentioned in nautical miles, cricket pitch still remains 22 yards and while mentioning the specification of a new cricket ball its mass is often mentioned as 5¾ ounce and not between 155.9 grams and 163 grams. Similar things happen while mentioning the size of the ball both in cricket and football, size of the tennis court and the height of the tennis net, etc. All these imply that anything with strong British flavour has been able to retain some Imperial touch.

These are in a way called legacy. And one cannot do away with it by imposing the rules and regulations. That provides us the pizzas with diameter in inches, electric motors and similar equipment are better identified with their 'horse power', plumbers talk about the diameters of pipes and other fittings in inches and fractions of an inch. This list may go on. Fortunately, the decimal unit is nowadays invariably used by the government departments in official transactions of land measurements.

In India the people picked up the new metric system with so much enthusiasm that the term 'naye' from 'nayepaise' could be dropped in a few years' time. From 1964 onwards this so-called nayepaise became paise and there was no confusion! The new paise with the old name began its journey. For India we should be thankful to the Indian Decimal Society for its initiative for metrication; otherwise this possibly would have been delayed.

Recent Developments in Science and Technology

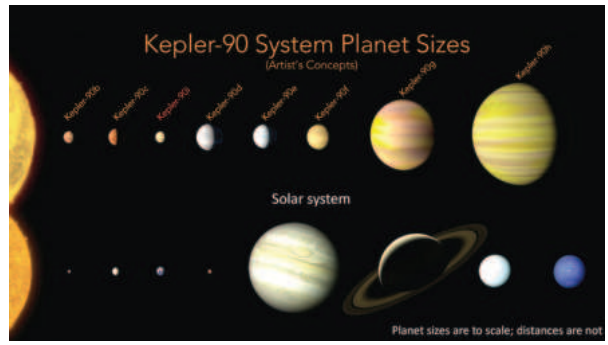
Biman Basu

The Kepler-90 planets have a configuration similar to our solar system with smaller planets found orbiting close to their star, and the larger planets found farther away. Kepler system has become the first star system known so far to have as many planets as our solar system.

First exoplanet in a mini-solar system discovered using AI

For the first time, an exoplanet has been discovered using Artificial Intelligence (AI). Before planets around other stars (exoplanets) were discovered in the early 1990s, our Sun was the only star known to have a planetary system. Even after NASA's *Kepler Space Telescope* started discovering planets around distant stars, only a handful of them were found to have more than a single planet. With eight planets, our solar system remained the largest planetary system known;but no more. In February 2017, NASA's *Spitzer Space Telescope* discovered the first known system of seven Earth-size planets around a single star known as the "TRAPPIST-1 system". But, with the recent discovery of an eighth planet circling Kepler-90, a Sun-like star 2,545 light-years from Earth, even the TRAPPIST-1 system is now overtaken and Kepler 90 has matched our solar system. The discovery of an eighth planet known as Kepler-90i, around Kepler 90 was announced by NASA in December. The discovery was made with the help of AI. With this discovery the Kepler system has become the first star system known so far to have as many planets as our solar system. The research team consisted of Christopher Shallue of Google AI and Andrew Vanderburg of the University of Texas and the Harvard-Smithsonian Centre of Astrophysics (CfA). The findings were published in *The Astronomical Journal* (14 December 2017).

According to NASA website, the Kepler-90 planets have a configuration similar to our solar system with smaller planets found orbiting close to their star, and the larger planets found farther away. However, the planets in our system are far more spread out; for example, at its closest, the farthest planet Neptune is 4.5 billion kilometres from the Sun. In comparison the most distant gas giant in the Kepler 90 system is 150 million kilometres from its



The Kepler-90 planets have a similar configuration to our solar system with small planets found orbiting close to their star, and the larger planets found farther away. In our solar system, this pattern is often seen as evidence that the outer planets formed in a cooler part of the solar system, where water ice can stay solid and clump together to make bigger and bigger planets. The pattern we see around Kepler-90 could be evidence of that same process happening in this system. (Credit: NASA/Ames Research Center/Wendy Stenzel)

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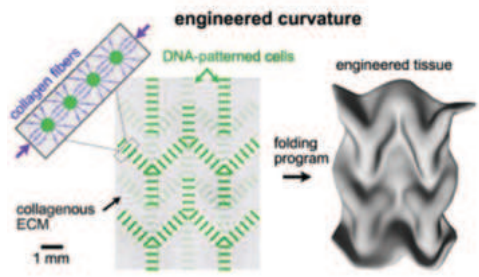
star – the same distance as between the third planet Earth and the Sun. "All the planets are found crowded very close to their star," Vanderburg said.

