



DREAM 2047

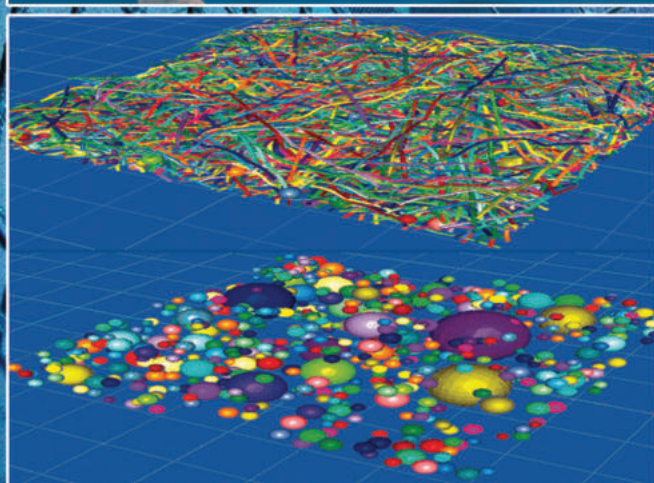
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Polymeric Materials for Space Research



Editorial: ESOF 2014 and HORIZON 2020 of the UK: Robust converge platforms in the interface of science, technology and the public	39
Polymeric Materials for Space Research	38
Pomegranate: a wonder fruit	34
Points to be noted about point	31
Vitiligo—When the skin loses its colour	27
Recent developments in science and technology	24
VP News	20

ESOF 2014 and HORIZON 2020 of the UK: Robust converge platforms in the interface of science, technology and the public



Dr. R. Gopichandran

The Euroscience Open Forum (ESOF) is scheduled to meet in Copenhagen this June. The principal objective is to deliberate on methods to “close distances” between science and society and enhance dialogues among stakeholders. This integrates facets of humanities and invites initiatives from across the world to share relevant insights to embellished suitably adapted locally relevant action. Science and technology communicators should note that the framework includes deliberations on directions of present and emerging research; not merely restricted to the rhetoric of outreach. The ESOFF Future Academy is designed to involve youth duly recognising well-informed leadership for the future. The forum recognises the centrality of science for development and hence the need to enhance public interest in science. Three other important facets of public engagement with science and technology are interest evinced by the public, interests of the public and their norms and values. Importantly, these facets have been embedded in several initiatives that engage the public in India too. These are of the four major institutions namely the NISCAIR of the CSIR, the NCSTC DST, Vigyan Prasar as an autonomous institution of the DST, and the NCSM and a large number of other institutions they work with. It may be a good idea for these institutions to share insights from their initiatives at the ESOFF 2014. This could help hybridise knowledge and set potential partnerships through bilateral and multilateral cooperation frameworks. Details regarding the ESOFF 2014 can be accessed from <http://esof2014.org/info/ESOF2014.pdf>.

The Science and innovation investment framework 2004 – 2014 of the Department of Education and Skills UK http://news.bbc.co.uk/nol/shared/bsp/hi/pdfs/science_innovation_120704.pdf is another typical case in point. Useful lessons on positioning science within society can be derived from the above cited framework. It recognises the need to address “societal

challenges”, public confidence on directions and regulations pertaining to technologies, and concerns of the public. Ethics, health, safety and environment are essential focal points of interventions designed in this context. Interestingly these facets have been integral to several initiatives at the grassroots level in India too, wherein the development agenda was twinned with enhancing scientific thinking. It is probably essential to enhance the spread and depth of these facets in communication than overemphasise fundamental principles of science alone.

HORIZON 2020 of the European Commission provides an interesting opportunity to compare http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-swfs_en.pdf India’s initiatives presently in progress. The Commission aims at making science education and career attractive to youth, mainstream gender equality in research and innovation, establishing institutional mechanisms including focal points for coordination and comprehend expectations of the public aligned with challenges they face in pursuing their goals. This initiative is also designed to build capacities of stakeholders to engage in well-informed action to sustain transitions.

The principal objective of this editorial is to help specialists and institutions engaged in science and technology communication in India recognise the fact that initiatives in progress in other parts of the world are designed along lines highly comparable with the agenda integral to meeting the goals of the STI Policy defined in 2013 by Government of India. It will be useful to share insights with specialists engaged in the cited and other initiatives, only to strengthen logical frameworks of action. Well-defined immediate, medium and long-term milestones can help expedite reaching these goals. Precision and speed of action are critical in this context.

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Polymeric Materials for Space Research



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Space endeavour has given us a lot, in terms of comfort in life, security, and a lot of conveniences. Today's telecommunication, television, navigation, etc., became realities, thanks to the orbiting artificial satellites launched by rockets. Mankind depends on the sea trade for transportation of food grains, fossil fuels, metal ores, etc. Global Navigation Systems (GNS) helps in timely delivery of these essential goods by providing the ships with essential navigational information. The GNS services are made available using networks of satellites which also enable satellite internet and satellite phones. Gone are the days, when we used to take an umbrella with us while going out if there were black clouds in the sky. Now we can rely on the weather reports updated on an hourly basis. It has become habit to look at the satellite imageries of Earth in the morning and plan the day's programme. The accurate weather forecast is possible only because of the satellites in the space. Satellites also help us in predicting crop yields, pest infestation, and the area under cultivation. It is easy to predict natural calamities such as floods, storms, tornadoes, cyclones and to locate wildfires and their extent with the help of satellites. We could save thousands of lives from the recent cyclone that hit the eastern coast of India as we could accurately predict its trajectory and site of landfall and accordingly warn the people and move them to safer locations. Minerals buried deep under the Earth's surface can be located using satellites. Precious fossil fuels can be found with the help of satellites. One of the benefits of space exploration is that we can get to know about the thousands of asteroids and we can also be vigilant about their "drifts". Many novel materials discovered for use in spacecraft and space shuttles are also used in the health care industry. Through telemedicine, doctors can treat patients across the globe without the barrier of distance.

Role of polymers in space revolution

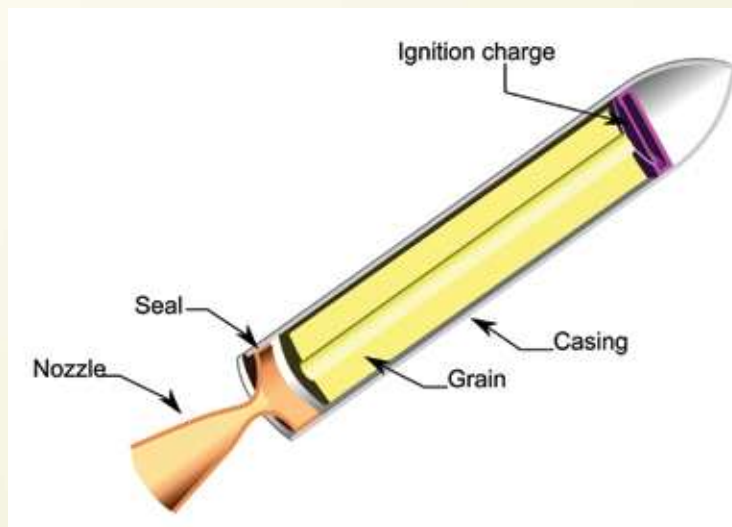
Space exploration needs rockets and satellites and related technologies. Space missions have been possible because of evolution in material science. Space technologists always look for special materials; one such material that has revolutionised space research is polymers.

What are polymers?

These are made of giant molecules or macromolecules. Polymers constitute an

by a host of commodity and engineering polymers – right from the shopping bag to light weight aircraft structural components. For use in space applications, polymers must meet certain special requirements such as: capability to function in hard vacuum, very low out-gassing to prevent contamination of surrounding components, resistance to extremely harsh ultraviolet radiation, resistance to on-orbit charged particle radiation, resistance to erosion from atomic oxygen, etc.

Polymers are also easily modified by the addition of other materials (fillers) to provide an almost limitless range of possibilities. Their application includes: rocket fuel, rocket construction material, thermal control paints, adhesives, lubricants, paints, circuit boards, coatings, thermal protecting/insulating systems, and high-stiffness composites. The recent past has witnessed great advancements in the development of high-performance polymers and polymer-based systems. The impetus for the development was derived to a large extent



A solid rocket motor with polymer composite casing that houses the polymer bound solid propellant and related polymer systems (Courtesy: Wikipedia, the free Encyclopedia)

extremely large class of materials generally based on carbon chemistry. Their long chain structures and unique molecular architecture make them distinct from metals and ceramics and provide them with a very wide range of properties. The high molecular weight and molecular entanglement of these materials give rise to unique properties. These include strength, toughness, resilience, low density, high and low melting points, ability to be moulded, high electrical resistance, and many other properties that may be varied over a wide range. Due to the enormous variety of their available properties and ease of processing, polymers find use in a wide range of space applications.

Our day-to-day life is made comfortable

from the exacting demands of the aerospace industry. Exotic materials developed with innovative technologies and their judicious combinations satisfy the high and conflicting demands of aerospace applications such as high strength and low weight, ability to withstand hard vacuum, hostile environment of very low and high temperatures, UV and particle radiation, etc.

Launch vehicles and satellites have become realities thanks also to the advancement of polymer technology. Several parts of the rocket, e.g., motor case, payload flare, nozzles, payload adaptors, thermal protection systems, insulators, etc., are made of polymers. Similarly a variety of structural and functional components of satellites are

also made of polymers. Several parts and systems of rockets are made of polymers.

Polymers in propulsion

Among the host of polymers traditionally used in launch vehicles and satellites, the most important class of polymers is the polymeric fuel binder for composite solid propellants. The polymer binder needed for the propellant is made as a liquid prepolymer, mixed with solid oxidisers like ammonium perchlorate and cross-linked to a hard mass in various sizes and geometries inside the motor which is sometimes made of fibre-reinforced polymer. (The term prepolymer refers to a monomer or system of monomers that have been reacted to an intermediate molecular weight state.) Various polymer-based systems like motor insulation and inhibitors are used to protect the rocket motor case and to give desirable burning pattern for the propellant grain. The propellant is bonded to the composite-based motor case through a rubber liner. It is equipped with suitable nozzles, nozzle throat, etc., mostly made of polymer composites. Some motor cases carry as much as 200 tons of propellants.

