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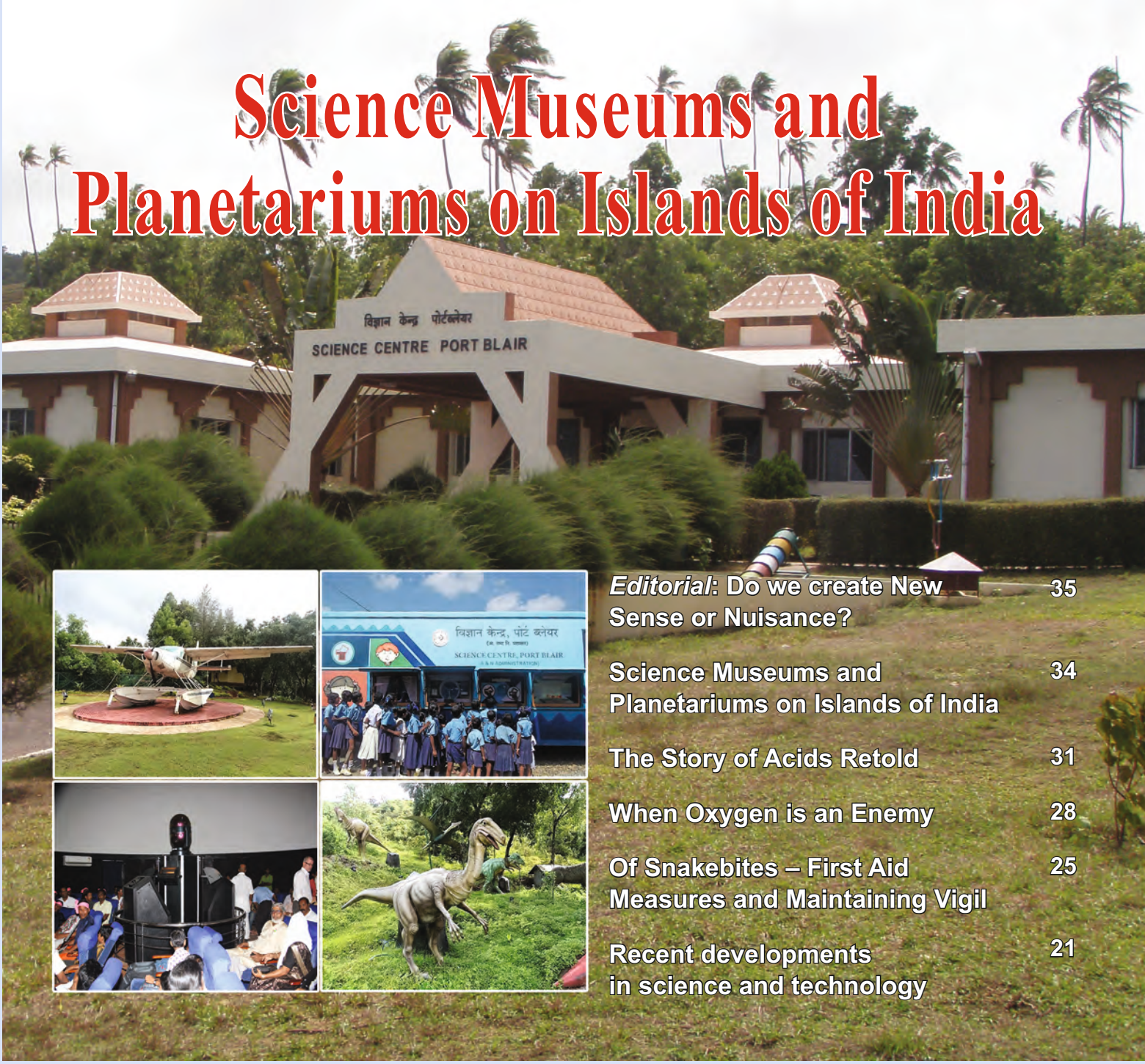

Science Museums and Planetariums on Islands of India

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

EDITORIAL

Do we create New Sense or Nuisance?

Dr. R. Gopichandran

Science communication is about clarity of content and purpose. The overarching guiding principle is commitment to the agenda of truth and not to shroud one's own agenda in the garb of sounding scientific. This commitment should translate into a clear statement of one's own limits and limitations of the spread and depth of content and its interpretation and the objective of communication. It is therefore important for communicators to ask themselves if they can create a new sense of confidence/engagement based on credibility or nuisance through self-perpetuation and antiquated self-assertions.

Some of the most important indicators of robust and inclusive communication will be:

1 An increase in the levels of awareness about the
   - a Cause-and-effect relationship centred on the concerned issue/ topic including qualitative and quantitative attributes;
   - b Means of further enhancing knowledge and use of tools to consolidate understanding
   - c Options and pathways to implement learning;
   - d Enrich collective learning through an understanding of each other's strengths;

2. Ability to judge the purpose of communication;
3. Experience inclusiveness by voicing insights and being heard;
4. Hand held to exert rights.

These are clearly about the perspective of stakeholders being communicated with.

Communicators on the other hand should look for the following indicators from their own perspective and demonstrate value of truth and inclusiveness in communication. These include:

Clarity of purpose: not negatively disruptively, understanding of strengths of stakeholders and eagerness to understand issues/topics of deliberation in a holistic manner;

5. Unbiased/not judgmental about preparedness of stakeholders and their value systems;
6. Knowledge enrichment inputs especially about open-endedness of science;
7. A perceptible enhancement of esteem of stakeholders.

We should salute the school we have been through as kids; hearts filled with innocence and joy; mind not cluttered with presumptions and arrogance that stems from half-baked ideas. Many of our teachers taught us the importance of knowing and practising such values as humility, truth and brotherhood amongst fellow citizens. Such teachers also practised these values themselves. I take this opportunity to salute such teachers. Many others outside the school are/were leading examples of such values. Is it not important to acknowledge the inclusiveness they exhibit? They inspire and do not thrust their ideas on our heads. They help us understand and do not distort our thinking. I invite you to correlate the eight aspects I have stated, with your own experiences and ask if we really see a scientific outlook in ourselves as communicators? To my mind these are essential rudiments of credible processes of science communication. It is not about judging or pre-judging scientific temper in others without even understanding the circumstances people live/grew/grow in. It is certainly not about the numbers of people that turn out to look at phenomena in nature or the awe they appear to exhibit.

Most importantly, science communicators have to evolve as a fraternity that respects diversity of thought. Harmony that acknowledges richness is more important than being homogenous. Communicators can be emphatic and not arrogant. Communicators should be seen as credible in all walks of life; actually, practise human values of compassion and assist others to derive insights based on their own thought processes. Finally, it is also about a tendency to always look askance at fellow citizens. Being inquisitive and rational is totally different from being suspicious. Based on these it is important to ask if I as a communicator can enrich and create new spaces for inclusive growth or create nuisance that implodes. Did you fall asleep while reading this editorial?

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Science Museums and Planetariums on Islands of India

Jayanta Sthanapati

Lakshadweep and Andaman and Nicobar Islands are two of our most unique archipelagos and a trip to these heavenly places is something we long for. Today we'll have a look at the science and technology interpretation centres established in these islands in the new millennium.

Introduction

Literacy, culture, technology, science, politics – every single sphere has its own domain and structural network. Irrespective of where we live, we are surrounded by these developments. We have schools, colleges, libraries, offices, malls, parks, science parks, museums and what not. But what about those places which lack certain things necessary for development. What about the masses who struggle to reach the zenith and hope for better conditions in their homeland? Lakshadweep and Andaman and Nicobar Islands are two of our most unique archipelagos and a trip to these heavenly places is something we long for. Today we'll have a look at the science and technology interpretation centres established in these islands in the new millennium.

Lakshadweep, the smallest Union Territory of India, is an archipelago consisting of 36 islands, 12 atolls, 3 reefs and 5 submerged banks. The islands have a total area of 32 km. sq. Only 10 islands, namely Agatti, Amini, Androth, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti, Kiltan, and Minicoy are inhabited. Kavaratti is the Administrative Headquarters of the Union Territory. As per census of 2011, population of Lakshadweep is 64,473 and rate of literacy is 91.85%. At present there are 34 schools and 3 colleges (one each in Androth, Kadmat and Kavaratti). These colleges were established in 2005 as centres of Calicut University.

Andaman and Nicobar Islands, the largest Union Territory of India, is also an archipelago consisting of 572 islands, but only 38 of them are inhabited, Port Blair being the capital. A & N Islands cover an area of 8,250 km. sq. and has a population of 3,80,581 with a literacy of 86.63% (Census of 2011). There are 428 schools imparting education from Pre-Primary to Senior Secondary level and 7 colleges, all in Port Blair. Two of the colleges are functioning under Pondicherry University.

