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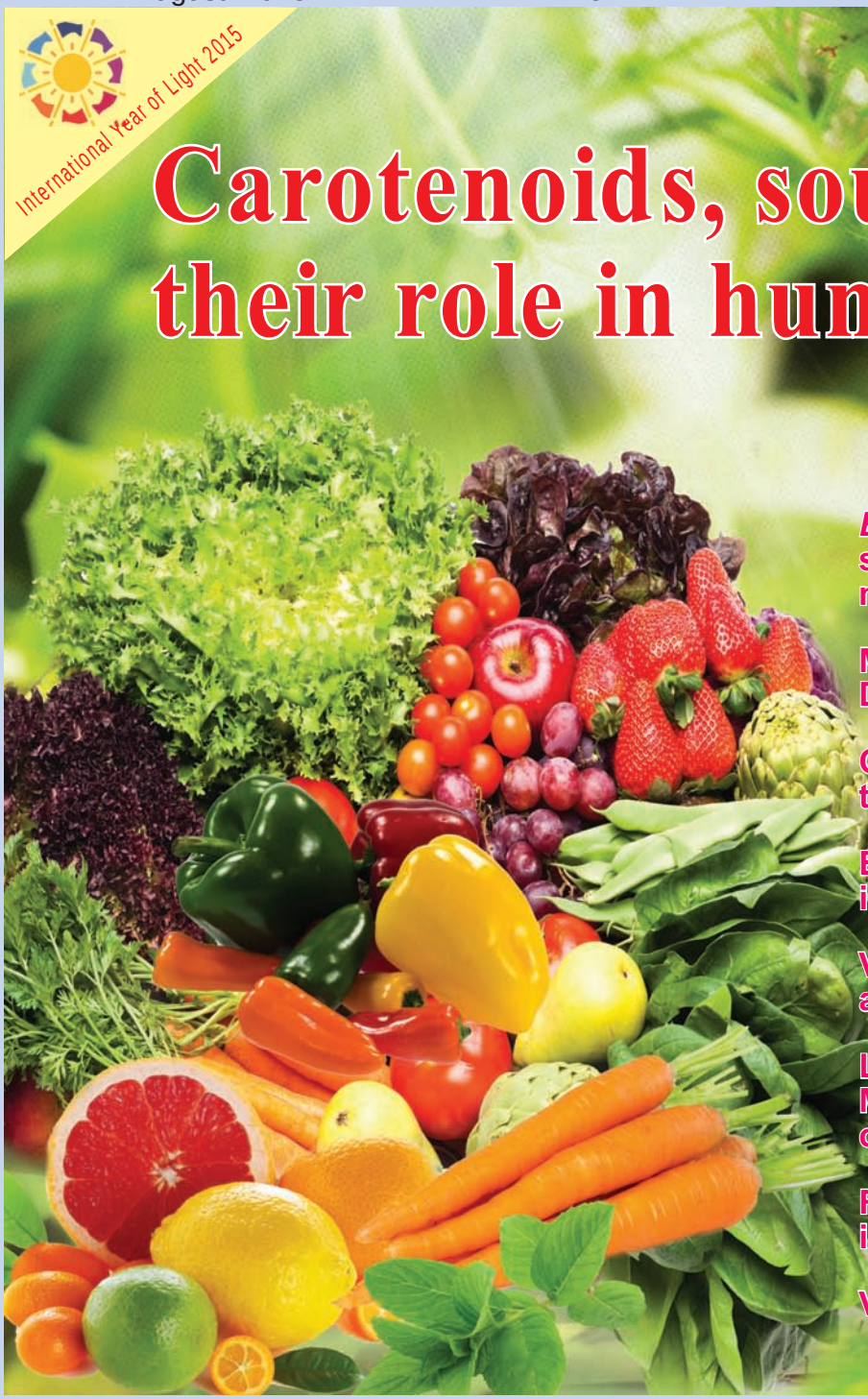
Carotenoids, sources and their role in human health



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

Credibility of science communicator and messages

Dr. R. Gopichandran

The main objective of this editorial is to share some interesting thoughts about the process and impacts of science communication. I imagine aspects of technology are embedded within the framework of science and therefore imply science and technology jointly whenever I use the word science in the following. The context is the dynamics between the main aim of communication about science to educate, inspire and transform minds and enabling circumstances that create the milieu to act on the basis of learnings. Easy access to credible alternatives that serve the purpose of the systems/materials that are substituted is well known to hasten transitions. Incentives for compliance motivate further. This is especially so in the case of environmental action with implications for quality of life in communities. Please note the word "credible". I wish to re-emphasise that credibility of messages could be quite strong when alternatives deliver equally robust services without disrupting related economic and other value based considerations.