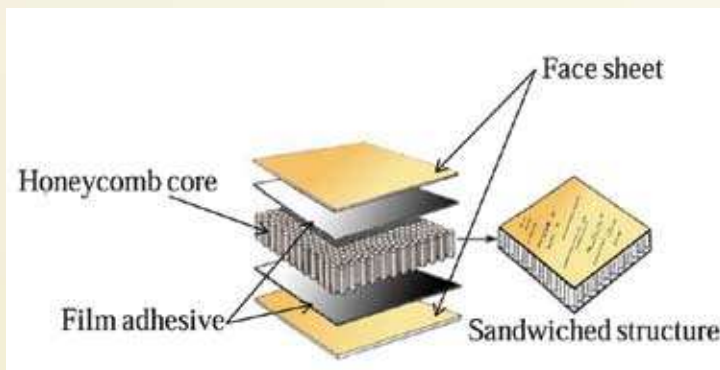
Composite solid propellants are used in major space boosters due to their high reliability and ability to be configured to provide high thrust levels and long shelf life. In Indian scenario the propellant binders have evolved from polysulphide to polyester to lactone-terminated polybutadiene. The present day composite solid propellant comprises of hydroxyl-terminated polybutadiene as the binder and ammonium perchlorate as oxidiser. The demand for chlorine-free, eco-friendly solid propellants with improved specific impulse has resulted in the development of a host of energetic oxidisers like ammonium dinitramide, hydrazinium nitroformate, etc., and energetic azido and nitro binders like glycidyl azide polymer, poly-(bis azido methyl oxetane), polyglycidyl nitrate, etc. Azido and nitro polymers have higher densities and higher enthalpy of formation compared to hydroxyl-terminated polybutadiene (HTPB) commonly used in many solid rocket motors to bind the fuel and oxidising agent into a solid mass. The use of azido and nitro polymers results in a significant enhancement of energetic



Atmosphere re-entering satellite protected by polymer ablatives

performance. New generation of propellants with energetic oxidisers and binders provide higher thrust in terms of specific impulse and chlorine-free exhaust products (during combustion).

In addition to binders, there are a number of polymeric systems used in rockets. These include polymers and composites for structural applications, thermal protection systems for different temperature regimes including cryogenic (liquid hydrogen/liquid oxygen) temperatures, coatings, adhesives, sealants, etc. For thermal protection of propellant tanks, lightweight polyurethane or polysiloxanes are used. Polymers become brittle and fail under mild load at temperatures of liquid hydrogen



Construction of honeycomb sandwich using polymer film adhesive

(-253.15°C). The polymers meant for such environments are specially designed to retain partial flexibility even at -253.15°C . Polytetrahydrofuran-based polyurethane is one such polymer. Certain fluorinated polymers and polyimides and polyether ether ketone are also capable of standing cryo-temperatures. These thermoplastic matrix resins have the advantage of reparability and are used in conjunction with carbon fibre in specific applications like cryotanks.

When it concerns recovery of satellites from space, the extreme heat flux encountered during atmospheric re-entry calls for

using high-heat flux dissipating ablatives. (Ablatives are materials that vaporise at high temperatures.) Thermal protection systems based on ablative composites are developed mostly using phenolic resins in combination with carbon silica/ fibre, etc. These are required to combat extreme temperature conditions as encountered during re-entry of a satellite/vehicle. These undergo sacrificial loss of mass by absorbing the heat and protecting the materials and humans on board. Phenolic resins formed from phenol and formaldehyde are heat curable resins, forming three-dimensional network matrix with good thermal resistance and ablation characteristics.

Polymer composites for structural applications

Composite materials based on high-modulus (stiff) fibres dispersed in polymer matrix resins have become a standard construction material for spacecraft. They are most widely fabricated as laminates, with the fibre and resin layers alternating in direction over a number of angles. This construction is intended to balance the mechanical properties and results in a "quasi-isotropic" laminate. The use of composites includes spacecraft busses (spacecraft bus is the basic structure of a spacecraft, usually providing locations for the payload), torque tubes, optical benches, and other high-dimensional-stability components. Composites offer high strength-to-weight and stiffness-to-weight ratios that reduce spacecraft mass while improving mechanical performance. Other major considerations in selecting are impact resistance and moisture

absorption. Even minor impact damage can degrade the compressive strength of a typical epoxy composite by more than 50%. Water absorption must be considered in terms of both dimensional stability and the amount of out-gassing. Typical epoxy composites may gain up to 2.5% water at saturation, and have an expansion of 200 parts-per-million per percent water content. This is basically because curing of epoxy resins by amines generates a lot of polar groups capable of absorbing water.

New classes of composites based on very high modulus fibres and poly-(cyanate

ester) resins offer very low water absorption, more uniform cure, higher dimensional stability and excellent radiation resistance. The water absorption of commercial poly-(cyanate ester) is about 0.3% at saturation, and the moisture expansion is less than 100 parts-per-million per percent absorbed water. Many spacecraft constructions are moving to cyanate-based composites due to these improved properties.

Despite the higher cost and more demanding fabrication techniques, composites offer lower mass, high specific stiffness, high specific strength, and high dimensional stability that are practically unavailable with any other class of materials. Composite materials have become a standard replacement for aluminium, titanium and steel in spacecraft with demanding mass and stability requirements. Traditionally, the composite structures for satellites have been derived from epoxy/carbon fibre systems. The use of epoxy has temperature limitations. Advanced composites based on carbon fibre and phthalonitriles, polyimides, etc., perform consistently well up to 300°C.

A series of resins like cyanate esters and compounds known as bismaleimides are chosen as matrix resins for various advanced fibre-reinforced polymer composite applications for high temperature purposes. Specialty carbon fibre needed for these are made by controlled pyrolysis of polyacrylonitrile copolymer.

Polymeric fibres like poly p-phenylene terephthalamide or polyaramid, commercially known as Kevlar, have high specific strength and thermal stability. The strength and stiffness originate from the highly crystalline arrangement of molecules aided by intermolecular H-bonding. In combination with epoxies, they are processed into solid motor cases. In fact, by an appropriate combination of fibre and resin, composites of desired properties can be achieved.

Carbon/carbon composites are high-temperature structural material extensively used in space application. They can work at temperatures up to 2500°C in absence of oxygen. With suitable ceramic coating, they can serve even in oxygen environment. They are derived through the chemical impregnation routes, where pitch and phenolic resins are used as precursors. High char yielding polymers are preferred as precursor matrices.



Deployment of antenna through shape memory property. Antenna in skewed form (top) Antenna in unfurled form (bottom)

Polymers for thermal control

Thermal blankets are essential for regulating the temperature of most spacecraft. The blankets consist of either a polymer film filled with carbon black pigment to absorb sunlight, or coated with a layer of vapour deposited aluminium to reflect sunlight. Many layers of these films make up the multi-layer insulation (MLI) that constitutes the “blanket”. The films are usually based on polyethylene terephthalate and polyimide films. Polyimides are derived from aromatic diamines and dianhydrides. The intermediate polyamic acid is imidised by heating at high temperature. (Imidised is defined as the conversion of a polyimide precursor into an imide.)

The layers are also separated by fine woven cloths made from Nylon polymers. These films are also frequently coated with thin layer of indium tin oxide, which provides a path for the dissipation of static electricity. Thermal blankets are a necessity in providing a stable range of operating temperatures, and are used virtually on every

spacecraft flown.

A number of thermal control paints are available that serve the same purpose as blankets; that is, to regulate the spacecraft temperature. These paints are either black or white in colour and consist of pigments dispersed in an organic or an inorganic binder. The polymer binders most widely used are urethanes (black paints) or silicones (white paints). Black paints are virtually all filled with carbon black, which not only provides good solar absorbance (85%), but also serves to protect the binder from ultraviolet radiation damage. Black paints are used to absorb sunlight and to maintain and keep the spacecraft warm. White paints use a variety of pigments along with an inorganic binder (sodium silicate) or polydimethyl siloxane (PDMS). White paints have low solar absorbance and high thermal emittance so that the temperature is kept low enough to prevent over-heating.

Polymer adhesives

Since launch vehicles and satellite structures consist of a number of dissimilar materials, different adhesives are used for joining them. Specialty adhesives are used for bonding thermal insulators onto the aero shell of recoverable satellites. Applications include structural bonding, wire and cable staking, lamination of optical elements, and thread-locking compounds used to prevent loosening of fasteners under high vibration conditions. Satellite structures can be joined by adhesives. The most widely used class of adhesive are epoxies. The epoxies are also easily modified by the addition of fillers and can provide adhesives with low coefficients of thermal expansion.

Certain plastics like polyimide, phthalonitrile, phenolic triazine, etc., can withstand high temperature (up to 300°C) and cryogenic liquid hydrogen temperatures (−253.15°C). Other specialty grades of adhesives include electrically conductive and thermally conductive types. These compounds are usually filled with carbon or silver powders to impart electrical conductivity, or with alumina, boron nitride, and (sometimes) diamond dust to provide a thermal coupling across two surfaces. The intimate surface contact and good adhesion of these specialty polymers is often the only way to achieve thermal or electrical continuity between uneven surfaces. Transparent and ultraviolet curable

adhesives constitute another type of specialty adhesives. These adhesives are used for bonding together optical elements, such as lenses and fibre optic devices. Light-weight honeycomb structures for satellites and certain rocket parts are made by joining honeycomb panels with adhesives already formed into a film. Solar cells are bonded using UV-resistant silicone resins.

Materials for future applications

Future applications of polymeric materials may include extremely thin films for inflatable antennas, solar sails, very-large area reflectors and missions in the “Gossamer” class of programs currently being pursued by NASA. Space rigidisation concept uses a structure coated or embedded with a UV polymerisable resin. The resin can be acrylates, epoxy, etc. It can be deployed in space and then can be rigidised (made rigid) by exposing to light. Light induced polymerisation in space makes the system rigid and attains dimensional stability. A contrary concept that might further enable new material development is a “fugitive mass” coating. This is a polymer-based coating that could be applied to thin films to improve their handling and deployment, but then evaporates from the surface when exposed to the space environment. Currently, the classes of poly(silanes) and polybutyl methacrylate are being evaluated for this purpose. Both are degraded by ultraviolet light to gaseous products and result in decreased mass of thin films used in solar sail applications. The Si-Si bond and C-C bonds in both molecules can be broken easily.

Shape memory polymers

These are polymers that remember their shape on application of a stimulus such as heat. The polymer is shaped, compacted, and kept frozen below its transition temperature. Upon heating above the transition temperature, they return their original shape. Development efforts are on to develop shape memory polymers and their composites for making space-deployable spacecraft. These are open-celled elastomer foams that are fabricated to the desired shape, compressed to a low storage volume, cooled to below their transition temperature and then stored prior to launch. After space deployment, the “frozen” foam heats to above its transition temperature and expands back to its full dimensions.