Both Port Blair and Kavaratti have a science museum-cum–planetarium each to spread the message of science to the local populace.

Science Centre in Port Blair

A Science Centre is a science museum where majority of exhibits are interactive that involve visitors' participation. To promote extracurricular scientific activities for students in the islands of Andaman and

Science Centre at Port Blair

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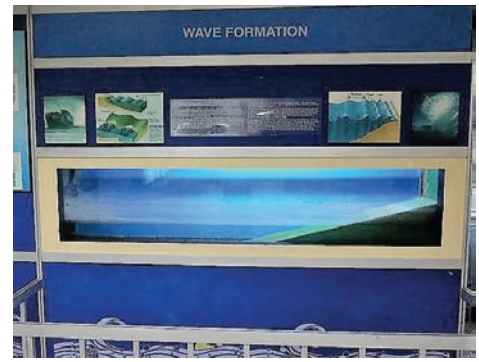
An exhibit in Fun Science Gallery at Port Blair

Nicobar, Lt. Governor of A & N Islands, Shri I.P. Gupta in the year 2000 came up with a wonderful plan of building a Science Centre in the capital Port Blair. Shri Ingit Mukherjee, DG and Dr Jayanta Sthanapati, Director National Council of Science Museums (NCSM) then visited the island and selected a 2-hectare plot in Goodwill Estate, Corbyn's Cove Road at Shadipur for setting up the science centre. With the land being decided, preparations commenced in December 2000. The project was supervised partly by Dr. Sthanapati as its First Director and then was taken up by Shri Samir K. Ray, Director CRTL of NCSM. The Port Blair Science Centre was inaugurated by Shri N.N. Jha, Lt. Governor, A & N Islands on 30 May, 2003. Shri Ingit Mukherjee, DG and Shri Samir K. Ray, Director, both from NCSM were also present on the occasion. The Science Centre has since been headed by Shri N. Mohan.

Within a floor area of 1,024 mt. sq. available, wonders of science and its branches have been strategically arranged for the visitors to enjoy. The first gallery which one comes across is titled "Fun Science", which houses exhibits like, '2D to 3D', 'Aerofoil', 'Brain generator power', 'Changing colours', 'Combination lock', 'Cone runs uphill', 'Conic sections', 'Copper plating', 'Curie point', 'Fun mirrors', 'Hand battery', 'How heavy is your brain', 'Impossible mixture', 'Infinity train', 'Infinity tunnel', 'Infinity well', 'Is light visible', 'Jumping disc', 'Lines of forces', 'Liquid painting', 'Magic tap', 'Moiré pattern', 'Planetary motion', 'Probability curve (liquid)', 'Probability curve (solid)', and many others.

The second gallery is titled "Ocean Gallery", which as the name suggests displays



An exhibit in the Ocean gallery at Port Blair

exhibits like 'Coastal research vessel', 'Coral reef', 'Deep sea mining', 'Exploring the sea', 'Flora & Fauna', 'Marine ecosystem', Ocean current', 'Ocean floor', 'Ocean thermal energy conversion', 'Our address', 'Our geological past', Quiz corner', 'Rock samples', 'The Island mosaic', 'Timber

Science Park exhibits at Port Blair

sample', 'Tourist dream', 'Volcano video', 'Wave formation', etc.

Third gallery is named "Modern Science Gallery". It has computer kiosks on 'Indian Scientists', 'Chandrayaan', 'Powers of ten', 'Greenhouse effect', 'Deep space', 'History of bio-technology', 'Large-scale structure of the Universe', 'Space science: the Indian achievement', 'Geo-synchronous satellite', 'Polar Sun-synchronous satellite', and 'Nuclear science'.

An essential part of any Science Centre is its Science Park, which carries a different charm for everyone. Hands-on exhibits, interactive displays are so much fun when indulged in. To amaze the visitors, exhibits puts up here have been segregated into two sections. One consists the interactive exhibits like: 'A swing is a pendulum', 'Amusing see-saw', 'Archimedes screw', 'Bird in a cage', 'Check your weight', 'Cone runs uphill', 'Echo game', 'Elliptical speaking tube', 'Hole in the palm', 'Inclined planes', 'Lever reduces effort', 'Lift yourself', 'Musical tubes', 'Nipkov's disc', and many others

The other section of the science park is about the prehistoric era of creatures with models and exhibits which include the Archaeopteryx (bird-like dinosaur), Brachiosaurus (arm lizard), Corythosaurus (helmet lizard), Oviraptor (egg robber),

Prehistoric Life Park at Port Blair

Table 1. Islands, Population and Literacy

Union Territory	No. of Islands	Inhabited Islands	Population	Literacy
Andaman & Nicobar Islands	572	38	3,80,581	86.63 %
Lakshadweep	36	10	64,473	91.85%

Table 2. Schools, Colleges, Science Museums and Planetariums

Union Territory	Schools	Colleges	Science Museums	Planetariums
Andaman & Nicobar Islands	428	7	1	1
Lakshadweep	34	3	1	1

Mobile Science Exhibition unit of the Science Centre, Port Blair

Diatryma (giant flightless bird), Dimetrodon Grandis, Gallimimus (rooster mimic), *Giant Squid,* Glyptodon (carved tooth), Irish Elk, *Land Scorpion,* Lemur, Meganeura, Moeritherium, Neanderthal Man, and a few others.

A Mobile Science Exhibition (MSE) bus with 24 exhibits on the theme of 'Popular Science' has been added to the science centre in 2010. Like other exhibits of the centre, the MSE was also developed by NCSM. The unit has been holding exhibitions in schools of many of the accessible islands since then.

The science centre has a 3D theatre for screening interesting scientific films for visitors. They also can watch shows in an inflatable dome planetarium, called 'Taramandal'. Further, the centre regularly stages Science Demonstration Lectures and Science Shows for its visitors.

In the capital where the population is a little over 1 lakh, the Port Blair Science Centre enjoys a visit of 60,000 to 70,000 every year on an average. The credit goes to the fabulously designed exhibits and more importantly, its maintenance done by the centre under A & N Administration, who incurs an expenditure of around 80 lakhs a year.

Seaplane at the Science Centre, Port Blair

Science Museum and Planetarium in Kavaratti

The project of establishing a science museum and a planetarium in Kavaratti was conceptualised and initiated by the Dept. of Science & Technology (DST), Kavaratti under Lakshadweep Administration in 2002. Going along the planning, Prof. K.K. George of Directorate of Technical Education, Thiruvananthapuram and Shri A. Salim of College of Engineering, Thiruvananthapuram drew up the architecture of the museum-cum-planetarium building. The Kavaratti Science Centre was inaugurated on 26 January, 2011 by Shri J.K. Dadoo, Hon'ble Administrator, U.T. of Lakshadweep and in presence of

An exhibit on appropriate technology at Kavaratti Museum

several VIPs. This Centre was established by the DST, UT of Lakshadweep with catalytic support from Kerala State Science & Technology Museum and Priyadarshini Planetarium, Thiruvananthapuram, at an expenditure of approximately Rs.8.5 crore.

The Museum-cum-Planetarium has a total of built up area of 1,000 sq. metres. The planetarium dome's inner diameter is 10 metres with a seating capacity of 61 people. The shows are projected through a digital projection system. It can project around two million stars to form the mock up universe inside the dome. Some of the interesting shows of the planetarium are titled as 'Planets', 'Black Hole', 'Infinity Express', 'Stars', 'Dawn of the Space Age', etc. Every year around 850 shows are presented for the visitors in English and Malayalam.

A big advantage of Kavaratti is that it

Inner view of Kavaratti Planetarium

is free from air and light pollution and so the island offers a clear view of the night sky. The museum, therefore, organises sky observation programs regularly, with the help of its eight-inch Celestron telescope. The telescope also enables the visitors to watch some of the natural wonders such as solar eclipse and occasional events like asteroid collision. In addition, the two-storey building has a theatre for showing interesting scientific films in 3D.

A unique feature of the Science Museum at Kavaratti is its gallery on "Appropriate Technologies". The exhibits on this theme include 'Appropriate housing technology for Island environment', 'Biogas plant', 'Coconut processing technologies', 'Rainwater harvesting', 'Beach cleaning', 'Desalination', etc.. There are exhibits on Environment too, namely 'Global warming', 'Sea erosion', 'Photosynthesis', 'Water cycle', 'Coral reefs', and so on. Lastly, fun component is added in the museum by installation of ten interactive exhibits on Popular Science such as 'Colour mixing', 'Curie point', 'Double-cone roll up the hill', 'Double harmonic pendulum', etc.