The credibility of the communicator could also get enhanced, especially when choices and methods of using them are not seen as disruptive by receivers of such messages. The latter may also watch if people/institutions that propose alternatives also actually imbibe the value of the alternatives and practice them in their own lives. Arguably, credibility will take a plunge if people who propose alternatives are not seen as practicing them at their own end. Communicators must be clear if they are propagating their own agenda or the true agenda of science in its real sense. I took the opportunity to highlight this aspect of credibility of the communicator in an editorial presented a few months ago too. Arguably communicators who do not follow a logical framework steeped in values of respect and mutually reinforcing learning run the risk of irreversibly losing their credibility; much as true science will remain untainted and surface ever more emphatically. Institutions and institutional mechanisms that recognise and follow this core resilience of science will benefit from the resilience that it confers.

I further believe credibility will also emerge as the most important limiting factor, even if all other determinants are in their best mix. Simply stated, communication and communicators have to be driven through firewalls of credibility steeped in some essentials as stated in the following. (1) Guide and do not dominate through positioning that is almost disruptive. (2) Respect the spread and depth of awareness, knowledge and values of people engaged with. This is because of their histories and circumstances peculiar to their own milieus that influence perceptions. They could carry values/thought processes more profound than the ones being proposed. (3) Establish the open-ended nature of scientific thanking that respects evolving knowledge bases and systems of applications. This will help position everyone's thinking within the larger framework of rationality. Such human values as truth and peace could reflect the soundness of scientific thinking. They transcend political and related trappings.

Some recent publications on the dynamics of science communication will help communicators devise their engagement strategies better. These include communication in the "post – expert digital age" by Amy Luers and David Kroodsma[1], literature on issue – specific communication strategies presented by the *Proceedings of the National Academy of Sciences* of the United States of America[2], Thomas Dietz's paper on the interplay of values and facts[3] and the Framework of Principles For Science Communication Initiatives[4]. Dialogues on "Scienceyness" also make interesting reading[5].

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Max Ferdinand Perutz:
Doyen of Structural Biology

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"Science is a part of culture. Culture isn't only art and music and literature, it's also understanding what the world is made of and how it functions. People should know something about stars, matter and chemistry. People don't know what heat is, they hardly know what water is. I'm always surprised how little people know about anything. I am puzzled by it."

– Max F. Perutz

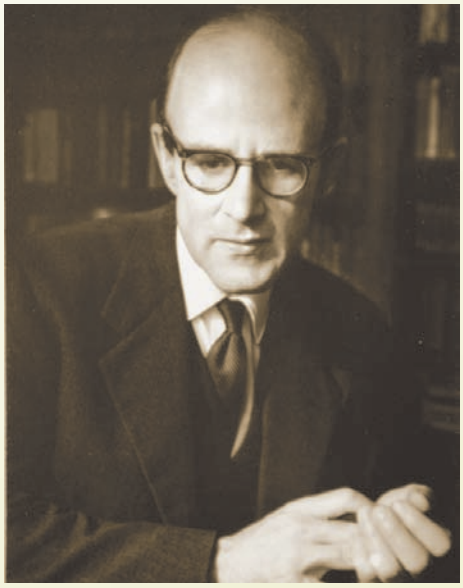
"Max is really the father to us all in structural biology; he solved a protein structure, analysed it to understand its functional mechanism at atomic detail, looked at the role of mutations in disease and thought about drug design. And he did it first! The character of a scientist is often transmitted through the generations. One can learn a lot about a scientist from the behaviour of his students and his students' students… Structural biology and its students are Max's lasting legacy."

– Alan F. Fersht in "Max Ferdinand Perutz OM FRS", Nature Structural Biology*, No. 9, pp. 245-246, 2002.*

"He (Max Perutz) was one of the greatest ambassadors of science, scientific method and philosophy. Apart from being a great scientist, he was a very kindly and tolerant person who loved young people and was passionately committed towards societal problems, social justice and intellectual honesty. His passion was to communicate science to the public and he continuously lectured to scientists both young and old, in schools, colleges and universities and research institutes."