Table 1. Matrix of resin and reinforcement for polymer matrix composites

Reinforcement	Matrix type	PMC Application
Carbon fibre	Polyimide (BMI/PMR)	LV structures, satellite structures etc.,
	Epoxy	Motor case, liner for He tank
Polyaramid	Phenolics	Nozzles, TPS, ablative re-entry capsules, carbon/carbon and ceramic matrix composites,
Carbon/silica fibre/fabric	Cyanate/PT/Epoxy	Satellite structures
Carbon/silica fabric	PEEK, Poly ether nitrile (PEN)	Composite cryo tank

Elastomer foams offer the benefits of being self-deploying, excellent vibration damping, low thermal conductivity and low thermal mass. They are resistant to micrometeorite puncture and are able to self-correct to their original dimensions in response to transient loads. This technology enables deployment of large antenna in space by simply heating a skewed, folded low-volume one in space above its transition temperature.

Self-healing polymers and composites

Micro-cracking, deep within structural polymers is difficult to detect and almost impossible to repair. Cracking leads to mechanical degradation of fibre-reinforced polymer composites and electrical failure in microelectronic polymeric components. Thermal and mechanical fatigue produces cracks that degrade the performance of adhesives. In all cases, cracks diminish the polymer's structural integrity, and hidden internal cracks cause a significant decrease in toughness without showing an outward indication of damage. This may result in total catastrophic failure without any early warning.

Self-healing composite materials mimic many of the features of a biological system. Damage in the form of a crack serves as the triggering mechanism for self-healing as the fracture event in biological systems (bones) does. The concept of self-healing composite is by using embedded microspheres to store a repair agent. Thanks to their small size and shape, the microspheres can be easily integrated into the composite matrix using existing manufacturing methods. The

micro-thin cracks formed can otherwise grow and break the whole material. The self-healing system senses damage/crack and repair it instantly. Self-healing ability could significantly prolong the life of a spacecraft.

Nanotechnology for space applications

Nanotechnology is defined as engineering of functional materials, devices and systems through control of matter on the nanometre scale and exploitation of properties at that dimension. The concept of nanotechnology offers immense advantages and benefits to space technology in terms of weight reduction, size reduction, improved capabilities and introduction of novel space systems. One of the most important advantages of nanotechnology is the weight reduction and associated cost saving and increased efficiency and operational life of the systems. Current estimate for launching payloads into space orbit stands at \$22,000/kg. Significant weight, and hence cost reductions, can be realised with the use of organic materials, but such materials tend to perform very poorly in the harsh space environment. Organic polymers with uniformly dispersed nano-scale inorganic precursors may enable these materials to withstand the harsh space environment. Nano-composites, as these types of materials are often referred to, have received much attention over the past decade as scientists search for ways to enhance the properties while retaining their processing ease.

Continued on page 28

Pomegranate: a wonder fruit



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The name *pomegranate* (*Punica granatum*, family Punicaceae) is derived from Medieval Latin words *pōmum* – meaning “apple” and *grānātum* – meaning “seeded”. Hence pomegranate means “seeded apple”. It was considered symbol of life, longevity, health, femininity, fecundity, knowledge, morality, immortality, and spirituality. In Ayurveda, it is considered “a pharmacy unto itself – astringent peels as cure for diarrhoea and oral ulcers, and juice as a “blood tonic”. Pomegranate derived products may be used for treatment of acquired immune deficiency syndrome (AIDS), cosmetic beautification, hormone replacement therapy, to treat allergic symptoms, for cardiovascular protection, oral hygiene, in ophthalmic ointment, an adjunct therapy to increase bioavailability of radioactive dyes during diagnostic imaging, and to prevent abortion.

Over 1,000 cultivars of pomegranate exist, originating from Middle East, extending throughout the Mediterranean, eastward to China and India, and on to the American Southwest, California and Mexico. The cultivation of pomegranate is mainly confined to semi-arid mild-temperate to subtropical climates and are naturally adapted to regions with hot summers and cool winters (Mediterranean countries), Afghanistan, Iran, India, China, Japan, and USA.

India is the second largest producer of fruits and first in pomegranate production. Maharashtra leads production of pomegranate followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. Ganesh, Bhagwa, Ruby, Arakta, and Mridula are different varieties of pomegranates produced in India.

The fruit

The size of a ripe pomegranate can be as small as an orange or as big as a grapefruit;

that is, approximately 7-12 cm in diameter, depending on its variety. It has a rounded hexagonal shape, with thick reddish outer layer. The fruit can be eaten raw – seeds as dessert toppings, or the juice extracted by pressing the seeds and pulp. The taste of the juice *can be sweet, sour or tangy*. The preference is given to those with fleshy and juicy pulp around the seeds. Types with relatively soft seeds are often classed as “seedless”.

Pomegranate is often deemed a large

acid. The seeds are rich in lipids, protein and crude fibres.

Health benefits

Pomegranate has become more popular because of its health-promoting phytonutritional content. (The term ‘phytonutrient’ is applied to those plant compounds that promote better health, although they are not absolutely essential to human health.) Clinical trials provide sufficient evidence for beneficial properties of the edible parts of pomegranate fruit. Pomegranate has been shown to possess antiviral, antibacterial, and antioxidant properties.

Pomegranate fruit extract is a rich source of chemicals known as polyphenols which provide flavour and colour and also exhibit antioxidant properties and thus protect cells from damage and reduce inflammation in the body. The fruit is also rich in vitamin C. Studies have shown that the pomegranate peel has higher antioxidant activity than the seeds and pulp. Peel is used to

produce dried extract that is added

to commercial tomato juice and orange juice with strawberries. Numerous studies on the antioxidant, anti-carcinogenic, and anti-inflammatory properties of pomegranate constituents, on treatment and prevention of cancer, cardiovascular disease, dental conditions, bacterial infections and antibiotic resistance, and ultraviolet radiation-induced skin damage and their associated medicinal properties have been published.

Medicinal properties

In *Ayurveda*, pomegranate has been extensively used as a source of traditional remedies since time immemorial. The rind is used against diarrhoea, dysentery and intestinal parasites. The seeds and juice are considered a tonic for heart and throat, and classified as a bitter-astringent (*pitta*) component and considered



Pomegranate - the wonder fruit

berry and is covered by a leathery pericarp with a waxy gloss on the peel. Inside are numerous tightly packed *arils* (seeds individually surrounded by a translucent juice-containing sac) which are deep red in colour when ripe. Thin acid-tasting, non-edible, translucent yellow material surrounding the arils is membrane which extends into the interior of the fruit from the pericarp for suspending the arils. The white, fleshy substance between membrane and rind is called albedo. Thus, the fruit consists of the seeds and juice (about 3% and 30% of the fruit weight, respectively) and the peels including interior membranes. Arils (200 to 800 nos.) represent 52% of fruit weight, comprising of 78% juice and 22% seeds. The fresh juice contains 85.4% moisture, 10.6% total sugars and 0.7 mg/100 ml ascorbic

a healthy counterbalance to a diet high in sweet-fatty (*kapha*) components. The astringency of juice and rind are considered valuable for stopping nose and gum bleeds, toning skin, and firming-up sagging breasts, and have also been used to treat cuts, sore throats, tapeworms, dysentery, and gum disease. Pomegranate juice is also used as eye drops to slow the development of cataracts.

Pomegranate can also fight several forms of cancer, slowing the progression of prostate cancer and suppressing the growth of colon, breast and lung cancer cells. It appears to shield against unsightly signs of aging by supporting the health of skin.

Therapeutic applications

Pomegranate is used in several systems of medicine for a variety of ailments, like treatment and prevention of cancer, cardiovascular disease, diabetes, obesity, dental conditions, erectile dysfunction, bacterial infections and antibiotic resistance and radiation-induced skin damage.

Anticancer properties

Pomegranate has been shown to be helpful in the prevention and treatment of breast, skin, prostate and lung cancer. A topically-applied pomegranate fruit extract can block skin tumour formation in mice. Significant antitumor activity of pomegranate-derived materials against human prostate cancer and promotion of differentiation (ability of cancer cells to revert to normal counterparts) has been demonstrated. Studies show that polyphenols from pomegranate are potent inhibitors of cancer cell proliferation and induce apoptosis, cell cycle arrest and also reduce inflammation.

Lung cancer is one of the most common and leading causes of deaths in the world as it does not cause any symptoms and normally diagnosed at the late stage when treatment is ineffective. So agents that can potentially prevent, delay or even reverse lung cancer progression are extremely important. Pomegranate juice possesses anticancer properties and may be potentially beneficial for lung cancer.

Colon cancer is another major cause of

cancer-related deaths in the Western world. Pomegranate has been found to be anti-carcinogenic and curtails the risk of colon cancer development

Antitumour activity

Polysaccharides isolated from pomegranate were found as potential antitumour agent



Parts of a pomegranate

against breast cancer, nasopharyngeal carcinoma and leukaemia cells.

Cardiovascular diseases (CVD)

Juice of the pomegranate may be effective in reducing risk factors for heart disease.

In a limited study of hypertensive patients, consumption of pomegranate juice was shown to reduce systolic blood pressure thus helping to prevent the development of atherosclerosis. Research has shown that pomegranate can reverse the process of atherosclerosis, by restoring endothelial health, lowering blood pressure and protecting LDL from oxidation. Even in advanced atherosclerosis, ingesting pomegranate juice produced significant decrease in risk for heart attack and stroke.

Obesity and diabetes

Consumption of pomegranates could slow weight gain and help lower cholesterol. Positive effects on fat reduction have been shown using the pomegranate extracts. Consumption of pomegranate juice may lower blood cholesterol levels and risk of CVD in individuals with type-2 diabetes. Juice may also improve insulin sensitivity and lower the risks of type-2 diabetes, and slow the absorption of LDL cholesterol by immune cells which is a major factor to atherosclerosis.