The centre's first Project Director was Dr. Sayeed Ismail Koya, Director, DST and Coordinator was Shri P. Pookoya, Asst. Director, of the same department. The present Director is Dr. Pranjal J. Hazarika and Officer-in-charge is Shri P. Pookoya.

Acknowledgement

The author is thankful to Shri N. Mohan, Curator, Science Centre, Port Blair and Shri P. Poonkoya, Officer-in-charge, Science & Technology Museum and Planetarium, Kavaratti for providing valuable information and photographs on respective centres.

The Story of Acids Retold

Dr. C.P. Reghunadhan Nair

All sour fruits contain various carboxylic acids in differing proportions. On ripening, in majority of cases, the sucrose orglucose produced subdues the sour taste and we feel mainly the sweet taste. Typical examples are ripened mangoes that contain gallic acid as the acidic component. Organic acids are of great significance in plants. As intermediates in the metabolic processes of the fruit, these acids are directly involved in growth, maturation, and senescence.

There is hardly anybody among us who has not enjoyed the sour taste of raw mangoes and raw tamarind. Particularly the older generation would definitely remember having plucked these fruits on the way to school and enjoyed their peculiar taste. But how many of you knew that you were chewing and swallowing ACIDS!. Don't get terrified by the terminology acids! What we are normally familiar with are the mineral acids like sulphuric, hydrochloric, nitric acid, etc., which are very strong acids. When compared to these, the so-called acids found in fruits are extremely mild organic acids. Apart from these acids (contained in these fruits), we are also familiar with vinegar (acetic acid, additive in curries), citric acid (artificial lemon juice), formic acid used (as rubber latex coagulant), lactic acid (in curd), etc.

The strength of an acid is measured by the ease with which it liberates an H^+ ion. The unit commonly used is designated as pH, which ranges from 1 to 14. A pH value below 7 indicates an acid while values above 7 denote alkaline.

Mineral acids show a pH value to the tune of 2 or less, while the organic acids show values in the range 4-5. This scale, however, is not a linear scale like a centimetre scale (in which two adjacent values have the same difference). It is a logarithmic scale in which two adjacent values increase or decrease by a factor of 10. Thus an acid with a pH value of 2 is 1,000 times stronger than the one with a pH value of 5.

All sour fruits contain various carboxylic acids in differing proportions. On ripening, in majority of cases, the sucrose or glucose produced subdues the sour taste and we feel mainly the sweet taste. Typical examples are ripened mangoes that contain gallic acid as the acidic component. Organic acids are of great significance in plants. As intermediates in the metabolic processes of the fruit, these acids are directly involved in growth, maturation, and senescence.

Some of the major acids in fruits include citric, malic, and tartaric acids. Organic acids also influence the growth of microorganisms in fruit juices and therefore affect the keeping quality of the product. At proper levels, certain acids are inhibitory to most bacteria. Another aspect of organic acids is their influence on the sensory properties of juice products. Acids are responsible for the fresh, tart taste of fresh fruits and their processed products. Colour is also influenced by the type and level of acids present in the product.

Apart from these, all these acids have important physiological role as well. Let us examine some of these:

Citric acid

Citric acid is the source of sourness and acidity of a lemon. However, it's not the only acid found in fruits, or even in lemons. In fact, there is a whole range of different acids, present in different fruits in varying amounts. Citric acid is well known for being present in lemons and limes, which contain the highest amounts of it. It is also present in other citrus fruits. Perhaps less well known is that it is

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also the principal acid in many berries, including strawberries, raspberries, and gooseberries (to name a few). Citric acid lends a relatively sharp acidity, and is often used independently as a flavouring agent in foods and drinks. Additionally, it can be used in some scale removal and cleaning products, as well as in pharmaceuticals and cosmetics to help adjust their acidity. More broadly, it's also found in most living organisms, including human beings, as salts of citric acid are part of the citric acid cycle (also called the Krebs cycle), which occurs in all living cells.

Malic acid

The other organic acid found in a large number of fruits is malic acid. Apples are probably the fruit in which its presence is best known. It also crops up in fruits with stones, such as cherries, apricots, and peaches. Watermelon's acidity is relatively low compared to other fruits, but its principal acid is also malic acid. Wines, too, contain a fair amount of this compound. Like citric acid, salts of malic acid are found in the cells of most living things as well, as they are involved in some cellular reactions.

Tartaric acid

Tartaric acid is found in comparatively fewer fruits than citric and malic acids, primarily occurring in grapes along with malic acid. It's also found in avocados, and in the tamarind fruit, as the principal acid.

Like malic acid, tartaric acid is sometimes used in sour sweets. Most of us are familiar with it, however, from its presence in tamarind, used profusely in south Indian curries. Tartaric acid contributes to the tartness of the wine, along with malic acid.

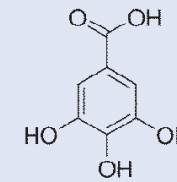
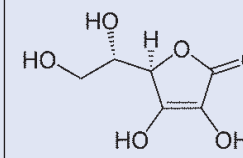
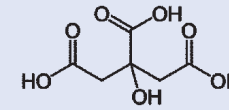
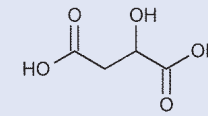
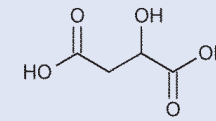
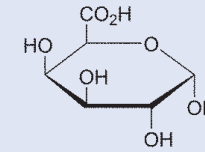
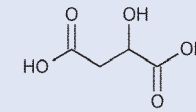
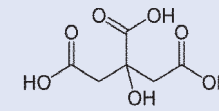
Oxalic Acid

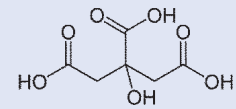
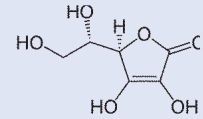
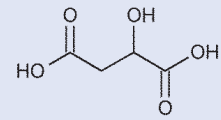
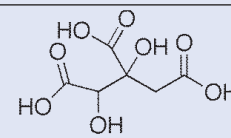
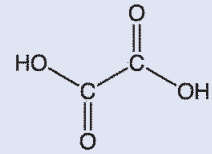
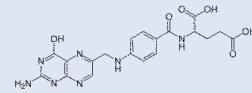
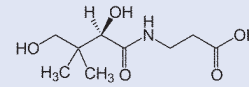
Oxalic acid, or oxalate, is primarily found in leafy green vegetables, rhubarb and beets. Research on whether people who have calcium oxalate kidney stones should avoid these high-oxalate foods is inconclusive. Oxalic acid is found in low amounts in a number of berries, and in tomatoes.

Lactic Acid

Many dairy products use bacterial fermentation to achieve distinct characteristics and flavour. Lactic acid is a product of this fermentation, and it can be found in yogurt, cottage cheese, buttermilk and sour cream. Consuming lactic

Table 1. Fruits, acids and their structures

Fruit	Major carboxylic acids present others	Structure of major acid component
Mango 	Gallic acid (major)	
	Ascorbic acid Citric acid Ketoglutaric acid Malic acid Caffeic acid Tartaric acid Oxalic acid	
Orange 	Ascorbic acid(major)	
	Folic acid Citric acid Malic acid Pantothenic acid Hydroxy-cinnamic acid Oxalic acid	
Lemon 	Citric acid (major)	
	Malic acid Ascorbic acid	
Apple 	Malic acid (major)	
	Citric acid Tartaric acids	
Guava 	Malic acid (major)	
	Galactouronic acid	
	Ascorbic acid Citric acid Lactic acid	
Grapes 	Malic acid (major)	
	Citric acid, Tartaric acid	

Tomato 	Citric acid (major) Malic acids Oxalic acids Ascorbic acids	
Gooseberry 	Ascorbic acid (major) Citric acid	
Cherry 	Malic acid (major)	
Apricot 		
Peach 		
Watermelon 		
Kudampuly 	Hydroxyl citric acid (major)	
Irumpanpuly 	Oxalic acid (major) Malic acid	
Asparagus 	Folic acid (major)	
Avocados 	Pantothenic acid (major)	

acid can aid in the digestion of lactose, or milk sugar; prevent and treat diarrhoea; and help fight infection.

Ascorbic Acid

Ascorbic acid, otherwise known as vitamin C, can be found in a variety of fruits and vegetables. Our body needs vitamin C to grow and repair tissues, heal wounds and maintain the strength of bones and teeth. Persistent lack of vitamin C in our diet can lead to a condition called scurvy. Symptoms of scurvy include easy bruising, easy bleeding and joint and muscle pains. Sources of ascorbic acid include citrus fruits, berries, leafy green vegetables, tomatoes and green peppers. Gooseberry contains about one per cent vitamin C.