– S. Ramaseshan in Current Science*, Vol. 82, No.5, pp. 586-90, 2002.*

Max Ferdinand Perutz was one of the greatest scientists of the twentieth century. He played an instrumental role in the development of molecular biology and his work paved the way in a significant manner for the emergence of modern biotechnology and developing better ways of creating and testing drugs. He was the first person to demonstrate how to determine a protein's structure by X-ray crystallography. He worked out the finest details of the structure of haemoglobin (a molecule containing some 12,000 atoms), the red protein in blood, which contains iron and can take up oxygen in the lungs and later gives it up to the body's other tissues. Perutz toiled and struggled for years to work out the haemoglobin's three-dimensional structure. He introduced the heavy atom or isomorphous technique to solve the protein's structure by X-ray crystallography. In this technique heavy metal atoms such as mercury or gold are incorporated into the molecule under study and such introduction of heavy atoms alters the diffraction patterns, making it easier to compute the positions of atoms in the molecule. After working out its structure, Perutz continued to investigate the function of haemoglobin, in both health and disease. His work enabled scientists to understand the role of haemoglobin in transferring oxygen and carbon dioxide through the bloodstream. In 1957, his colleague and his



Max Ferdinand Perutz

first doctoral student, John Kendrew (1917-1997), using Perutz's technique determined the structure of myoglobin, a molecule smaller than haemoglobin. Perutz and Kendrew shared the 1962 Nobel Prize in Chemistry 'for their studies of the structure of globular proteins.'

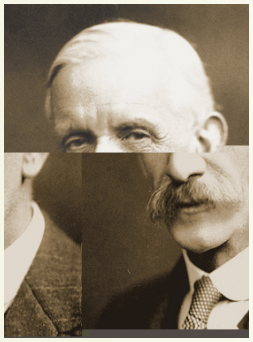
John Kendrew

Perutz created one of the best research laboratories in the world, the MRC (Medical Research Council) Molecular Biology Laboratory. Some of the best-known pioneers of molecular biology spent their formative years in this laboratory.

Max Ferdinand Perutz was born on 19 May 1914 in Vienna, Austria. His father Hugo Perutz owned a small textile factory. His mother Adele "Dely" Perutz (nee Goldschmidt) also came from a textile-manufacturing family. His parents were of Jewish ancestry. However, Perutz was baptized in the Catholic religion. He studied at Theresianum, then an elite school in Vienna. His parents wanted him to study law as a preparatory step to enter the family business. However, Perutz decided to pursue a career in science. At school, one of his teachers got him interested in chemistry. After his school he enrolled as a chemistry undergraduate at the University of Vienna and completed his degree in 1936.

While an undergraduate student at Vienna, Perutz was fascinated by a course of organic biochemistry given by Fritz von Wessely in which he described about the researches being carried out in the field of biochemistry by Frederick Gowland Hopkins (1861-1947), the Nobel Prize winner biochemist, and his group at the Cambridge University. Perutz became interested in the subject

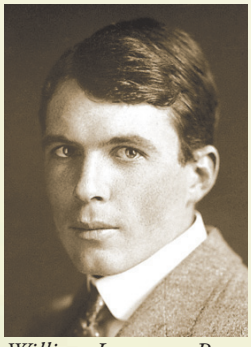
and wanted to join Hopkins' group and so he requested his teacher Marks, who was soon to visit Cambridge, to find out whether there would be a place for him in Hopkins' laboratory. Marks apparently forgot to ask Hopkins. But he also visited John Desmond Bernal (1901-1971), known for his pioneering work in the application of X-ray crystallography in molecular biology and came to know that Bernal was looking for a research student who would assist him in his investigations on X-ray crystallography. Marks suggested Perutz to join Bernal's group. However, Perutz had no knowledge about X-ray crystallography and so he was hesitant to try for a position in Bernal's group but then he was persuaded by Marks who told him that he would learn it soon. In 1936, he joined Bernal's crystallography Laboratory in Cambridge.