Pomegranate arils: Nutritional facts

Nutritional value per 100 g

Energy	83 kcal
Carbohydrates	18.7 g
Sugars	13.7 g
Dietary fibre	4.0 g
Fat	1.2 g
Protein	1.7 g
Thiamine (vit. B ₁)	0.07 mg (6%)
Riboflavin (vit. B ₂)	0.05 mg (4%)
Niacin (vit. B ₃)	0.29 mg (2%)
Pantothenic acid (vit. B ₅)	0.38 mg (8%)
Vitamin B ₆	0.08 mg (6%)
Folate (vit. B ₉)	38 µg (10%)
Vitamin C	10 mg (12%)
Calcium	10 mg (1%)
Iron	0.30 mg (2%)
Magnesium	12 mg (3%)
Phosphorus	36 mg (5%)
Potassium	236 mg (5%)
Zinc	0.35 mg (4%)
Percentages are relative to US recommendations for adults. Source: USDA Nutrient Database	

Antimicrobial properties

The antimicrobial properties of pomegranate have been extensively studied. Juice consumption may inhibit viral infections. *In vitro* research indicates that an anti-HIV1 microbicide (a substance to kill microbes) could be made from pomegranate. Owing to broad-spectrum antimicrobial activity, pomegranate peel extracts may also be exploited as bio-preservatives in food applications and nutraceuticals (products derived from food sources that provide extra health benefits, in addition to the basic nutrition).

Eyes

Pomegranates contain β -carotene which plays an important role to maintain and develop healthy eyes. It minimises damage of the retina that occurs with age. Thus a diet supplemented with pomegranate or extracts can ensure good eye health.

Dental care

Topical applications of pomegranate preparations have been found to be effective for controlling oral inflammation and microbial counts in periodontal disease. Clinical studies have shown that regular use of pomegranate-containing toothpaste and mouthwash may fight dental plaque and tartar formation by inhibiting the activities of the microorganisms.

Male infertility

Pomegranate juice improves sperm count, spermatogenic cell density, and sperm motility and decreases the number of abnormal sperms in rat model and thus may be helpful in preventing male infertility.

Osteoarthritis

Pomegranate extracts have been found to possess the ability to slow the deterioration of human cartilage in osteoarthritis and help to treat degeneration of joint tissue

Alzheimer's disease

The neuroprotective (protecting degeneration of nerve cells) properties of pomegranate polyphenols were evaluated in mice with Alzheimer's-like symptoms. Pomegranate juice was shown to exhibit neuroprotective role, probably by protecting the brain against changes that can lead to Alzheimer's disease.

Skin care

Products containing pomegranate extracts and seed oil are available that promise rejuvenation, youthfulness and beauty. Oral supplementation with pomegranate extract provided protection against UV induced pigmentation in human subjects who were prone to sunburn. Pomegranate is used in skin care products against acne, to prevent skin cancer, increase skin elasticity, soothing minor irritations, reduce inflammation, wrinkles, scars and saggy skin and skin regeneration. It also promotes blood circulation and rejuvenates skin cells.

Various products

A number of pomegranate containing products have been introduced in the international market and are being advertised for their health-promoting benefits. These products include 100% juice, pomegranate-containing beverages, liquid and powdered polyphenolic extracts, leaves, flowers, arils and peel, seed oil, and skin care products

containing extracts and/or seed oil as ingredients. Various products available in world market include jams jellies, frozen kernels, kernels in preserve, distilled liquor and vinegar, juices, frozen arils, concentrate, sauce, wine, *anar* rub, etc. Many products from peel are available in the market, which are useful either from health angle or for beautification.

By virtue of various medicinal properties and health benefits pomegranate possesses, it can be called as a "wonder fruit" and the old phrase "*An apple a day- keeps doctor away*" may be redefined and revisited.

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Points to be noted about point



Dr. C.K. Ghosh¹



Dr. B. Chakrabarti²

Introduction

The concept of decimal is quite crucial in mathematics. Hence, needless to mention, one has to be conceptually clear about its implication and application in mathematics. The authors have experienced very strange kind of misconceptions among the students in particular and people in general so much so that they felt inspired to narrate them and find ways to allay such misgivings. The article is an outcome of the said effort.

Every point is not a decimal point

One of the authors (CKG) had assigned a problem to the mathematics teachers of a school. It was a multiple-choice type question as mentioned below:

In a One-Day International match the team batting second has scored 198 runs in 39.2 overs. The target was 250 in 50 overs. What was the required run rate correct up to two places of decimal? The options given were:

- a) 4.87, b) 4.95, c) 5.00, d) 5.05

It was quite amazing that each one of them ticked (c). They calculated that, overs left = $50 - 39.2$; i.e., 50 overs minus 39 overs and 2 balls, which is 10 over and 4 balls. So overs left was 10.4, runs left = $250 - 198 = 52$, and $52 \div 10.4 = 5$. While performing this division, they considered the point between '10' and '4' as a decimal point which was not correct. Since the total number of legal deliveries in an over is '6', 10.4 overs actually mean $10 + 4/6 = 10 + 2/3 = 10 + 0.67 = 10.67$ overs. Now, the point has become a decimal point and so the required run rate would be $= 52 \div 10.67 = 4.87$, and hence (a) is the correct option. Among the wrong answers, (b), (c) and (d), everybody got readily distracted to (c), may be because the division was simple, might not have even required a calculator. The matter of concern here is that the meaning of the word 'point' has been misconstrued by none other but mathematics teachers, who ought to know the correct answer.

Let us narrate another example.

One of the authors (BC) had been to a college where he overheard students talking among themselves. It was about one of them telling his classmate that, "Our mathematics class is going to take place in Room Number Two Point One Zero (2.10)." It was essentially meant that the mathematics class would be held in Room Number Ten of the second floor. So, the student concerned was asked, "Should you not have told 'Two Point Ten' rather than 'Two Point One Zero'? His answer was, "Sir, after decimal point, we are not supposed to spell out the whole number as one, but we are supposed to mention only the digits separately one at a time". Then he had to be told that the 'point' in '2.10' was not a decimal point. It was used as a means to distinguish between the Floor Number and the Room Number. So '10' should be pronounced as 'ten' and not as 'one-zero'. It is noteworthy that the incident again involved students of mathematics.

Similar situation arises when one reads out Section Numbers appearing in a chapter of a book. Section Number of say, the fourteenth section of chapter five (i.e., 5.14) will be read as five point one-four, whereas it should be read as Five Point Fourteen.

One has to realise that every point appearing between two numbers is not a decimal point. Ignorance of this very simple fact is quite common and it becomes a matter of serious concern when the teachers and students of mathematics exhibit a casual attitude about it. Let us look into the mathematical implication of the matter.

The numbers that follow the decimal point

We all know how to convert a fraction into a decimal, like $\frac{1}{2} = 0.5$, $\frac{1}{5} = 0.2$, $\frac{1}{4} = 0.25$, $\frac{1}{8} = 0.125$, and so on.

The examples which we have taken above are all cases of terminating decimals; but what about non-terminating decimals? For examples $\frac{1}{7} = 0.142857\ldots$. In fact if

we had continued with the process, we would have obtained, $\frac{1}{7} = 0.142857142857\ldots$, which is called a recurring decimal, and is denoted as $0.\dot{1}4285\dot{7}$. Similarly, $\frac{1}{3} = 0.3333\ldots = 0.\dot{3}$ or $\frac{1}{6} = 0.1666\ldots = 0.1\dot{6}$. But we should also know where to stop. In order to know that we have to understand the meaning of significant digits or the significant places after decimal point. (There are two ways of writing – one can put the dot over the digit as it is done in the case of $\frac{1}{3}$ expressed in decimal; i.e., as a recurring decimal. But when more than one number get repeated, as in the case of $\frac{1}{7}$, then we put a bar (like vinculum) over the number, e.g., $0.\overline{142857}$).

The issue of significant number of digits (or significant digits)

At a physics practical class, a student was supposed to measure the length of an object using a metre scale. As per the instructions given in the book the same length had to be measured thrice and the average of the three readings would be taken as the desired length. For making the measurement the left end of the object has to correspond to a mark on the scale, which can be called Left End Reading (LER) and take the Right End Reading (RER) in the same way. The length of the object is then equal to 'RER' minus 'LER'. Since there can be errors due to parallax and possible non-uniformity in the scale markings, the reading had to be taken for at least three different values of LER which in turn would give three different values of RER. The three values of length obtained by the student were 21.2 cm, 22.2 cm, and 22.3 cm. So the desired length was equal to $\frac{1}{3}(21.2 + 21.2 + 21.3)$ cm = $21.2333\ldots$ cm and the number of '3's would be unending. The students did not know where to stop. So, let us try to analyse that.

In the instant case one has to take cognisance of the fact that the measuring device was a metre scale whose smallest division is 1 mm, i.e., 0.1 cm. In other

words, the scale was capable of measuring correct up to 0.1 cm; that is, up to one place after the decimal point if the measurement was to be expressed in centimetre. Now, if we had expressed the final result as 21.23 cm, it would have implied that the device can measure correct up to 0.01 cm, which was not the case. It means that the result should not have been mentioned as 21.23 cm. For similar reasons, it is out of question to express the final result as 21.233 cm, and so on. In other words, only one place after the decimal point was significant, and the student should have stopped at the first place and declared that final result as 21.2 cm. *The result of any measurement should not be indicative of a level of accuracy more than that is provided by the device or the measuring instrument concerned.*

Some more examples

In this connection, another example of a physics experiment becomes relevant. For experiments with a suspended moving coil galvanometer wherein the deflection of the galvanometer needle is read by locating the mirror reflection of the filament of a bulb on a scale, the students are advised to take readings corresponding to direct and reverse currents and then take their average. The idea is to eliminate any error which may creep in due to problems of levelling of the galvanometer, alignment of the scale and related issues. Here also the smallest division of the scale used is 1 mm; that is, 0.1 cm. Now, if the deflections corresponding to direct and reverse current are 8.2 cm and 8.3 cm, the average is taken as 8.25cm, which is improper, because it is indicative of a level of accuracy up to 0.01 cm, whereas the smallest division in the scale is only 0.1 cm. So the average should be rounded off at the first place. The convention for rounding off is that if the following digit is equal to or greater than five, then it should round off to the next number and if it is less than five, then the number has to be retained after rounding off. So 8.25cm gets rounded off to 8.3 cm. Students come across similar situation while taking the readings in a digital milliammeter while obtaining the I-V characteristic of a Zener diode, where

they take reading with 'voltage increasing' and 'voltage decreasing'.