Folic acid

Folic acid is a man-made supplement, while folate occurs naturally in some citrus fruits. Orange, etc., contain good amount of folic acid. It is available in plenty in green leaves Asparagus is a rich source of folic acid. Folate is part of the vitamin B complex, and is a particularly important part of the diet for pregnant women. Folate is said to prevent serious birth defects of the neural tube, which forms very early in pregnancy. It helps generate the red blood cells and thus the cell growth. Further, it can prevent stroke related problems.

Pantothenic acid

This acid also known as vitamin B5 is available in avocados. Mushroom is another rich source of it. Pantothenic acid is an essential nutrient. Animals require pantothenic acid to synthesise coenzyme-A, as well as to synthesise and metabolise proteins, carbohydrates, and fats.

Galacturonic acid

This acid present in guava fruit is capable of healing the natural damages of blood vessels. It is believed to prevent ulcerative colitis. Table 1 compiles the different acids present in various fruits and their chemical structures.

Tamarind contains tartaric acid. Eating too much tamarind causes acid levels in stomach to increase beyond the limits. This can lead to hyperacidity and eventually to ulcer. Kudampuli, also known as Malabar tamarind contains mainly hydroxyl-citric acid. Though acidic, it is highly reducing type and can act as an antioxidant in the body. Thus kudampuli is capable of slowing down the oxidative ageing process in human beings. ■

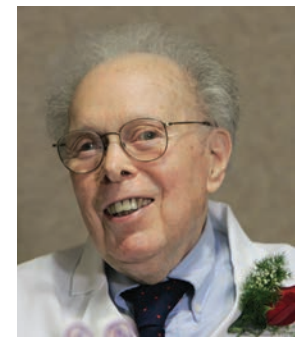
When Oxygen is an Enemy

Dr. Chaganty Krishnakumari

Oxygen is used in our body to oxidise food in the process of cellular respiration thus releasing energy. However, oxygen may be potent and dangerous gas and in some forms it is harmful to life.

The gas that makes up 21% of our atmosphere is diatomic oxygen (O_2), more widely known simply as 'oxygen'. It plays a vital role in the breathing process and in the metabolism of living organisms. Probably, the only living cells that do not need oxygen are some anaerobic bacteria that obtain energy from other metabolic processes. Oxygen is used in our body to oxidise food in the process of cellular respiration thus releasing energy. Complex carbohydrates and fatty acids are gradually broken down into simpler carbohydrates, and then oxidised in our cells, producing energy, carbon dioxide, and water. It is basically a highly controlled process of burning our food that gives us the energy we need to live. Oxygen is part of the water molecule. Cells are about 70-90% water by mass, and therefore without water and its ability to form hydrogen bonds, life would likely not be possible at all.

Besides being life-giving, oxygen is also a potent and dangerous gas. In many forms it is harmful to life. According to the atmospheric chemist James Lovelock, if the oxygen content of the atmosphere were a little higher, say 25%, the Earth would be consumed in an enormous uncontrollable forest fire. Rusting, the oxidation of iron by air is a graphic demonstration of what oxygen does to iron. This reaction is not good for structures made of iron.



Denham Harman

Enzymatic browning of apples.& prevention by antioxidant

Our skin does not rust in air like iron. Living systems are protected against oxidation so long as they are alive. But our foodstuffs are vulnerable to oxidation. The cells of apples, pears, bananas, peaches, potatoes, etc., contain an enzyme called polyphenol oxidase (PPO) or tyrosinase that, when exposed to oxygen, catalyses one step of the biochemical conversion of plant phenolic compounds to brown pigments. This reaction is known as enzymatic browning of fruit and vegetable products; it occurs at warm temperatures when the pH of the plant material is between 5.0 and 7.0. This browning can be prevented by applying a few drops of lemon juice on the cut surface of the fruits. This is a simple demonstration of the principle of anti-oxidation. Lemon juice contains vitamin

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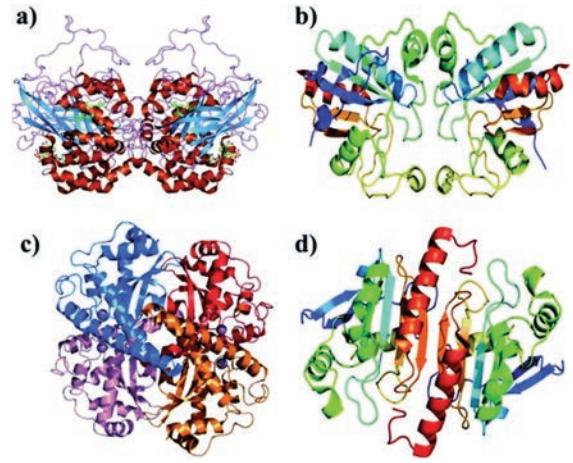
C, a powerful antioxidant.

Rancidity is a term generally used to denote unpleasant odours and flavours in foods resulting from deterioration in the fat or oil content of a food. In fats and oils, oxidation is the prime cause of rancidity. All edible fats and oils will become rancid given enough exposure to air, sunlight and heat. Oxidation of unsaturated fats results in the formation of peroxides. Oxidative rancidity arises from the decomposition of peroxides. The products resulting from the decomposition of peroxides include aldehydes, ketones, and hydrocarbons. Flavours and odours associated with oxidative rancidity are due to these decomposition products. Rancid fats are certainly unpleasant to eat. Consumption of rancid oil can expose us to accelerated aging, raised cholesterol levels, obesity and weight gain. Daily consumption increases the risk of degenerating diseases such as cancer, diabetes, Alzheimer's disease, and atherosclerosis, a condition in which artery walls thicken due to a build-up of fatty materials. Antioxidants are used to keep fats free from rancidity for a reasonable period of time.

Free radicals

Gerontologist Denham Harman was the first to discover the concept of free radicals in 1954, while researching an explanation for aging. Free radicals are a type of a highly reactive atom or group of atoms with at least one unpaired electron that is naturally produced by our body as a result of normal metabolism and energy production. They are our natural biological response to environmental toxins like cigarette smoke, sunlight, chemicals, cosmic and manmade radiation. Our body also produces free radicals when we exercise and when we have inflammation anywhere in our body

Free radicals are formed when oxygen interacts with certain molecules. In our body, oxygen reacts with many other biochemicals to form reactive oxygen species (ROS) and reactive nitrogen species (RNS). ROS is a type of unstable molecule containing oxygen. These species are free radicals and are also known as oxygen radicals. Molecules with oxygen radicals are very unstable and react quickly with other molecules, trying to capture the needed electron to gain stability. Generally, free



(a) CAT, (b) GSHPx, (c) SOD, and Prx-I.

radicals attack the nearest stable molecule, "stealing" its electron. When the "attacked" molecule loses its electron, it becomes a free radical itself, beginning a chain reaction. Once the process is started, it can cascade, finally resulting in the disruption of a living cell. A build-up of reactive oxygen species in cells may cause damage to DNA, RNA, and proteins, and may cause cell death. These biological oxidation reactions are also known as "biological rusting," an effect caused by too much oxygen in our tissues.

Generation of free radicals

The generation of ROS begins with rapid uptake of oxygen, activation of the enzyme NADPH oxidase (nicotinamide adenine dinucleotide phosphate-oxidase), and the production of the superoxide anion radical. The NADPH oxidase is a membrane-bound complex, a cluster of proteins that faces the extracellular space. Cluster of proteins donate an electron from NADPH to molecular oxygen (O_2) to produce superoxide (O_2^-) free radical.

List of the ROS

Symbol	Name
$^1O_2$	Singlet oxygen
$O_2^{\cdot -}$	Superoxide anion radical
$^{\cdot}OH$	Hydroxyl radical
$RO^{\cdot}$	Alkoxyl radical
$ROO^{\cdot}$	Peroxyl radical
H_2O_2	Hydrogen peroxide
LOOH	Lipid hydroperoxide

Free radicals attack all major classes of biomolecules, mainly the polyunsaturated fatty acids (PUFA) of cell membranes. The oxidative damage of PUFA, known as lipid peroxidation is particularly destructive, because it proceeds as a self-perpetuating chain reaction. Oxidised cholesterol is introduced into our system every time we eat something cooked in vegetable oil. As soon as the oil is heated, it goes rancid. Rancid oil is oxidized oil.

Low-density lipoprotein, or LDL

This "bad" cholesterol circulates in our blood and is more prone to oxidation. According to conventional thinking, cholesterol can combine with fat, calcium, and other substances in the blood to form plaque. Plaque then slowly builds up and hardens in the arteries, causing them to narrow and become less flexible. This build-up of plaque, a condition called atherosclerosis, can lead to heart disease, heart attack, and stroke. So we fight against or find ways to prevent it.