Frederick Gowland Hopkins

John Desmond Bernal

Perutz later described his first impression about his joining Bernal's group at the Cavendish Laboratory. He wrote: "In 1936, when I joined J.D. Bernal's Crystallographic Laboratory, it was a small, dingy sub-department of the famous Cavendish Laboratory headed by Ernest Rutherford, the discoverer of the atomic nucleus, who was regarded as the world's greatest experimental physicist. On the other hand, I was trained as a chemist and my interests grew in another direction. It had just been discovered that all chemical reactions in living cells are catalysed by enzymes and that all enzymes are proteins. Genes were also believed to be made of proteins, but next to nothing was known about the structure of proteins, let alone their mechanism of action. They were black boxes. Protein structure therefore seemed to be the central problem of biology, and X-ray crystallography was the only method in principle capable of solving it."



William Lawrence Bragg

Perutz did not take long to learn X-ray crystallography. Bernal advised him to study protein structure with the help of X-ray crystallography. However, Bernal's lab did not have appropriate protein crystals to study. It was at the suggestion of Felix Michael Haurowitz (1896-1987), a Professor of physiological chemistry at Prague and husband of a cousin of Perutz. Thus at the suggestion of Haurowitz, Perutz decided to work on horse haemoglobin. It may be noted that Haurowitz had earlier observed that needle-like crystals of horse oxyhaemoglobin got transformed into purple hexagonal plaques of deoxyhaemoglobin crystals after the depletion of oxygen by bacterial growth. Perutz also came to know from Haurowitz that to start with he could obtain haemoglobin crystals from Gilbert Smithson Adair (1896-1979) in Cambridge, who was an early protein scientist.

After obtaining horse haemoglobin crystals from Adair, Perutz obtained beautiful X-ray diffraction pictures. Sir William Lawrence Bragg (1890-1971) was very much impressed with Perutz's results. It was under the supervision of Bragg that Perutz completed his PhD. Bragg appointed Perutz as his research assistant under a grant from the Rockefeller Foundation in January 1939. This was a great help to Perutz. Till then he could stay at Cambridge because of the financial support extended to him by his parents. However, when Adolf Hitler invaded Austria and Czechoslovakia his parents not only lost their family business, they had also to flee to Switzerland as refugees and were later taken to Cambridge by Perutz. Perutz exhausted his funds and without Bragg's support he could not have continued his research at Cambridge. The grant continued till 1945 though there were a number of interruptions because of the War.

In 1940, Perutz was arrested when the British Government decided to arrest all persons of foreign origins living in coastal areas. He was taken to Canada by ship where he met several other imprisoned scientists including the German-born British theoretical physicist Emil Julius Klaus Fuchs (1911-1988), also known as Karl Fuchs and the Austrian-born astrophysicist Thomas Gold (1920-2004). Perutz came back to Cambridge in 1941, but he had to join a secret war effort called project Habbakuk. The project, which was named after a Hebrew prophet, was instituted to study mechanical properties of ice and to create an aircraft carrier made of ice in the middle of the North Atlantic. However, it had to be abandoned because of its impracticability.

Emil Julius Klaus Fuchs

Thomas Gold

In 1945, Perutz was given an Imperial Chemical Industry Fellowship. In October 1947, the MRC Unit for Research on the Molecular Structure of Biological systems was established with Perutz as its Chairman. At the beginning, Perutz and his doctoral student John Kendrew comprised the entire staff of the MRC Unit. Later they were joined by Francis Harry Crompton Crick (1916-2004), who joined in 1948 and James Dewey Watson (1928-), who came to the Unit as Visitor in 1951. This Unit eventually became the MRC Laboratory of Molecular Biology with Perutz as Chairman. The Laboratory under the leadership of Perutz became the leading Centre in molecular biology in the world and as mentioned earlier many of the well-known molecular biologists were trained here.

Perutz maintained his connection with his teacher and mentor Lawrence Bragg and he remained grateful to him for his guidance and support. He began his Nobel Lecture by saying: "Forty years ago William Lawrence Bragg came here to thank you for awarding the Nobel Prize to himself and to his father, and to tell you how they had brought into being a new and fruitful branch of physics by unraveling the atomic arrangement in

crystals of common salt and other simple compounds. Today Sir Lawrence Bragg ranks as one of the fathers of X-ray crystallography, but he has also been something of a scientific father to me personally, and I feel immensely proud that it should now be my own turn, as his former pupil, to thank you for having bestowed on me this supreme honour."