In science experiments, particularly in the physics laboratory, we come across many instances where a final result, say the value of 'acceleration due to gravity' or 'the thermal conductivity of a substance' is to be obtained by way of calculation starting from an expression, in the form of a fraction. The fraction may have the product of various quantities in the numerator and many such quantities in the denominator. There may also be experiments in electronics, optics, electricity, etc. Some of these may involve invariants like π or some parameter having a supplied value or a pre-assigned value. But rest would be measurable quantities like mass, length, time, angle, current, voltage, etc. Among them it needs to be seen which has the lowest level of accuracy of measurement. For example, it may be 0.01g for mass, 0.1cm for length, and 0.01s for time. So among them length measurement has the lowest level of accuracy which is up to one place after the decimal point. And hence one cannot claim that the final result is more accurate than up to the level of one place after the decimal point. So the final result has to be expressed correct only up to one place after decimal point. We have seen students presenting results such as the value of acceleration due to gravity in metres per second square, as 9.73, 9.745, 9.7287 and so on, obtained by performing the good old simple pendulum experiment in a physics laboratory in Kolkata, whereas in each of the above cases, it should have been expressed as 9.7 only, as only one place after the decimal point is significant.

Pronouncing the numbers after decimal point separately

We are now in a position to clarify why we separately pronounce the numbers after the decimal point. A number correct up to two place of decimal is say, 2.23. Now the number could have been 2.231, 2.2326, 2.23359, or for that matter a number of the form $2.23pqrst\dots$, where ' p ' is less than '5'. This is why 2.23 should not be called as 'two point twenty three', but as 'two point two-three', because it is not the number

'23' which has actually appeared after the decimal point.

Decimal number ending with zero (s)

Now, are 2.23, 2.230, 2.2300, etc., all same, when the points are all decimal points? The answer to the given question is a restricted 'Yes'. They are all equal up to two places of decimal, because each one of them is indeed 2.23, up to two places of decimal. And, then, what is the difference between 2.23 and 2.230 or 2.2300? The answer is very obvious. We have seen that 2.23 could be $2.23pqrst\dots$, where ' p ' is less than 5, Similarly, 2.230 could be $2.230pqrst\dots$, again when ' p ' is less than 5, and likewise for 2.2300. It eventually means that 2.230 could have been 2.2301, 2.2302 and so on, and since we have considered up to three places after the decimal point, we have curtailed the digit at the fourth place. So 2.23, 2.230, 2.2300 are all same but with a restricted sense as mentioned above. Having said so, let us look into the case of difference between numbers such as '28' and '28.0' or say '35' and '35.0'.

Comparing 'n' and 'n.o' (n is any integer)

It has been observed that it is a practice among newscasters that they will read, say the maximum and minimum temperatures of a day in New Delhi respectively as '35.2°C' and '28°C' whereas the visual would show the figures as '35.2' and '28.0'. Now, as regards '35.2', there is absolutely no issue, but perhaps the newscaster would not be knowing that '28' and '28.0' are not one and the same; 28.0°C means that the temperature has been read by a thermometer whose smallest division is 0.1°C. So it can read correctly up to one place after the decimal point. The minimum temperature could have been 28.01°C and it would have been detected thus by using a thermometer whose smallest division is 0.01°C. Indeed there are thermometers of types other than 'liquid-in-glass' which can read correct up to four to five places after the decimal point. Hence, '28.0°C' should be read as 'twenty eight point zero degrees centigrade, and not just as 'twenty eight degrees centigrade'. A

temperature 28.0°C indicates that error in reading may be $\pm 0.1^\circ\text{C}$. So 28.0°C is in a way more reliable information.

Let us now discuss about another interesting situation we normally come across at a physics laboratory.

Linear and angular vernier scales

We know that vernier scales, named after the French mathematician Pierre Vernier, are used in the physics laboratory for enhancing the accuracy of measurement. Broadly there are two kinds of vernier scales – linear and angular. As the names suggest, the former is used for measurement of length by callipers and the latter for angles, used quite effectively in spectrometer for measuring angles of deviation, diffraction, etc. The principle of measurement can be summarised with the help of the following equation:

$$\text{Final reading} = a + b.c,$$

Where a is the reading by the main scale (linear or angular depending on the measurement) without using the vernier, b is the vernier scale reading (linear or angular as the case may be) and c is called the vernier constant (v.c.). It is defined as the difference between the unit smallest main scale reading and unit vernier scale reading, expressed in terms of the smallest division of the main scale. For linear vernier scales, we generally come across three situations:

- 10 vernier scale division (v.s.d.) = 9 main scale divisions (m.s.d.) (with smallest m.s.d 0.1 cm)
- 20 v.s.d. = 19 m.s.d (with smallest m.s.d = 0.1 cm)
- 50 v.s.d. = 49 m.s.d. (with smallest m.s.d = 0.05 cm)

For (a), the v.c. = 1 m.s.d – 9/10 m.s.d.

$$= (1 - 9/10) \text{ m.s.d.}$$

$$= 1/10 \text{ m.s.d.} = 0.1 \text{ m.s.d.}$$

If one m.s.d. = 1 mm = 0.1 cm, the v.c. = $0.1 \times 0.1 \text{ cm} = 0.01 \text{ cm}$

$$\text{For (b), the v.c.} = (1 - 19/20) \text{ m.s.d.}$$

$$= 1/20 \text{ m.s.d.}$$

$$= 0.05 \times 0.1 \text{ cm} = 0.005 \text{ cm}$$

$$\text{For (c), the v.c.} = (1 - 49/50) \text{ m.s.d.}$$

$$= 1/50 \text{ m.s.d.}$$

$$= 0.02 \times 0.1 \text{ cm} = 0.002 \text{ cm}$$

We find that in each case, the fraction (1/10, 1/20, 1/50) gets converted into a terminating decimal. And so we express the

v.c. using decimal points.

But what is the situation with angular vernier? For angular vernier scales, we have situations like under:

$$\text{d) } 30 \text{ m.s.d.} = 29 \text{ m.s.d.}$$

$$\text{e) } 60 \text{ v.s.d.} = 59 \text{ m.s.d.}$$

And that the smallest division of the main angular scale is 1 degree, or $\frac{1}{2}$ degree, or $\frac{1}{3}$ degree, or $\frac{1}{4}$ degree.

$$\text{For (d), v.c.} = (1 - 29/30) \text{ m.s.d.} = 1/30 \text{ m.s.d.} = 1/30 \times 1^\circ$$

$$\therefore \text{v.c.} = 1/30 \times 60' = 2' \text{ (with other m.s.d this will be } 1', 40'', 30'' \text{ respectively)}$$

$$\text{For (e), v.c.} = (1 - 59/60) \text{ m.s.d.} = 1/60 \text{ m.s.d.} = 1/60 \times 1^\circ = 1/60 \times 60' = 1' \text{ (with other m.s.d this will be } 30'', 20'' \text{ and } 10'' \text{ respectively)}$$

Here, the fractions involved are 1/30 and 1/60. In each case the denominator is a factor of 1 degree, it being equal to 60 minutes. The design of the angular vernier has to take into consideration this (depicted through (d) and (e)) aspect, so that finally v.c. turns out to be a whole number, but in minutes. We cannot afford to have v.c. in degrees as it would end up in a non-terminating decimal. The point to be noted here is that both 1/30 and 1/60 are non-terminating decimals unlike 1/10, 1/20 and 1/50. Thus the concept of decimals plays a crucial role in the design of vernier scales.

Before concluding, we shall now discuss multiple miscellaneous facets about 'point'.

Many facets of the point

Well before the decimals entered our daily life by the introduction of metric measurements, it was there in English language not only as a full stop but on the top of small 'i' and small 'j'. It used to appear twice with a colon and once with a semicolon (as expected, after all it is semi) In the German 'Umlaut', as in 'ö' in the name of the celebrated physicist, Schrödinger, there are actually two points over 'ö' and not one. Yet the real avalanche breakdown took place after the introduction of metric system. People irrespective of their academic attainment or exposure learnt how to get, say 2.15 metres of cloth for their shirts, or for that matter how the mass of one litre of edible oil comes out to be only 0.915 kg. Yes, we have learnt that it would be zero point 'nine one five' and not zero point 'nine

hundred fifteen'.

Once Internet and email entered our everyday life the good old point that used to be referred to as the decimal turned into a dot. It also found special use in library services which adopted the methods of Dewey decimal and colon classification. By now we have understood that this dot is different from decimal in its significance but not in its appearance. In bank cheques, interestingly the decimal between the rupees and paise may be given relief by an equality sign. And it works. In the case of domain names on website or in case of writing an email ID, 'dot' truly got a very special importance. Dot at the wrong place can actually play havoc in the cyber world.

The role of decimal notwithstanding, the word decimal has got a status of a unit in land measurement in India. Now if someone owns say one decimal of land he actually owns about 436 sq ft or more precisely 435.5078 sq ft. Well, two questions come up. First why square feet and not square metre? Well, in India some of the fields have still preference for the old British units and the reason is possibly the convenience of use and their connection with the old local units like 'cottah' 'bigha', etc. People prefer to mention the floor area of one's apartment in square feet, but feel more comfortable with kilometre while indicating the distance of the apartment from the nearest metro station.

Let us go back to the decimal of land. One decimal expressed in square metres comes out to be about 40.5 sq metres; it is 40.46 square metres to be nearly exact. And naturally the question comes about the origin of such a 'not-so-easy-to-remember number'. The measurement comes from the fact that it is taken as one hundredth of an acre and here decimal refers to (1/100) so to speak. The area 'one acre' has a very old origin and used to refer to a piece of land measuring 43,560 sq ft. However that has undergone small changes over the years.

Interestingly the point is very much associated with detective stories. Often we find the investigator is identifying that the killer who shot a .22 bullet at the victim. Or sometimes people talk about revolver of .38 bore. No doubt these numbers have got something to do with the size, i.e., the diameter of the bullet and possibly with the

size of the nozzle of the gun from the bullet is shot. But what about the point? Interestingly this is a vast area and one will find number of experts on this with the police and other forces and of course with the army, navy or air force. Incidentally .22 bore refers, strictly speaking, to the diameter of the bore of the gun that is close to the diameter of the bullet. .22 bullet refers to that size of the bullet that can be fired from a gun whose nozzle diameter is 0.22 inches; i.e., 22 hundredths of an inch, or nearly one fifth of an inch. This unit is of course not mentioned. Same thing happens when one talks about .303 rifle that is actually pronounced as 'point three, not three'. Because of the absence of the utterance of the unit the point of a bullet remains somewhat mystifying and possibly provides the detective stories the necessary charm.