Antioxidants

This is where antioxidants come into picture. The antioxidant compounds react in one-electron reactions with free radicals in vivo/in vitro and prevent oxidative damage**.** As electron donors, antioxidants break the free radical chain reaction by sacrificing their own electrons to feed free radicals, but without turning into free radicals themselves.

Antioxidants within the human body

Since the movement of free radicals in the body could lead to potential harm, human cells have developed multiple protection mechanisms against the damaging effects of oxidation, for instance, through the presence of antioxidants that inhibit the accumulation of free radicals, and specific enzyme systems which break down the lipid peroxides into harmless molecules, oxygen and water. Antioxidants are nature's way of providing our cells with adequate defence against attack by reactive oxygen species (ROS). Certain compounds act as *in vivo* antioxidants by raising the levels of endogenous antioxidant defences.

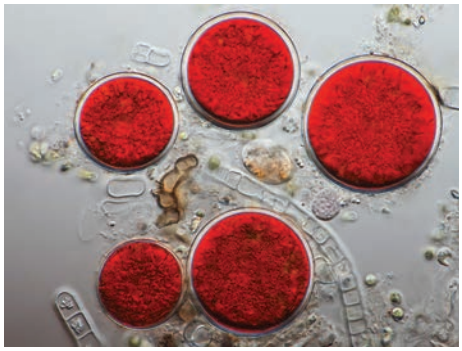


Fig 4 (a) Haematococcus pluvialis, Chlorophyta

Fig 4 (b) Astaxanthin is a deep red-colored phytonutrient synthesized by microalgae called Haematococcus Pluvialis

Expression of genes encoding the enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSHPx) increases the level of endogenous antioxidants**.** As long as we have these important micronutrients, our body will be able to resist aging and diseases caused by our everyday exposure to pollutants.

Antioxidants can be categorised in multiple ways

Based on their activity, antioxidants can be categorised as enzymatic and non-enzymatic antioxidants. Enzymatic antioxidants work by breaking down and removing free radicals. The antioxidant enzymes convert dangerous oxidative products to hydrogen peroxide (H_2O_2) and then to water, in a multi-step process in presence of cofactors such as copper, zinc, manganese, and iron. Examples of the enzymatic antioxidants are superoxide dismutase (SOD), catalase (CAT) glutathione (GSHPx) and peroxiredoxin (Prx-I)

Non-enzymatic antioxidants work by interrupting free radical chain reactions. Few examples of the non-enzymatic antioxidants are vitamin C, vitamin E, plant polyphenol, carotenoids, and glutathione.

The other way of categorising the antioxidants is based on their solubility. The antioxidants can be categorised as water-soluble and lipid-soluble antioxidants. The water-soluble antioxidants (e.g. vitamin C) are present in the cellular fluids such as cytosol, or cytoplasmic matrix, whereas the lipid-soluble antioxidants (e.g. vitamin E, carotenoids, and lipoic acid) are predominantly located in cell membranes.

The antioxidants can also be categorised according to their size, the small-molecule antioxidants and large-molecule antioxidants. The small-molecule antioxidants neutralise the ROS in a process called radical scavenging and carry them away. The main antioxidants in this category are vitamin C, vitamin E, carotenoids, and glutathione (GSH). The large-molecule antioxidants are enzymes (SOD, CAT, and GSHPx) and sacrificial proteins (albumin) that absorb ROS and prevent them from attacking other essential proteins. Glutathione is a tripeptide found in every single cell in our body. It is called the "master antioxidant" because it is intracellular and has the unique ability of maximising the performance of all the other antioxidants, vitamins C and E.

Oxidative stress

As the protective systems of our body are limited, an imbalance between reactive oxygen species and our body's capacity to neutralise and eliminate the free radicals may lead to accumulation of oxidative damage. The ROS and RNS create oxidative stress in different pathophysiological conditions. Oxidative stress is defined as an excessive production of reactive oxygenated species that cannot be counteracted by the action of antioxidants, but also as a perturbation of cell redox balance. Oxidative stress amplifies the oxidative reaction by repressing proteins included in the oxidative defense, and by depleting cellular storage of antioxidants like vitamin E and carotenoids. An overload of free radicals has been linked to certain diseases, including heart disease, liver disease and some cancers. Oxidation can be accelerated by stress, cigarette smoking, alcohol, sunlight, pollution, and other factors.

Increasing intake of natural antioxidants may help maintain a tolerable antioxidant status, perhaps the normal physiological functioning of the body. The reported chemical evidence suggests that the dietary antioxidants help in disease prevention. The antioxidant compounds react in one-electron reactions with free radicals *in vitro* and prevent the oxidative damage.

Dietary antioxidants

Natural vitamin E is a family of eight different compounds - four tocopherols and four tocotrienols. It is a fat-soluble vitamin present in nuts, seeds, vegetable and fish oils, whole grains (esp. wheat germ), fortified cereals, and apricots.

Vitamin C or ascorbic acid is a water-soluble vitamin present in citrus fruits and juices, green peppers, cabbage, spinach, broccoli, kale, cantaloupe, kiwi, and strawberries.

Carotenoids are a class of naturally-occurring pigments that have powerful antioxidant properties. They are the compounds that give foods their vibrant colours. Carotenoids can be classified into two groups:

Carotenes contain no oxygen atoms. Some examples are lycopene, found in red tomatoes and beta-carotene found in orange carrots, which is converted by our body into vitamin A.

Xanthophylls contain oxygen atoms, and examples include lutein, canthaxanthin, zeaxanthin, and astaxanthin. Zeaxanthin is the most common carotenoid that naturally exists in nature and is found in peppers, kiwi fruit, maize, grapes, squash, and oranges.

Astaxanthin is a deep red-coloured phytonutrient synthesised by microalgae called *Haematococcus pluvialis*. The algae produce astaxanthin which in turn absorbs free radicals to protect the algae from injury. These algae can survive up to 30 years without water during times of drought. Once the water reappears the algae pop back to life. Astaxanthin is effective at "singlet oxygen quenching," a particular type of oxidation caused by sunlight and various organic materials. It is considered as th 'king of carotenoids' for eyes, heart, and immune system. Astaxanthin can handle multiple free radicals simultaneously and multiple types of free radicals at any one time. Astaxanthin

Continued on page 22

Of Snakebites – First Aid Measures and Maintaining Vigil

Dr. Yatish Agarwal

Loss of human life due to snakebite can be reduced to a great extent if precious time just after the bite is not wasted over unproductive alternative treatments. Victims need to be provided with timely emergency care at a nearby medical facility. A doctor can evaluate the victim's basic condition to decide on the line of treatment.

Snake bites claim more than 50,000 human lives in India each year. Many of them can be saved, provided no time is wasted over unproductive traditional treatments and the victim receives apt and timely emergency care at a medical facility. A doctor can evaluate the victim's basic condition to decide on the line of treatment. In a large number of cases, a snake bite may not pose any danger to life. Studies estimate that some 70 per cent of all snake bites are from non-poisonous snakes, and of those bitten by poisonous snakes only 50 per cent suffer such severe poisoning that it may imperil the victim's life.

The course of treatment is based on the severity of situation. If the bite is not serious, the doctor may simply clean the wound and give the victim a tetanus vaccine. Contrarily, if the situation is life threatening, the doctor may decide to administer the anti-venom serum. The anti-venom serum is an antidote to the snake venom. It is produced through a tedious process by injecting snake venom into animals, typically horses, and harvesting antibodies that are produced by the animal's immune system. These antibodies usually peak in the animal's bloodstream in about eight to ten weeks. They are harvested through bloodletting and purified through a complex process. The cost to produce anti-venom is large, and hence, it must be put to judicious use.

If used aptly and well in time, the anti-venom serum can help save the life. In situations where it is necessary, the sooner it is given, the better are the results. A health centre or hospital stocked with anti-venom sera can handle the crisis well, provided irreversible serious complications have not set in.

Sensible First Aid Measures

Should you, a family member, neighbour or an acquaintance be bitten by a snake, it is essential to get emergency treatment at the nearest medical facility as quickly as possible. Make this doubly sure especially if the bitten area changes colour, begins to swell or is painful. While you are waiting for medical help, take care to follow these basic steps:

Calmness pays

Remain calm and move beyond the snake's striking distance. Keep the bitten person comfortable, and control his/her anxiety. Share the information that most of the snake bites are non-venomous.

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Fear, severe stress and excitement tend to increase the heart rate and blood circulation. If this happens, the venom may spread within the body much faster.