Perutz had proved himself as an accomplished writer. While an undergraduate student he wrote remarkable letters, which were later published in a book form titled, *What a Time I am Having: Selected Letters of Max Perutz* (Cold Spring Harbor Laboratory Press, New York, 2009). In his later years he regularly contributed to the *New York Review of Books* and the *London Review of Books* and many of these reviews/essays were published as a book titled, *I Wish I Had Made You Angry Earlier* (Cold Spring Harbor Laboratory Press, New York, 2002). He wrote other books: *Proteins and Nucleic Acids: Structure and Function* (Elsevier, Amsterdam, 1962); *Is Science Necessary? Essays on Science and Scientists* (Barrie and Jenkins, London, 1989); *Mechanisms of Co-operativity and Allosteric Regulation in Proteins* (Cambridge University Press, Cambridge, 1990); *Protein Structure: New Approaches to Disease and Therapy* (Freeman, New York, 1992); and *Science Is Not a Quiet Life: Unraveling the Atomic Mechanism of Haemoglobin* (World Scientific, Singapore, 1997). Perutz won the Lewis Thomas Prize for Writing about Science in 1997. He was very happy about receiving the Prize. It has been reported that one of his relatives, Leo Perutz, a distinguished writer, had told Max Perutz when he was boy that he would never become a writer. Perutz amply demonstrated that it was an unwarranted judgment.

Perutz did not agree with the view of the British philosopher Karl Raimund Popper (1902-1994) that science advanced through a process of hypothesis formation and refutation. Perutz was of the opinion that hypotheses were not necessarily the basis of scientific research and refutation was not always the case, at least in molecular biology. He regarded the US philosopher and historian of science Thomas Samuel Kuhn's (1922-1996) notion that science progresses in paradigm shifts that are subject to social and cultural pressures as an unfair representation of modern science. Perutz had rejected religion and in later years of his life he was an atheist but he vehemently opposed the idea of offending others for their religious beliefs. Perutz was not in favour of military interventions after September 11 terrorist attacks in USA in 2001. He wrote to the British Prime Minister Tony Blair: "I am alarmed by the American cries for vengeance and concerned that President Bush's retaliation will lead to the death of thousands more innocent people, driving us into a world of escalating terror and counter-terror. I do hope that you can use your restraining influence to prevent this happening."

Besides the Nobel Prize, as mentioned earlier, he received a number of other important honours including Commander of the Ordre of the British Empire (1963), The Austrian Decoration of Science and Arts (1967), the Royal Medal of the Royal Society (1971), Companion of Honour (1975), Copley Medal of the Royal Society (1979) and the Oder of Merit (1988). He was a Fellow of the Royal Society of London and a Member of the German Academy of Sciences Leopoldino. He was also an honorary member of the Academy of Arts and Sciences. In 1980, he was invited to deliver the Royal Institution Christmas Lecture on "The Chicken, the Egg and the Molecules'.

Perutz died on 6 February 2002 at Cambridge. He was 87. The inscription on a plaque in the Max Perutz Lecture Theatre that was unveiled on the afternoon of Perutz's funeral reads: "'In science truth always wins,' MFP". In fact as Alan R. Fersht observed 'that simple, direct statement sums up Max the scientist and Max the person.'

The Medical Research Council (MRC) of UK has established an award for science writing in honour of Max Perutz, an accomplished communicator. It is called Max F Perutz Prize for Science Writing and its objective is to encourage and recognise outstanding written communication among MRC PhD students. The University of Vienna and the Medical University of Vienna have jointly established the Max F Perutz Laboratories as a Centre to provide an environment for excellent research and education in the field of molecular biology. A biography of Max Perutz titled, *Max Perutz and the Secret of Life* and written by Georgina Ferry was published by the Cold Spring Harbour Press in 2007. Perutz's contributions to molecular biology in Cambridge are documented in *The History of the University of Cambridge* Volume 4 (1870 to 1890) published by the Cambridge University Press in 1992.

We would like to end this write-up by quoting Perutz: "Creativity in science, as in art, cannot be organised. It arises spontaneously from individual talent. Well-run laboratories can foster it, but hierarchical organisations inflexible bureaucratic rules, and mountains of futile paperwork can kill it. Discoveries cannot be planned; they pop up, like Puck, in unexpected corners."