Decimal Day

Having presented varied features about the decimal point and its difference with the ordinary point or 'dot', let us conclude by referring to something different. Did you know that 15 February 1971 is known as 'Decimal Day' in Britain and Ireland? They adopted decimal system on that day whereas it was adopted in India on 1 April, 1957. Perhaps they were reluctant to give up the British system, their own baby, but could not ultimately ignore the convenience aspect which is the cardinal feature of the metric

system. So from the British point of view, that day was especially significant as it lost one of its last bastions, which was so much English in nature. That way the point possibly points towards the end of a colonial era not only politically but culturally and possibly economically. And that is of course an important point.

Concluding observations

The point, it appears in spite of its small size occupies a very important place in different spheres of our life. The use of phrases like 'pointless discussion' or 'coming to the point' or 'point to point' or 'point by point' or 'point blank', and so many others have special connotations. It appears that the point will be able to score an important point once the decimalisation of a few more countries that includes the USA takes place. Otherwise the point that is no more confined to the books on geometry has been able to point out its steady gain in its use and globalisation from this point of view of its use.

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Continued from page 35

(Polymeric Materials for Space Research)

Launch vehicles would greatly benefit from appropriately designed nano-composites that could provide improved barrier properties and gradient morphologies enabling liner-less composite cryogenic fuel tanks. Nano-composite materials also offer the unique opportunity for improved tailorability of physical and structural properties such as the coefficient of thermal expansion, which would be especially useful in constructing large aperture telescopes and antennas.

Outlook

Polymeric materials have played an undisputed role in revolutionising space technology. Polymers and polymer-based systems are indispensable for the current and future space endeavours. Emerging materials and innovative technologies have made the journey possible and goals achievable for mankind. Research becomes challenging and exciting as the missions become more and more ambitious and requirements become more and more stringent. Extensive use of resin matrix/fibre-reinforced composites has been identified as a viable means of reducing weight and thus increasing the fuel efficiency and payload fraction in aerospace applications. The tailorability to the requirements and high specific mechanical properties of polymer matrix composites render them the most suitable candidates for many structural, thermo-structural and other functional space applications. The smart and nanomaterial research will pave the way for another era in the R&D of materials and systems including novel materials and improvisation of the existing technologies. This hopefully will culminate in smarter, lighter and more efficient space systems in most areas of interest.

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Vitiligo— When the skin loses its colour



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People who have vitiligo have irregular patches of pale skin. Caused by the loss of melanin—the pigment that determines the colour of the skin, hair and eyes, the condition usually starts as small areas of pigment loss that spread with time. Vitiligo affects all races, but is more noticeable in people with darker skin.

Although it can start at any age, vitiligo often first appears between the ages of 10 and 30. It does not cause physical discomfort, but some people become distressed by the discolouration that affects their skin.

The disorder attracts considerable social attention, is caught up in a large number of superstitions and often stirs public discrimination. Some communities erroneously think it to be a close cousin of leprosy, and believe it to be infectious. But that is far from truth. The condition has no relationship to the organism that causes leprosy, and is utterly non-infectious.

Causes

Vitiligo occurs when melanin-forming cells (melanocytes) that produce melanin die or fail to produce melanin—the dark pigment in the epidermis that gives the skin its normal colour. The involved patch of skin then becomes white. It is not known why this occurs.

Doctors and scientists have theories as to what causes vitiligo. It may be due to an immune system disorder.

Heredity may be a factor because there is an increased incidence of vitiligo in some families. About 1 in 3 people with vitiligo have a family history of the condition. About the same proportion also have another type of autoimmune disorder, such as pernicious anaemia.

Some people have reported a single event—such as sunburn or emotional distress, that triggered the condition. Sometimes pigment loss can occur in someone who has had a melanoma, a malignancy of the cells that produce melanin. However, none of these theories has been proved as a definite cause of vitiligo.

Symptoms and signs

The tell-tale signs of vitiligo are:

- Pigment loss that produces milky-white patches on the skin
- Premature whitening or graying of the hair on the scalp, eyelashes, eyebrows or beard
- Loss of colour in the tissues that line the inside mucous membranes of the mouth
- Loss of or change in colour of the inner retinal layer of the eye

Distribution of the patches

Although any part of the human body may be affected by vitiligo, depigmentation usually develops first on sun-exposed areas of the skin, such as the hands, feet, arms, neck, face and lips. Genitals also may be affected.



Patterns of vitiligo

Vitiligo generally appears in one of three patterns:

Generalised

In this most common subtype, pigment loss is widespread across many parts of the body, often symmetrically.

Segmental

Loss of skin colour occurs on only one side of the body. This type tends to occur at a younger age, progress for a year or two, and then stop.

Focal

Depigmentation is limited to one or a few areas of the body.

Natural course of the disorder

The natural course of vitiligo is difficult to predict. Sometimes the patches stop forming without treatment. In most cases, pigment loss spreads and can eventually involve most of the surface of the skin.

However, the good bit is that about 3 in 10 affected people regain their natural skin colour spontaneously.

When to see a doctor

You must see a doctor if areas of your skin, hair or eyes lose colouring. A dermatologist, or a doctor who specialises in skin disorders, is best trained to handle the condition.

While you are waiting to see the doctor, limit your sun exposure and wear a broad-spectrum sunscreen with a sunburn protection

factor (SPF) of at least 30. If you're feeling self-conscious about the changes in your skin, you can use cosmetics or sunless tanning products to cover the depigmented areas.

What your doctor might do

Your doctor might like to ask for a detailed history, including your personal and family medical history and examine your skin. The diagnosis is usually obvious, but he may use a device called a Woods lamp, which shines ultraviolet (UV) light



onto the skin, to determine whether you have vitiligo. He might also examine you to rule out other skin conditions, such as pityriasis versicolor, dermatitis, or psoriasis.

Your doctor may also take a small sample (biopsy) of your affected skin; draw blood to check your blood cell count, thyroid function and to look for the presence of anti-nuclear antibodies (a type of autoantibody) that would indicate an autoimmune disease.

Your doctor may also recommend that you see an eye specialist — ophthalmologist — for an eye examination to check for inflammation (uveitis) in your eye.

Treatments and drugs

Medical treatment for vitiligo isn't always necessary. For some, skin colour returns without treatment. For others, self-care steps may suffice. In mild vitiligo, the discoloured areas can be hidden by applying cosmetic camouflage cream. No other treatment is needed. The affected areas cannot tan, so you should avoid exposure to the sun and use a sun-block (sunscreen) in direct sunlight. This may improve the appearance of your skin. For fair-skinned individuals, avoiding tanning can make the areas almost unnoticeable.



Depending on the number, size and location of the white patches, you may decide to seek medical treatment. Medical treatments for vitiligo aim to even out skin tone, either by restoring colour (pigment) or by destroying the remaining colour.

Treatment for vitiligo may take as long as six to 18 months, and you may have to try more than one treatment before you find the one that works best for you.

Medical therapies

Topical corticosteroid therapy

Corticosteroids may help return colour to your skin, particularly if the medication is started early in the disease. Milder topical corticosteroid cream or ointment may be prescribed for children and for people who have large areas of depigmented skin. It may take as long as three months of treatment before you begin to see any changes in your skin's colour. This treatment is easy and effective, but your doctor needs to monitor you closely for side effects, such as thinning of the skin (atrophy) and streaks or lines on your skin.

Calcipotriene, a vitamin D derivative, also may be used topically and is sometimes used with corticosteroids or ultraviolet light.

Topical immunomodulators

Topical ointments containing tacrolimus or pimecrolimus are effective for people with small areas of depigmentation, especially

on the face and neck. This treatment may have fewer side effects than corticosteroids and can be used in combination with ultraviolet B (UVB) treatments.

However, studies conducted on these treatments have been small, and there is concern that they may be associated with an increased risk of lymphoma and skin cancer.

Topical psoralen plus ultraviolet A (PUVA)

This option, which is also called photochemotherapy, may be effective for you if less than 20 per cent of your body has depigmented patches. You'll have to visit the doctor once or twice a week for treatment. Your doctor or nurse applies a thin coating of the topical psoralen about 30 minutes before the light exposure. Psoralen makes your skin more sensitive to ultraviolet light. Your skin is then exposed to UVA light, which turns the treated areas pink. As the skin heals, a more normal skin colour appears.

A variation is known as water bath PUVA, in which you lie in a tub of water containing psoralen for 15 minutes before you're exposed to the light.

Possible side effects include severe sunburn and blistering, though you can minimise your risk of complications by avoiding direct sunlight after each treatment. Hyperpigmentation — overdarkening of the skin — is usually temporary and eventually lightens when treatment stops.

Oral psoralen photochemotherapy (oral PUVA)

If you have depigmented areas that cover more than 20 per cent of your body, your doctor may recommend oral psoralen. For this treatment, you take the oral psoralen about two hours before exposure to UVA light.

You'll have to visit the doctor two or three times a week, allowing for at least a day in between treatments. As with topical psoralen, the treated skin becomes pink after UVA exposure, and then eventually fades to a more normal skin tone.

This treatment can also be done using natural sunlight. Your doctor will let you know how much exposure you need and will want to monitor your skin changes frequently.

Sunburn, nausea, vomiting, itching, abnormal hair growth and overdarkening of the skin are potential short-term side effects of this treatment, whether it's done in the doctor's office or using natural Sun. Your risk of skin cancer may be increased if you use this therapy long term. Oral PUVA is not recommended for children under 10 due to a greater risk of damage to the eyes, such as cataracts.

You can reduce your odds of skin cancer and sunburn by staying out of direct sunlight for one to two full days after treatment. The use of sunscreen can also help reduce your risk of side effects. To protect your eyes from serious damage, such as cataracts, wear UV-protective sunglasses for up to 24 hours after each treatment when you're exposed to the Sun.

Narrowband ultraviolet B (UVB) therapy

Narrowband UVB, a special form of UVB light that uses a more specific wavelength of ultraviolet B, is an alternative to PUVA. This type of therapy can be administered like PUVA and given up to three times a week. However, no pre-application of psoralen is required, which simplifies the treatment process.

Since it is simpler to administer, this type of phototherapy is gaining wide acceptance. However, more research is needed to

determine if it is superior to PUVA and to assess its long-term safety. Narrowband wavelengths of light can also be delivered to smaller areas of vitiligo using either an intense light source (focal) or a laser. Small trials have shown positive results. However, due to the added expense of these devices they may not be available in all dermatologists' offices.

Excimer laser

This type of laser delivers controlled beams of a specific wavelength of UVB light to the skin. It can be used only on small areas of vitiligo, and it's often used in combination with topical drugs. Side effects can include redness and blistering.