Record the time

Make a note of the time of the bite. This simple information may be most important for the doctor.

Do not hunt for the snake

Do not try to capture or kill the snake or waste time hunting it down. Instead, take a picture of the snake if you can. Or simply try to remember its colour and shape so that you can describe it well to the healthcare provider. However, if somebody does kill the snake, take it to the hospital. The doctor may use this vital information to recognise the type of snake, relate the clinical signs of the victim with it and decide upon the ideal line of treatment.

Avoid all physical activity

The person who has been bitten should ideally stay absolutely still. S/he must not be allowed to walk. If it is safe, lie down flat on the ground, taking care not to lift the bitten part above the chest. Else, the venom might well spread within the body more quickly.

S/he must be carried or transported to the nearest medical facility in a vehicle. Any physical movement or motion on the part of the victim may cause the venom to pass through more quickly within the body.

Do not wash the wound

Often, the bitten person, a family member or a bystander might think of first washing the wound in an attempt to remove the venom left on the surface. This is not such a good idea. The act of wound toilet stimulates the flow of snake venom into the circulation. Hence, it is best not done.

Remove tight clothing and jewellery

Should the victim be wearing tight clothing, shoes, rings, watch or jewellery on the part that's been bitten, try and remove them before the part swells. Due to the bite, the surrounding area is likely to swell and these objects may act like a tourniquet in that case.

Immobilise the bitten limb

Immobilise the bitten limb with a splint or sling. Use bandages or cloth to do so, taking care not to apply pressure on the limb or block its blood supply. Do not apply any compression in the form of tight ligatures, they don't work and can be dangerous. The idea behind the use of a splint is to restrict movement and muscular contraction, because that would increase the absorption of snake venom into the bloodstream and lymphatic system.

Do not tie the bitten part

Do not tie a tourniquet around the bitten part. Traditionally, people make a tight tourniquet using a rope, belt, string or cloth and tie it around the part in order to try and arrest the flow of snake venom into other parts of the body.

However, this old remedy has little to recommend it. First of all, it has been found that it serves no useful purpose. Often, it fails to block the spread of poison. Two, it gives the victim and his/her family a false sense of security, which encourages them to delay their journey to a hospital. Three, it is fraught with a number of risks and complications. If a tourniquet is tied too tightly, it can produce a total loss of blood flow in the affected part causing the part to necrose and die out. This is particularly true of the snake bites which take place in India. Worse, when the tourniquet is loosened, the sudden flooding of the system with large amounts of poison can produce severe nervous system paralysis, a sudden lowering of blood pressure, or a blood clot — the specific effect being powered by the type of venom.

Use no ice on the bite

Do not use a cold compress on the bite.

Do not attempt to remove the venom

Do not cut into the snake bite wound or attempt to remove the venom by trying to suck it out by mouth. Do not also use a pump suction device. Such devices were used in the earlier times in order to try and suck out the snake venom, but it has not been found to be useful and may do more harm than good.

Cutting into a victim's bitten part may put him/her to significant risk of severe bleeding since the venom can knock off the body's natural clotting mechanism. At the same time, the cut may expose the person to risk of infection.

No caffeine or alcohol

The victim should not drink tea, coffee, or alcohol, which could speed up the rate at which the body absorbs venom.

Traditional healers may not be a big help

There is little point in wasting time with traditional healers or quacks. They have no proven merit. Whatever benefit they provide is at the psychological platform, and that's why they may appear to be useful in non-venomous bites.

Avoid all undue medicines

Do not give the person any medications unless directed by a doctor. Folk and traditional medicines may cause undue complications and hamper in the treatment.

Rush to nearby hospital

The person who has been bitten should be taken to the nearest community health centre or hospital immediately. No time must be wasted trying any traditional remedies. They have no proven benefit in treating snakebite, and may prove perilous because of needless delay in effective treatment.

Keep a vigil while transporting the victim

While the bitten person is being transported to the nearby hospital, a tight vigil must be kept on his/her vital physical parameters. Should s/he develop any new bodily signs or symptoms, such as drooping of eyelid, make a note of it and inform the doctor immediately on reaching the hospital.

On the way, if the person begins to develop signs of shock, a health worker can try and administer all first aid at hand to keep the victim alive. Remember, the key idea should be to reach the health facility in the quickest possible time. Each moment may make a big difference to the eventual outcome. Many of the snake bite related deaths occur simply because of delay in reporting to a health facility.

Maintaining a Vigil - Symptoms and signs to watch

Scenario 1: When venom has not been injected

Some people who suspect or imagine that they have been bitten, or stand actually bitten by a snake may develop quite striking symptoms and signs despite no venom having been injected into their body.

Signs due to fear and anxiety

Since they are deeply anxious, such people may overbreathe. This may produce a pins and needles sensation in the extremities, stiffness and or tetany of their hands and feet and dizziness. Some others may develop vaso-vagal shock and suffer with faintness and collapse with profound slowing of the heart. Others may become highly agitated and irrational and may develop a wide range of misleading symptoms. Blood pressure and pulse rate may increase and there may be sweating and trembling. These symptoms and signs result purely out of fear that they have been bitten by a poisonous snake.

Signs due to incorrect first aid and traditional treatments

Wrong first aid and traditional treatments may also produce significant symptoms and signs. Constricting bands or tourniquets may cause pain, swelling and congestion that suggest local envenoming. Ingested herbal remedies may cause vomiting. Instillation of irritant plant juices into the eyes may cause conjunctivitis. Forcible blowing of oils into the respiratory tract may lead to aspiration pneumonia, bronchospasm, ruptured ear drums and pneumothorax. Incisions, cauterization, immersion in scalding liquid and heating over a fire can result in devastating injuries.

Scenario 2: When venom has been injected

Early symptoms and signs

The immediate pain in the skin and underlying tissue caused by the snake's bite, may be followed by an increasing local pain producing a burning, bursting, throbbing pain at the site of the bite, local swelling that gradually extends up the bitten limb and tender, painful enlargement of the regional lymph nodes draining the site of the bite.

However, bites by kraits, sea snakes and certain cobras may be virtually painless and may cause negligible local swelling. Someone who is sleeping may not even wake up when bitten by a krait and there may be no detectable fang marks or signs of local envenoming.

Clinical patterns of envenoming

The symptoms and signs vary in relation to the species of snake responsible for the bite and the amount of venom injected. Sometimes the identity of the biting snake can be confirmed by examining the dead snake. It may be strongly suspected from the patient's description or the circumstances of the bite or from knowledge of the clinical effects of the venom of that species.

This key information may enable the doctor to choose appropriate anti-venom, anticipate the likely complications and, therefore, take appropriate action.

If the biting species is unknown, the patient should be observed closely to allow recognition of the emerging pattern of symptoms, signs and results of laboratory tests. The clinical syndrome, together with other evidence, may suggest which species was responsible.

Local symptoms and signs in the bitten part

- Fang puncture marks
- Local pain
- Local bleeding and bruising
- Lymphangitis (raised red lines tracking up the bitten limb)
- Lymph node enlargement
- Swelling, redness, heat (inflammation)
- Blistering, local infection, abscess formation, and necrosis

Generalised symptoms and signs

General

Nausea, vomiting, malaise, abdominal pain, weakness, drowsiness, and prostration.

Circulatory symptoms

A bite by a poisonous snake of the viperidae family may produce such symptoms as visual disturbances, dizziness, faintness, collapse, shock, hypotension, heart rhythm irregularities, accumulation of water in the lungs (pulmonary oedema), and conjunctival swelling.

Bleeding and clotting disorders

A bite by a poisonous snake of the viperidae family may produce prolonged bleeding from the fang marks, venipuncture (puncture of a vein through the skin) sites and old partly healed wounds.

The victim may also suffer spontaneous systemic bleeding from gums, nose bleed, bleeding in the brain (cerebral haemorrhage), bleeding in the lungs, bloody vomiting, rectal bleeding, haematuria, vaginal bleeding, bleeding into the conjunctiva, skin and retina.

Rarely, cerebral arterial thrombosis may occur with a western Russell's viper *Daboia russelii* bite.

Neurological symptoms

A bite by a poisonous snake of the elapidae family like cobra; and Russell's viper may produce neurological complications leading to drowsiness, numbness and tingling, abnormalities of taste and smell, "heavy" eyelids, drooping eyelids, paralysis of external muscles of eyeball, paralysis of facial muscles and other muscles innervated by the cranial nerves, nasal voice or loss of speech, regurgitation through the nose, difficulty in swallowing secretions, respiratory and generalised flaccid paralysis.