According to NASA, the researchers used Machine Learning from Google to analyse the data from the *Kepler Space Telescope*. They developed a neural network, a type of machine-learning technique that can learn to identify patterns in large data sets. "The key idea is to let the computer learn by example instead of humans programming specific rules," said the researchers. Machine Learning is a current application of AI based around the idea that we should really just be able to give machines access to data and let them learn for themselves. It is an approach to artificial intelligence in which computers "learn" using a neural network. To work properly, a neural network needs lots of practice. In the present case, the scientists "trained" theirs using a set of 15,000 *Kepler* signals that had already been studied and properly labelled by humans. Using that data, the computer learned to identify the signatures of actual planets and distinguish them from false positives. When the scientists finally tested their neural network on signals that it had not seen before, it correctly sorted out the planets from the false positives a whopping 96% of the time. The newly-discovered planet, known as Kepler-90i, is a sizzling hot, rocky planet that orbits its star once every 14.4 days.

The discovery of Kepler 90i is the first to be made using AI. This AI-based method could now allow researchers to go back into more *Kepler* data enabling them to detect even weaker signals that can be missed when done manually, which may lead to identification of more hitherto undiscovered planets in other star systems also.

Scientists engineer 3D shapes from living tissue

As a fertilised egg grows into embryo and finally into mature organism, the mammalian body stretches, wrinkles and folds like a fabulously intricate piece of origami as it grows. Till now, 3D bioprinting had allowed scientists to create synthetic tissues from human or animal cells, but even the most advanced bioprinters often fell short in successfully replicating the key structural features of tissues that grow according to developmental programs



A diagram from the Developmental Cellpaper shows how a pattern laid down before development produces a predictable folding structure.

that guide the growth from fertilised egg to mature organism. For example, natural folds in human tissue – the many stretchy and wrinkly parts of our body that help us to function – are not easy to replicate using a 3D bioprinter. Now bioengineers from the University of California, San Francisco, led by Zev Gartner, have found a way to recreate many of the complex folded shapes that form mammalian body parts and internal tissue structures, with very simple instructions(*Developmental Cell*, 28 December 2017; DOI: 10.1016/j.devcel.2017.12.004).

The research involved the use of a precision 3D cell-patterning technology called DNA-programmed assembly of cells (DPAC), which can be employed to set up a 'spatial template' of a tissue. This tissue template then folds itself into complex shapes, mimicking the way in which tissues assemble themselves hierarchically during development. Extracellular matrix (ECM) is a collection of extracellular molecules secreted by cells that provides structural and biochemical support to the surrounding cells. By arranging mouse or human cells onto thin layers of ECM fibres, the researchers could create bowls, coils, and ripples out of living tissue. The cells collaborated mechanically through a web of these fibres to fold themselves up in predictable ways, mimicking natural developmental processes. The team created simple models to predict the behaviour, development and folding patterns of these cells and tissues and were surprised to find that the cells behaved as predicted, allowing the researchers to build living constructs from developmental folding and shape-forming behaviours.

The key to the success were specialised cells called mesenchymal cells, which play a special role in folding some tissues during development. "Like spiders pulling on their webs, these cells can reach out to tug on the network of rope-like ECM fibres that cells naturally secrete around themselves for structural support", said Gartner.