Bleaching of depigmentation

Bleaching or depigmentation may be an option for you if you have vitiligo that covers more than half of your skin. Depigmentation therapy lightens the unaffected parts of your skin to match the areas that have already lost colour. For this treatment, you apply a medication called monobenzone ether of hydroquinone twice a day to the areas of your skin that still have pigment. Treatment continues until the darker areas of your skin match the already depigmented areas.

Redness and swelling are potential side effects of depigmentation therapy, and you have to be careful to avoid skin-to-skin contact with other people for at least two hours after you've applied the drug, so you don't transfer it to them. Other potential side effects include itching and dry skin. Depigmentation is permanent and will make you extremely sensitive to sunlight permanently.

Surgical therapies

Autologous skin grafts

This type of skin grafting uses your own tissues (autologous). Your doctor removes tiny pieces of skin from one area of your body and attaches them to another. This procedure is sometimes used if you have small patches of vitiligo. Your doctor removes very small sections of your normal, pigmented skin, often containing a small hair, and places them on areas that have lost pigment. Possible complications include scarring, a cobblestone appearance, spotty pigmentation or failure of the transferred skin to repigment.

Blister grafting

In this procedure, your doctor creates blisters on your pigmented skin, primarily by using suction. The tops of the blisters are removed and transplanted where a blister of equal size has been created and removed in an area that has no pigment. Blister grafting may cause a cobblestone appearance and scarring, and the area may not repigment. However, there is less risk of scarring with this procedure than with other types of skin grafting.

Tattooing (micro-pigmentation)

Tattooing implants pigment into your skin with a special surgical instrument. For the treatment of vitiligo, tattooing is most effective around the lips and in people with dark skin. Sometimes the tattoo colour doesn't match skin colour closely enough. Additionally, tattoo colours fade and they don't tan.

Experimental therapies

Doctors are continuing to try to find better ways to treat vitiligo. One newer option is a procedure called an autologous melanocyte

transplant. Using a sample of your normal skin, researchers can grow melanocytes in the lab. These newly developed melanocytes are then transplanted to the areas on your body that lack pigment. This treatment is still considered experimental and isn't widely available.

Another treatment in development uses a compound found in black pepper called piperine, which in animal trials has been found to be effective at causing repigmentation. Piperine was found to be more effective when it was used in combination with UV light. Redness and skin peeling were temporary side effects of this treatment.

What you can do

Certain self-care tactics may help you care for your skin and improve its appearance:

Protect your skin

If you have vitiligo, particularly if you have fair skin, use a sunscreen with an SPF of at least 30 that protects against both UVA and UVB light to protect your skin from the sun's harmful rays.

Sunscreen helps protect your skin from sunburn and long-term damage. Sunscreen also minimises tanning, which makes the contrast between normal and depigmented skin less noticeable.

Conceal imperfections

Concealing cosmetics may lessen the appearance of the white patches and help you feel better about yourself, especially if your vitiligo patches are on exposed skin. You may need to experiment with several brands of concealing cosmetics before finding a product that blends best with your normal skin tone.

Sunless tanning products (self-tanners) also may help conceal imperfections by adding colour to depigmented areas. The colouring doesn't wash off, but it gradually fades as the dead skin cells slough off in several days.

Coping and support

The change in appearance caused by vitiligo can affect your emotional and psychological well-being. You may experience emotional stress, particularly if vitiligo develops on visible areas of your body, such as your face, hands, arms or feet. You may feel embarrassed, ashamed, depressed or worried about how others will react. Young people, who are often particularly concerned about their appearance, can be devastated by widespread vitiligo.

Certain strategies may help you cope with vitiligo. Consider these tips:

Learn all about it

Find out as much as you can about vitiligo and its treatment options so that you can participate in making important decisions about your health care.

Communicate your feelings

Let your doctor know if you're feeling depressed. A psychologist can help you deal with depression.

Confide in loved ones

Seek understanding and support from your family and friends.

Recent developments in science and technology



Biman Basu

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Scientists find another evidence of Big Bang

The birth of the universe as a result of an event that came to be known as the Big Bang is now generally accepted. Some evidence of the Big Bang in the form of the cosmic

Massachusetts, USA. Using a telescope called BICEP2 (Background Imaging of Cosmic Extragalactic Polarisation 2) at the South Pole, the team claims to have detected the suggested swirling polarisation pattern, called 'B-mode polarisation'. The telescope allowed scientists to analyse the polarisation of light left over from the early universe. In theory, this swirling polarisation pattern could only be created by gravitational waves. And that is what BICEP2 has found. According to the researchers, this is the first ever direct evidence of the Big Bang, the theory that the entire universe

the Nobel Prize in Physics in 1978.

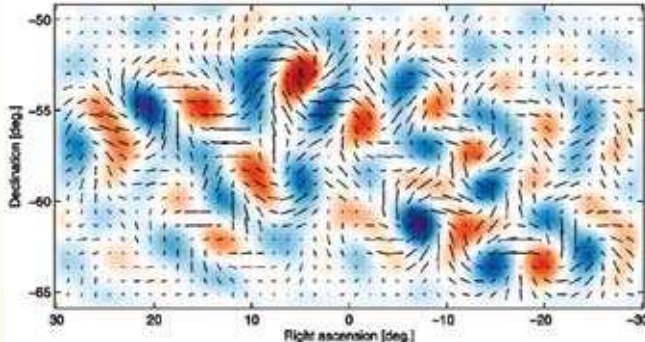
The BICEP2 scientists emphasised that they were eager to see other experiments confirm their results, and that a faster and more powerful version of the telescope called BICEP 3 now being built will allow them to probe even further the polarisation pattern to learn more about inflation.

Indus Valley Civilisation collapsed due to Climate change

The Indus Valley Civilisation or the Harappan Civilisation was a Bronze Age civilisation and the first urban civilisation in the world that flourished in the vast plains created by the River Indus and its tributaries in north-western part of the Indian subcontinent. The Indus Valley Civilisation thrived from around 2600 BC to 1900 BC. With an estimated population of over five million, this civilisation had well-developed cities, sewerage system, metallurgy techniques, trade system, many other mathematical and scientific achievements, and a script that has never been deciphered.

Till recently, it was not known for certain what caused such a flourishing civilisation to suddenly disappear, sometime between 1800 BC and 1700 BC. One theory was that Aryan invasion from the northwest was responsible for the decline, but there was no concrete evidence of such a happening. Now scientists and archaeologists seem to have unearthed the real reason: climate change. Research carried out by scientists of the University of Cambridge and Banaras Hindu

University, reveals that a series of droughts lasting some 200 years hit the Indus Valley region and was probably responsible for the rapid decline of the great civilisation. The research shows that an abrupt weakening of the summer monsoon affected northwest India 4,100 years ago, leading to the formation of a desert-like condition (*Geology* 25 February 2014 | doi: 10.1130/G35236.1).



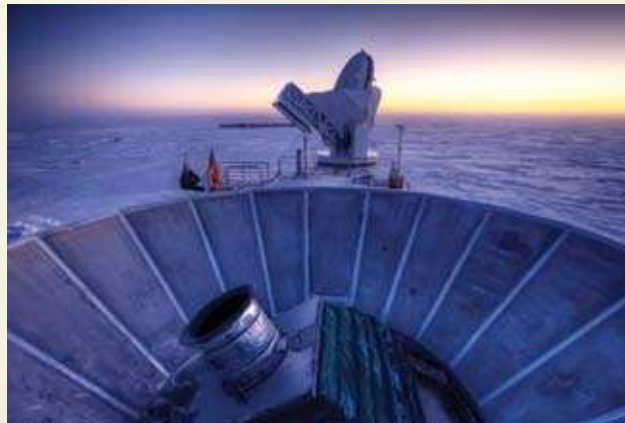
The swirling pattern in the polarisation of the CMB caused by gravitational waves and detected by the BICEP2 telescope

microwave background radiation (CMB) and the abundance of helium in the universe indeed support the Big Bang theory. But till recently there was no evidence available of what happened in the first few fractions of a second after the Big Bang. Cosmologists believe that when the universe was very young – a mere 10^{-35} s after the Big Bang – it underwent a period of extremely rapid expansion, known as “inflation”, when its volume increased by a factor of up to 10^{80} in a tiny fraction of a second. About 380,000 years after the Big Bang, the CMB – the thermal remnant of the Big Bang – came into being. Over the years, the CMB has been measured with great accuracy.

According to cosmologists, the rapid inflation soon after the Big Bang would have produced powerful gravitational waves that would have expanded right across the universe at that time. While moving across the still-young universe the gravitational waves would have left its imprint in the form of polarisation of the CMB. Evidence of such polarisation of CMB has recently been announced by a team of researchers led by John Kovac of the Harvard-Smithsonian Center for Astrophysics, Cambridge,

sprung into existence from a tiny spot in the universe 13.8 billion years ago.

Significantly, the discovery of gravitational waves from the Big Bang comes half-a-century after two Bell Labs scientists



The BICEP2 telescope (foreground) at the South Pole

Arno Penzias and Robert Wilson used a horn-shaped antenna to make measurements of the microwave background radiation in 1964. They detected a noisy background signal in their data, and despite efforts to get rid of it, it remained. Eventually, they realised it was not due to faulty equipment, but was actually the faint afterglow of the Big Bang – the cosmic microwave background radiation. For the discovery, the two shared



The ruins of the ancient city of Harappa, now in Pakistan, one of the major centres of Indus Valley Civilisation that disappeared probably because of climate change



Freshwater snail Melanoides tuberculata

The researchers came to this conclusion after studying shells of the tiny freshwater snail *Melanoides tuberculata* preserved in the sediments of an ancient lake called Kotla Dahar in Haryana. When they analysed the ratio of the rare oxygen-18 isotope to the more prevalent oxygen-16 in the calcium carbonate (CaCO_3) present in the shells, they were able to tell how much rain fell in the lake where the snails lived thousands of years ago.

Kotla Dahar is a closed basin, filled only by rain and runoff and has no outlets. Thus rainfall and evaporation alone determine its water volume. During drought, oxygen-16, which is lighter than oxygen-18, evaporates faster, so that the remaining water in the lake and, consequently, the snails' shells, become enriched with oxygen-18. Analysis of the team's data showed a spike in the relative amount of oxygen-18 between 4,200 and 4,000 years ago, suggesting that rainfall dramatically decreased during that time. Moreover, their data suggest that the regular summer monsoons stopped for some 200 years.