Skeletal muscle symptoms

A bite by poisonous sea snakes, and some krait species like *Bungarus niger* and *B. candidus*, western Russell's viper *Daboia russelii* may severely affect the muscles. This can lead to generalised pain, stiffness and tenderness of muscles, trismus,

myoglobinuria (presence of myoglobin in the urine), hyperkalaemia (higher than normal levels of potassium in the circulating blood), cardiac arrest, and acute renal failure.

Kidney related symptoms

A bite by a poisonous snake of the viperidae family or sea snakes may excite loin (lower back) pain, blood in the urine, haemoglobinuria, myoglobinuria, cessation of urine formation, and symptoms and signs of kidney failure with the victim developing acidotic breathing, hiccups, nausea, and pleuritic chest pain.

Endocrine symptoms

A bite by a Russell's viper may produce acute pituitary and or adrenal insufficiency. During the acute phase, this may cause shock and lowering of blood sugar (hypoglycaemia). Months to years after the bite, the victim may develop weakness, loss of secondary sexual hair, loss of libido, amenorrhoea, testicular atrophy, and hypothyroidism.

Treatment for snake bites

A thorough clinical evaluation of the bitten person and a battery of tests can lead the healthcare team to the best line of treatment. In some cases, a bite from a venomous snake is not life-threatening. The severity depends on the location of the bite, the amount of poison injected, and the age and health of the victim.

If the situation is life threatening, the doctor may administer anti-venom. Anti-venom treatment can be expected to neutralise free circulating venom, prevent spread of the venom and allow recovery. However, these processes take time and the severely envenomed patient may require life support systems such as treatment of shock, assisted ventilation and renal dialysis until the severely damaged organs and tissues have had time to recover.

Outlook for a snake bite

The outlook for a person with a snake bite is highly variable. For a non-venomous snake bite, the outlook is excellent if the wound is cleaned and treated promptly. For a venomous bite, the outlook is good if the victim receives emergency care very soon after the bite has occurred. Healthy adults with shallow bites have a better outlook than children and those with weakened immune systems who have received deep bites.

Prevention of snake bites

Snake bites can be prevented in many cases. It is best to refrain from approaching or handling snakes in the wild. Avoid typical places where snakes like to hide, such as patches of tall grass and piled leaves, and rock and woodpiles. If you encounter a snake, give it space to retreat and let it take cover. It is in the snake's nature to avoid interaction.

When working outside where snakes may be present, wear tall boots, long pants, and leather gloves. Avoid working outside during the night and in warmer weather, which is when snakes are most active.

When Oxygen is an Enemy *(Continued from page 26)*

is well-known worldwide as 'King of antioxidants.

Antioxidant food sources

Most of the vegetables, especially the green leafy ones, are loaded with potent phytochemicals, which are plant compounds that act as antioxidants.

Sprouts are also powerful sources of antioxidants, minerals, vitamins, and enzymes that promote optimal health. Peas and sunflower sprouts provide us with the highest-quality protein.

Fresh berries like blueberries, blackberries, cranberries, and raspberries are the best antioxidant fruits, as they contain powerful phytochemicals that directly inhibit the DNA binding of certain carcinogens. Berries are also great sources of antioxidants like vitamin C, carotenes, and carotenoids, as well as nutrients like zinc, potassium, iron, calcium, and magnesium.

Nuts like walnuts and hazelnuts are excellent antioxidant foods that can boost our heart health and overall health.

Aside from being an abundant source of antioxidants, **herbs and spices** can have potential anti-cancer benefits. Some of our best choices are ground cloves, ground cinnamon, oregano, turmeric, ginger, and garlic.

Organic green tea is rich in antioxidants and contains epigallocatechin-3-gallate (EGCG), a catechin polyphenol and one of the most powerful antioxidants known today. EGCG benefits by lowering our risk of heart attack and stroke, glaucoma, high cholesterol, and more. Studies have also found that it can increase fat oxidation, and even help prevent obesity due to its regulatory effect on fat metabolism.

The scientists at the US Department of Agriculture (USDA) have created a scale called the Oxygen Radical Absorbance Capacity (ORAC) score for measuring an antioxidant food's or supplement's ability to neutralise free radicals. The higher a food's ORAC score, the more powerful it is in fighting age-related degeneration and disease.

Recent Developments in Science and Technology

Biman Basu

The scientists identified negatively charged molecules called 'carbon chain anions' in Titan's atmosphere, which are understood to be building blocks of more complex molecules, and may have acted as the basis for the earliest forms of life on Earth. The detections were made using Cassini's plasma spectrometer, called CAPS, as Cassini flew through Titan's upper atmosphere, 950-1,300 km above the surface

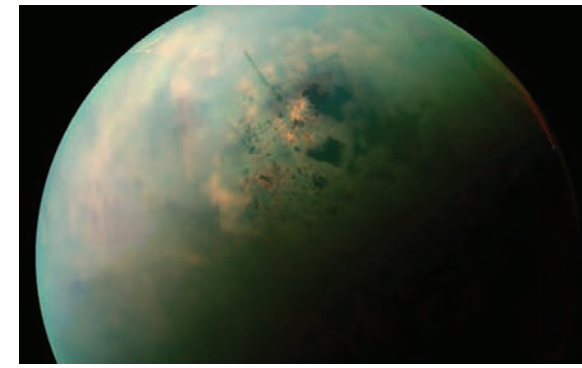
Building blocks of alien cells discovered on Titan

Life-forming molecules have been detected within the hazy upper atmosphere of Saturn's largest moon Titan. The discovery was made by a team of scientists led by Ravi Desai of University College London (UCL) after analysing data received from the *Cassini* probe that has been observing Saturn and its moons since 2004. The scientists identified negatively charged molecules called 'carbon chain anions' in Titan's atmosphere, which are understood to be building blocks of more complex molecules, and may have acted as the basis for the earliest forms of life on Earth. The detections were made using Cassini's plasma spectrometer, called CAPS, as *Cassini* flew through Titan's upper atmosphere, 950-1,300 km above the surface (*The Astrophysical Journal*, 26 Jul 2017 | DOI: 10.3847/2041-8213/aa7851).

According to Ravi Desai, who led the UCL study, "We have made the first unambiguous identification of carbon chain anions in a planet-like atmosphere, which we believe are a vital stepping-stone in the production line of growing bigger, and more complex organic molecules, such as the moon's large haze particles".

In another significant discovery, an international team of scientists using data from the Atacama Large Millimetre/submillimetre Array (ALMA) in Chile found molecules called vinyl cyanide on Titan that may link together to form membranes like those of living organisms on Earth. Scientists suggest this chemical composition is similar to Earth's primordial atmosphere, and the extreme cold and liquid methane on Titan could allow vinyl-cyanide molecules to link together and form sheet structures similar to lipid bilayers found in living cells on Earth – the main component of a cell's membrane.

The presence of complex molecules in Titan's atmosphere is not surprising.



An important type of molecule that helps produce complex organic material has been detected within Titan's hazy upper atmosphere by a UCL-led team as part of the international Cassini-Huygens mission.

According to the researchers, Titan's thick nitrogen and methane atmosphere drives some of the most complex chemistry seen in the Solar System. Nitrogen and methane in Titan's upper atmosphere are exposed to energy from sunlight and energetic particles in Saturn's magnetosphere, which drive reactions involving nitrogen, hydrogen and carbon and lead to more complicated prebiotic compounds. These large molecules

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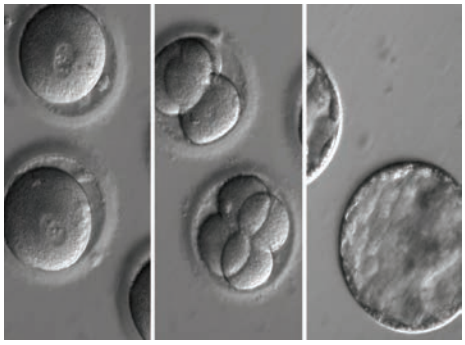
drift down towards the lower atmosphere, forming a thick haze of organic aerosols, and are thought to eventually reach the surface. But the process by which simple molecules in the upper atmosphere are transformed into the complex organic haze at lower altitudes is complicated and difficult to determine. This discovery adds vital information that will help scientists understand the chemical process.

The scientists believe the processes going on in Titan's atmosphere mimic the atmosphere of early Earth, before the build-up of oxygen. As such, Titan can be seen as a planet-scale laboratory that can be studied to understand the chemical reactions that may have led to life on Earth, and that could be occurring on planets around other stars.