The researchers found that when mesenchymal cells in different parts of a tissue pull on the web of ECM fibres in tandem, they create forces within the tissue that can cause it to bend and fold into a variety of shapes, "from the finger-like villi that line the gut and aid in digestion to the buds that eventually form an animal's hairs or feathers". The researchers then demonstrated that they could apply these natural developmental processes to re-create tissue folding in tissue samples in the laboratory. By laying down specific patterns of mouse or human mesenchymal cells, the researchers could cause thin slabs of living tissue to fold themselves into bowls, coils, and ripples, as well as more abstract shapes like cubes not typically found in nature. The research could help scientists create complex and functional synthetic tissues, setting the stage for future applications ranging from lab-grown organs to soft biological robots.

The Yeti myth busted by DNA analysis

Stories of sightings of the Yeti or Abominable Snowman, supposed to be a mysterious, ape-like creature, taller than an average human said to inhabit the Himalayan region of Nepal, Bhutan, and Tibet, have been going round for centuries. Various groups have claimed to have found footprints or seen the creature roaming the

An artist's conception of the Yeti (left) and a Himalayan brown bear (right)

mountainous area and stories have been passed down from generation to generation. Huge footprints, tufts of hair and strange elongated bones all seemed to point to a giant wild man living in the wilderness, and even the Nazis are said to have launched a secret expedition to find the monster in the 1930s, believing it may represent the origin of the Aryan race.

The scientific community has generally regarded the Yeti as a legend, given the lack of evidence of its existence. In fact, it is one of the most sought-after animals that do not exist. A long line of explorers, including mountaineers Sir Edmund Hillary and Reinhold Messner, reported seeing strange figures and footprints in the Himalayas. Said to walk on two legs through the Tibetan Plateau, the Yeti is described as a hairy and humanoid primate, resembling a gorilla.

But now it appears that there is nothing like the Yeti or Abominable Snowman; what have been sighted were probably the Himalayan brown bear (*Ursusarctosisabellinus*) or Tibetan brown bear (*Ursusarctospruinosus*). The evidence comes from a new DNA analysis of purported Yeti samples from museums and private collections. The study, published in *The Proceedings of the Royal Society* B (29 November 2017), was led by Charlotte Lindqvist, who studies bear evolution at the University at Buffalo in New York and Singapore's Nanyang Technological University.Lindqvist and her colleagues extracted DNA from nine Yeti samples and more than a dozen known bear specimens, collected in zoos and a national park in Pakistan. The samples included a scrap of skin from the hand or paw of an alleged Yeti– part of a monastic relic – and a fragment of femur bone, allegedly from decayed Yeti, found in a cave on the Tibetan Plateau. According to Lindqvist, of the samples examined, one turned out to be from a dog. The other eight were from Asian bears – one from an Asian black bear, one from a Himalayan brown bear, and the other six from Tibetan brown bears. The Himalayan brown bear is probably related to the yeti myth because of its rarity and size.

In an earlier genetic study in 2014, researchers had claimed the DNA from hair samples found in the Himalaya to be from a prehistoric bear that lived the Pleistocene epoch. Though Himalayan brown bears are neither abominable nor snowmen, they are still pretty unusual animals, Lindqvist's DNA analysis revealed.According to Lindqvist, the new genetics research indicates that the isolated bears are a "relict population." Put another way, these were the first brown bears to split off from all the other subspecies, 600,000 years ago.

The importance of Lindqvist's work lies in the fact that besides tracing the origins of the Yeti legend, it is uncovering information about the evolutionary history of Asian bears. She says, "Bears in this region are either vulnerable or critically endangered from a conservation perspective, but not much is known about their past history. The Himalayan brown bears, for example, are highly endangered. Clarifying population structure and genetic diversity can help in estimating population sizes and crafting management strategies."

Scientists create glowing nanobionic plants

We cannot see or work in the dark without light. We have to depend on electric lights, and lighting accounts for about 20 percent of worldwide energy consumption. But there are living organisms like the firefly which can emit light without electricity through a phenomenon called bioluminescence. Bioluminescence in the firefly works by the interaction of an oxidative enzyme called luciferase with luciferin, a light-emitting compound found in many firefly species, in presence of another molecule called co-enzyme A. Luciferin typically undergoes an enzyme-catalysed oxidation and the resulting excited state intermediate emits light upon reverting to its ground state. Now scientists at Massachusetts Institute of Technology (MIT), Cambridge, USA, led by Michael Strano have created, by embedding specialised nanoparticles carrying luciferase, luciferin and co-enzyme A into the leaves, watercress plants that glow like fireflies,. The nanoparticles help each component get to the right part of the plant. They also prevent the components from reaching concentrations that could be toxic to the plants. The introduction of the three compounds, the researchers report, induced the plants to give off dim light for nearly four hours (*Nano Letters*, 17 November 2017 | DOI: 10.1021/acs.nanolett.7b04369).