At around the same time, archaeologists have found evidence, of previously maintained streets starting to fill with rubbish, a gradual reduction in sophistication in the crafts they used, disappearance of the script that had been used for several centuries, and of changes in the location of settlements, suggesting some degree of demographic shift. The Indus Valley 'megacities' – some with populations of up to 100,000 – rapidly declined. Populations shrank and the old urban civilisation, which had lasted almost 700 years, collapsed.

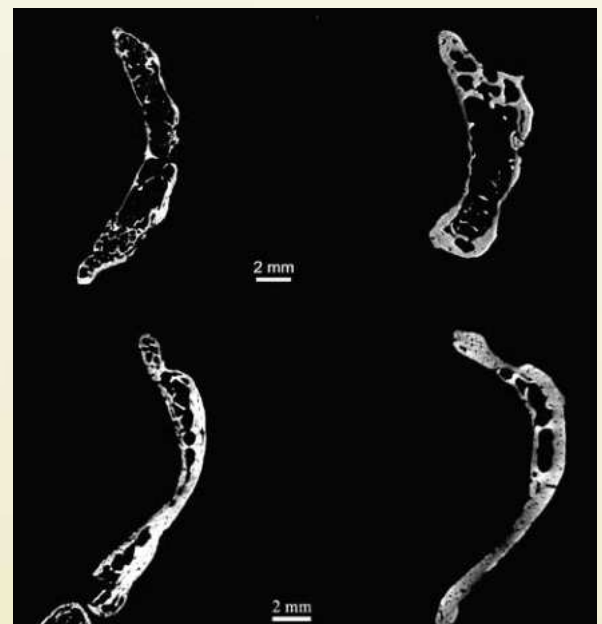
Neanderthals could speak like humans

Neanderthals (*Homo sapiens neanderthalensis*) are an extinct species of human ancestor that was widely distributed in ice-age Europe between 120,000 and 35,000 years ago. They were our closest extinct human relative. Neanderthals made and used a diverse set of sophisticated tools, controlled fire, lived in shelters, made and wore clothing, were skilled hunters of large animals and also ate plant foods, and occasionally made symbolic or ornamental objects. There is evidence that Neanderthals deliberately buried their dead and occasionally even marked their graves with offerings, such as flowers. No other primates and

no earlier human ancestor had ever practised such sophisticated and symbolic behaviour.

It is usually assumed that the way we humans speak is a recent phenomenon, coinciding with the emergence of modern humans (*Homo sapiens sapiens*), and that the Neanderthals could not speak like we do and communicated only through grunts and other sounds. It was believed that other pre-human ancestors, including the Neanderthals with whom our ancestors shared Earth for thousands of years, simply lacked the necessary vocal structure for speech. But recent research by an international team shows that the Neanderthals may well have spoken in languages not much different from the ones we use today.

The researchers arrived at this conclusion after finding a highly specialised bone in Neanderthals that is also found in humans and enables them to speak. According to the researchers, the horseshoe-shaped bone in the throat, called the hyoid, supports the very base of the tongue and is critical for speech. Higher primates like apes do not have the bone, which is why they cannot speak. The research team worked with a fossilised Neanderthal throat bone found in Kebara Cave, Israel, creating a 3-D model on computer that they then manipulated to see how it might have worked and found that it worked just like the throat bone of the modern human does (*PLoS ONE*, 18 December 2013 |doi: 10.1371/journal.



Different views of the hyoid bone of humans (top) and Neanderthals (bottom)

pone.0082261).

By analysing the mechanical behaviour of the fossilised Neanderthal bone with micro x-ray imaging, the researchers were able to build models of the Neanderthal hyoid that included the intricate internal structure of the bone. When compared to models of modern humans it was found that in terms of mechanical behaviour, the Neanderthal hyoid was basically indistinguishable from that of modern humans, strongly suggesting that this key part of the vocal tract was used in the same way for articulated speech by our distant cousins.

Sea anemone is half animal, half plant

Sea anemones are a group of water-dwelling, predatory animals classified in the phylum Cnidaria. The polyps stick to the sea floor with an adhesive foot called a basal disk and have a column-shaped body ending in an 'oral disk'. Most measure 1.5 cm to 3 cm in diameter, but some measuring up to two metres have been found. They can have up to a few hundred tentacles. With their bright colours and daisy-like shape, sea anemones look like flowers of the sea. However, in reality they are predatory animals and use their stinging tentacles to catch their prey. Recent research shows that genetically they actually are half animal and half plant, as they show a 'genomic landscape' that is similar to the human genome, but also displays mechanisms similar to those used by plants.

In the last few decades, the sequencing of the human and many animal genomes have shown that anatomically simple organisms such as sea anemones possess a surprisingly complex gene collection like higher organisms. This means that the difference in structural complexity between sea anemones and higher animals cannot be easily explained by the presence or absence of individual genes. Some researchers had hypothesised that it is not the individual genes that code for more complex body plans, but it is how they are wired and linked between each other that decides their structures. Accordingly, researchers expected that these gene networks are less complex in simple organisms than in humans or "higher" animals.

Study of the sea anemone genome has shown that it displays a complexity of regulatory elements similar to that of fruit



Sea anemones look like flowers, but are actually predatory animals

flies or other animal systems, suggesting that this principle of gene regulation is very old, dating back to 600 million years. At the same time, a recent study by a team of scientists led by Ulrich Technau of the University of Vienna, Austria, of the regulation of gene expression by short regulatory RNAs called microRNAs, has shown that sea anemones are more similar to plants rather than to vertebrates or insects (*Genome Research*, 18 March 2014 | doi:10.1101/gr.162503.113 and doi: 10.1101/gr.162529.113).

MicroRNAs are short regulatory RNAs, which can bind to target RNAs and inhibit their translation or lead to dissociation of the target RNA. In the last few years, hundreds of microRNAs have been identified in many animals and more than 1,000 microRNAs in humans. Many of these play an important role in metabolism

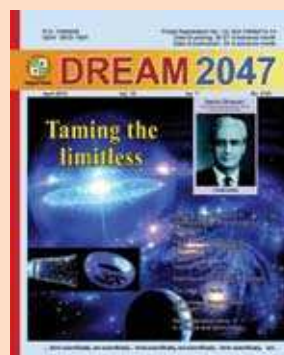
and are crucial in developmental processes. Mutations in distinct microRNAs are known to be associated with severe diseases such as cancer.

MicroRNAs have also discovered in plants, but probably they arose independently from animal microRNAs because they do not show any sequence similarity to them. Plant microRNAs have a different pathway of biogenesis (production of living organisms from other living organisms) and have a different mode of action. In the recent study, the researchers were able to show that the microRNAs of the sea anemone depict all the hallmarks of plant microRNAs. According to the researchers, since the sea anemone genome displays the regulatory behaviour of both animals and plants, this clearly shows that the sea anemone is genetically half animal, half plant.

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 50,000 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



Science Radio Serial for Varli tribes



(Left to right) Shri Jayesh Pandya, Programme Executive, All India Radio, Shri Kapil Tripathi, Scientist-E VP, Dr. T.V. Venkateswaran Academic Head, VP, interacting with participants

As part of the ongoing activity of Vigyan Prasas in popularising science using the medium of radio, a meeting was organised at Daman (UT) jointly with All India Radio, Daman (UT) on 4 March 2014 to deliberate and brainstorm on the possible themes and topics to be taken up for a proposed radio serial in Varli, the local tribal language spoken in Daman (UT), Maharashtra, and Gujarat. The basic economic activity of the region is agriculture, involving about 60% of the working population. Local population is also involved in forestry and their agricultural practices promote its conservation. This tribal group is famous for their Varli art, and superstition is deeply rooted in their cultural activities.

Eleven experts including writers, teachers, professors, and social activists belonging to the Varli tribe attended the meeting. They included Professor Kalpesh Patel; Retired Professor Shri Gajubhai Patel; Retired Teacher Shri Naginbhai Vadu; Professor V.G. Chaudhari; Dr J.T. Chaduhari; Shri Gaju Patel; Shri Jayesh Pandya, Programme Executive, All India Radio; Shri Saraswati Patel; Shri P.C Kataria; Dr T.V. Venkateswaran, Academic Head, Vigyan Prasas; and Shri Kapil Tripathi, Scientist-E, Vigyan Prasas.

Input was gathered from all the participants about the local issues and 13 topics related to agriculture, health and hygiene, science behind Varli paintings, superstitions, environment and forest medicinal plants, etc., were identified and assigned to the writers for developing scripts.

The serial would attempt to explain natural phenomena, demystify natural occurrences and superstitions prevailing in the community and discuss of the rich practical knowledge garnered by the community in form of medicinal plants and grass-root technologies and techniques and so on. This proposed serial will be produced and broadcast by All India Radio, Daman.

Letters to editor

Forgetting SN Bose

I have read the article on elementary particles by Dr. Vinay Kamble in January 2014 issue of Dream 2047. It was painful that this excellently written article failed to mention the monumental contribution of Prof. SN Bose, who also developed the famous Bose-Einstein equation. The basic concept of this group of particles developed from work of Prof. Bose and they are collectively called bosons as recognition of his contribution. I feel adequate credit must be given to work of Indian scientists in articles published in this journal which reaches such a large number of future scientists of our country.

Prof. B.N. Dhawan
Ex-Director
Central Drug Research Institute
3, Ram Krishna Marg, Faizabad Road, Lucknow - 226 007-01.

Interview with Bharat Ratna CNR Rao

The questions asked by Meher Wan as well as the replies of Prof. Rao on decline of Indian universities, lack of scientific temper in the country and media, and finally the definition of time, etc., (Dream 2047, March 2014) were brilliant!

Vigyan Prasas should publish such interviews in every issue.

PP Sharma
Executive Director
Railway Board, Ministry of Railways
Rail Bhawan, New Delhi.

Informative medical articles

I am Dr. Tavleen Kaur, intern at the Government Medical College, Amritsar. I am a regular reader of Dream 2047 and especially like the articles by Dr. Yatish Agarwal. I want to congratulate you for publishing such awesome articles, as they help many common people understand some uncommon medical problems. Kindly keep updating us about more common diseases.

Tavleen kaur
Intern
Government Medical College, Amritsar.

Excellent Article

I received a copy of July, 2013 issue of DREAM 2047. In this issue, Editorial Column; Some Important Facets of Science Communication and Surgical Options for Benign Prostate Enlargement by Dr. Agarwal are excellent articles. Thanks to the author.

Nishant Gaurav
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