Nipping genetic diseases in the bud

A genetic disease is caused by one or more abnormalities in the genome, a condition that is usually present from birth. In most cases it arises from a mutation in the gene of one or both parents, which can be detected through DNA analysis using a sample of blood, mouth swab or tissue. There is a mutation known to be responsible for an inherited form of heart disease known as hypertrophic cardiomyopathy (HCM) that is often deadly to healthy young athletes and adults in their prime. Till now it has been possible to correct a few selected genetic defects in humans by using the gene-editing technique known as CRISPR-Cas, but only in an individual, which did not stop the transmission of the mutated gene to future generations. Now researchers at Oregon Health and Science University (OHSU) in Portland, USA, in collaboration with the Salk Institute, USA, and Korea's Institute for Basic Science, have used the technique to carry out "germ-line editing," using human embryos expressly created for the purpose, *in vitro*. The experiment achieved for the first time alteration of the human genome to erase a disease-causing mutation that causes HCM not only from the DNA of the primary subject but from the genes of his or her progeny as well (*Nature*, 24 August 2017; DOI: 10.1038/nature23305). Chinese scientists had first reported applying CRISPR to human embryos in 2015. In that case, the embryos had chromosomal abnormalities that would have prevented them from surviving. In the latest work, the fertilised embryos were viable; their only defect was a small deletion – just four base pairs – in MYBPC3 gene inherited from the father.



Sequence of images showing days-old embryos developing after their DNA was altered using the gene-editing technique CRISPR.

Hypertrophic cardiomyopathy, caused by a dominant mutation in the MYBPC3 gene, is the most common cause of sudden death in otherwise healthy young athletes, and affects approximately 1 in 500 people worldwide. But the defect often goes undetected until it is too late, and people with a mutant copy of the MYBPC3 gene have a 50 percent chance of passing it on to their own children. For the study, the researchers recruited a dozen healthy egg donors and one sperm donor who carried the MYBPC3 defect. They generated induced pluripotent stem cells from a skin biopsy donated by the male with HCM. The researchers hope, being able to correct the mutation in embryos would prevent the disease not only in affected children, but also in their descendants.

The most significant finding of the experiment was that the technique is safe and efficient. Not only did a high percentage of embryonic cells get repaired, but also gene correction did not induce any detectable off-target mutations and genome instability – major concerns for gene editing. In addition, the researchers developed a robust strategy to ensure the repair occurred consistently in all the cells of the embryo.

The researchers are of the opinion that the success could pave the way for improved outcomes of *in vitro* fertilisation (IVF) as well as prevention of some of the thousands of diseases caused by mutations in single genes. According to Shoukhrat Mitalipov, a biologist at OHSU, who led the study, the new findings might also be used to correct genetic variants that can cause breast and ovarian cancer, cystic fibrosis and muscular dystrophy in those who inherit them.

The researchers emphasise that, "although promising, these are very preliminary results and more research will need to be done to ensure no unintended effects occur". Future work will continue to assess the safety and effectiveness of the procedure and efficacy of the technique with other mutations.

Strong adhesive for wound healing synthesised

Can you stick Band Aid on wet skin or stick something with glue on a wet surface? The answer is of course, an emphatic 'No'. It is well known that to stick anything to a surface it has to be clean and dry. But now scientists have come out with a new, flexible adhesive material inspired by the glue secreted by slugs that sticks to biological tissues (even when wet) without causing toxicity. The adhesive has been developed by a team of researchers from the Wyss Institute for Biologically Inspired Engineering and the John A. Paulson School of Engineering and Applied Sciences (SEAS) at Harvard University, USA. It is a super-strong "tough adhesive" that is biocompatible and binds to tissues with strength comparable to the body's own resilient cartilage, even when they are wet (*Science*, 28 July 2017 | DOI: 10.1126/science.aah6362). The new glue sticks to wet surfaces, including the surface of a beating heart, and according to the scientists, since it is not toxic to cells, it has an advantage over many commercially available surgical glues.

The dusky slug (Arion subfuscus), which excretes a sticky, yellow-orange slime that adheres well to wet surfaces.

The inspiration for the glue came from the dusky slug (*Arion subfuscus*) – a large and slimy species of slug found in North America and Western Europe. These slugs excrete a sticky, yellow-orange slime that adheres well to wet surfaces and help them cling to leaves and other surfaces. After analysing the slime secreted by the slug, the researchers found that the sticky mucus has two components: polycations that help the mucus adhere to surfaces through electrostatic interactions and covalent bonding, and a tough matrix linked by ionic bonds that absorbs and dissipates stress. This combination allows the slug to stick strongly to a surface by resisting forces – such as those from wind, rain, or the beak of a hungry bird – that could dislodge it. These "hybridised" cross-links make the slug mucus both tough and stretchy.

To mimic this design, the researchers created a stress-dissipating matrix from cross-linked polymers, polyacrylamide, and alginate. The researchers then coated the matrix with the polycation chitosan (a linear polysaccharide made by treating the shells of shrimp and other crustaceans with an alkaline substance, like sodium hydroxide), which inserts itself into the matrix and produces an adhesive surface. The researchers tested the synthesised adhesive on a variety of both dry and wet pig tissues including skin, cartilage, heart, artery, and liver, and found that it bound to all of them with significantly greater strength than other medical adhesives. The tough adhesive also maintained its stability and bonding when implanted into rats for two weeks, or when used to seal a hole in a pig heart that was mechanically inflated and deflated and then subjected to tens of thousands of cycles of stretching. A big advantage of the new adhesive was that it caused no tissue damage or adhesions to surrounding tissues when applied to a liver haemorrhage in mice – side effects that were observed with both super glue and a commercial thrombin-based adhesive.

According to the researchers, such a high-performance material has numerous potential applications in the medical field, "either as a patch that can be cut to desired sizes and applied to tissue surfaces or as an injectable solution for deeper injuries". It can also be used to attach medical devices to their target structures, such as an actuator to support heart function.

Crows are smarter than we think

We all know that crows are clever birds. The story of a thirsty crow dropping pebbles into a jar to get water to the top for drinking is well known. A study in 2015 had shown that crows can be taught to 'count' and discriminate between groups of dots on computer screens in a similar way to humans. Other studies have shown their ability to make tools. For example a crow can bend wire to fish out or lift items from a hard-to-reach spot. Recent studies have shown that crows, or their big-size relatives, the ravens, are smarter that we take them to be. Like humans, these birds also have the ability to remember past events and use this ability to plan for the future.

One characteristic that distinguishes humans from other animals is the capacity to take decisions about future events that will unfold at other locations. This is possible

A raven uses a stick to poke for food in a tube. (Credit: Helena Osvath)

because the human brain can store memories of past events to guide decision-making about current and future events. This ability allows humans to plan outside the current sensory context and covers a wide range, for example, from planning a dinner party or a vacation to making retirement plans. It was generally assumed that that animals do not use memories in this way but are mostly concerned with present needs and are unable to plan for the future. In fact, whether any other animals can plan across time has been one of the cardinal questions in animal behavioural sciences during the past decade.

A recent study with ravens (*Corvus corax*) by Can Kabadayi and Mathias Osvath of Lund University, Sweden, has shown that this notion is untenable, as carefully designed experiments have demonstrated their ability to plan for expected future events based on past experiences. The researchers tested ravens with tasks designed to specifically assess their general planning abilities. The results confirmed the birds' forward-planning abilities, at least as well as apes and 4-year-old human children in this complex cognitive task (*Science*, 14 July 2017 | DOI: 10.1126/science.aam8138).

What is more, the study showed that ravens can anticipate the nature, time, and location of a future event based on previous experiences. According to the researchers, this behaviour is not merely prospective, anticipating future states; rather, they flexibly apply future planning in behaviours not typically seen in the wild.

In a series of experiments, the researchers investigated whether ravens plan for the future. Each experiment included two main conditions – a technical and a social one, namely tool-use and exchanging something for food with humans. Ravens are not habitual tool users, and exchanging food for something has never been observed in the wild. Specifically, the researchers tested whether ravens can make decisions for an event 15 minutes into the future and over longer intervals of 17 hours. In addition, they also tested whether ravens can exert self-control when making decisions for the future.

The researchers presented five ravens with a choice of objects. Only one of these objects was a functional tool, which could be used to retrieve food from a puzzle box. The ravens were also trained to exchange tokens for food. The ravens chose correctly not only when they were offered the box but also when they had to store the tool and plan for the next day. One experiment investigated whether ravens could select, save, and later use either a tool or an exchangeable token that acquired functionality 15 minutes after being taken, at a different location from where it was selected. The second experiment extended the delay between item selection and use to 17 hours (overnight). Surprisingly, when the ravens knew that food would be offered only on the next day, they chose and stored these tokens as soon as they were offered to them. The results from the two experiments clearly showed that ravens take the time gap between item choice and reward into account, exercise self-control, and make decisions for predicted futures rather than arbitrary ones.