Illumination of a book with the nanobionic light-emitting watercress plants. (Credit: Seon-YeongKwak, MIT)

Plant nanobionics, a new research area pioneered by Strano's lab, aims to give plants novel features by embedding them with different types of nanoparticles. The researchers used two types of nanoparticles for the present research. Silica nanoparticles about 10 nanometres in diameter were used to carry luciferase, and slightly larger particles of the polymer Poly Lactic-co-Glycolic Acid (PLGA) and chitosan(a sugar obtained from the hard outer skeleton of shellfish) were used to carry luciferin and co-enzyme A, respectively. To get the particles into plant leaves, the researchers first suspended the particles in a solution and then immersed the plants in the solution and exposed them to high pressure, allowing the particles to enter the leaves through tiny pores called stomata.

There have been previous efforts to create light-emitting plants, but they relied on genetically engineering plants to express the gene for luciferase, which was a laborious process that yielded extremely dim light. Those studies were performed on tobacco plants and *Arabidopsis thaliana*, which are commonly used for plant genetic studies. In contrast, the method developed by Strano and his team could be used on any type of plant. So far, they have demonstrated it with four plants that include spinach and watercress.

Early efforts yielded plants that could glow for about 45 minutes, which have since been improved to almost four hours. According to the researchers, the watercress had an especially strong reaction to the chemical formula, producing brightness comparable to half of a one-microwatt LED light. The researchers believe they can boost the light emitted, as well as the duration of light, by further optimising the concentration and release rates of the components.

Vigyan Prasar Books Released

Publication of *Dream 2047* monthly and popular science books is one of the major programmes of Vigyan Prasar. Since 1994, Vigyan Prasar has been involved in publication of popular science books. Over this period, the organisation has brought out almost 300 popular science books in English, Hindi and many regional languages. These books fall in broad categories such as Popular Science Classic Reprints, Do it yourself, Biography, Natural History, etc. The authors of Vigyan Prasar books are renowned scientists, academicians and science writers.

During the New Delhi World book fair this year, Vigyan Prasar released five of its new publications. This book release function was held on 13 January 2018 in the Climate Change & Environment-based theme pavilion in Pragati Maidan, New Delhi. The released books are: *Story of Universe, Witness to the Meltdown, Essays on Chemistry, Chuninda Vigyan Kathayen* and *Natak Natak men Vigyan.* The books were released by Shri Chander Mohan, Director, Vigyan Prasar, along with the respective authors. Speaking on the occasion, Shri Chander Mohan described books as an important vehicle for science communication and emphasised the role of popular science books in attracting the youth towards science. The authors Dr. Govind Bhattacharjee, Shri Dinesh C. Sharma, Prof. S.V. Eswaran, and Shri Ram Sharan Dass interacted with the audience and shared the central idea and concept of their respective books. The book release function was moderated by Shri Rintu Nath, Scientist F and Head (Publication), Vigyan Prasar.

As the part of book release function, a panel discussion was also held on the theme "Climate Change Adaptation: Is India Ready?" During this discussion, Dr. Mustafa Ali Khan (Team Leader, Indian Himalayas Climate Adaptation Programme) spoke about the need for public engagement to combat climate change. He also stressed upon the role of education and training in respect of climate change adaptation. Another expert, Shri Raman Mehta, Advisor, Vasudha Foundation, elucidated the present scenario of impact of climate change on agriculture and human beings at large. He said that sometimes the impact of this global phenomenon is not clearly visible, but when we study it at micro levels, the outcomes reflect a dismal picture of climate change. Shri Dinesh C. Sharma, Chief Editor, India Science Wire, moderated the panel discussion.

Reported by: ***Dr. Manish Mohan Gore***