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

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Carotenoids, sources and their role in human health

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Carotenoids, the precursor of vitamin A, have preventive action against many eye diseases and cancer. In humans and animals, carotenoids play an important role in protection against photo-oxidative processes (light-dependent generation of active oxygen) by acting as oxygen and peroxyl radical scavengers. Acting together with other anti-oxidants makes them even more potent compounds. Carotenoids, the basic source of yellow, orange, and red plant pigments, are widely distributed in nature. They are regarded as essential compounds for life mainly due to their various beneficial roles. Carotenoids are present in all living organisms, from bacteria and algae to higher plants and are also present in most commonly consumed vegetables and fruits.

Carotenoids consist more than 700 phytochemicals (chemical substances obtained from plants), which constitute photosynthetic membranes and produce colours in plants and animals. Out of these, only about twenty-four commonly occur in human foodstuff. The most-studied carotenoids are alpha-carotene, beta-carotene, lycopene, lutein, and zeaxanthin. The principal carotenoids of foods are beta-carotene, beta-cryptoxanthin, lycopene, and lutein. Carotenoid pigments, which are abundant in many fruits and vegetables, have been studied for their diverse roles in phytochemistry and phytomedicine (the use of plants, parts of plants, and chemicals obtained from plants as medicine). Carotenoids are mainly C_{40} compounds known as isoprenoids, consisting of eight isoprene units. There are two main groups of carotenoids, namely (i) carotenes (beta-carotene, lycopene), which contain only hydrogen and carbon and may be cyclic or linear; and (ii) oxycarotenoids (xanthophylls, lutein), which contain hydrogen, carbon and oxygen in the form of hydroxy, epoxy, or oxy groups.

Among the carotenes, only alpha, beta and epsilon carotene possess vitamin A activity, and out of them beta-carotene is the most active. Alpha carotene possesses 50-54% and epsilon carotene 42-50% of the antioxidant activity as compared to beta-carotene. These carotenes along with lycopene and lutein, which do not convert to vitamin A, offer protection against lungs, colorectal, breast, uterine and prostate cancers. They are tissue-specific in protection, but overall protective effects are greater when all carotenes are taken together.

Dietary carotenoids are obtained from several fruits and vegetables, such green leafy vegetables, spinach, carrots, peaches, apricots, and sweet potatoes. Human diet supplemented with carotenoids is beneficial in reducing chronic conditions related to coronary heart diseases, certain cancers and macular degeneration. Evidence shows that beta-carotene, lutein and perhaps even lycopene, can prevent UV-induced erythema (redness of the skin) and contribute to life-long protection against exposure to harmful effects of sunlight.

Bright coloured fruits and vegetables are rich in carotenoids

The nutraceutical industry produce five major carotenoids on an industrial scale (lycopene, beta-carotene, canthaxanthin, zeaxanthin, and astaxanthin) for use in a range of food products and cosmetics, such as vitamin supplements and health products and as feed additives for poultry, livestock, fish and crustaceans. One of the most commercially valuable pigments, astaxanthin, is primarily synthesised by marine microorganisms, such as the green alga *Haematococcus pluvialis* and accumulates in fish such as salmon, thus, colouring their flesh red. Astaxanthin has been implicated as a potential therapeutic agent treating cardiovascular disease and prostatic cancer.

Accumulation, storage and insights from biofortification

The storage of carotenoids requires a lipophilic (fat-loving) environment, usually within the membranes of plastid organelles (specialised parts of the cell), which behave as a sink for their accumulation. Carotenoids are usually synthesised in differentiated plastids of roots, flowers, fruits and seeds, and are accumulated mostly in chloroplasts, chromoplasts, and amyloplasts (starch-storing plastids), and elaioplasts (lipid-storing plastids).

Xanthophylls, mostly found in green vegetables and yellow fruits, are stored in the retina of the eye. They are expected to protect vitamin A, E and other carotenoids from oxidation and also the skin from adverse effects of sunlight. Lutein and zeaxanthin protect photoreceptor cells from light-generated oxygen radicals. They are more effective than alpha and beta-carotenes and lycopene in chemo-preventive activity. Lycopene exerts greater antioxidant activity compared to beta-carotene and it has also been reported to protect cholesterol against oxidative damage. It does not convert to vitamin A, but may provide important health benefits such as protection against cancer by quenching the destructive potential of singlet oxygen. Beta-cryptoxanthin occurs in oranges, mango, papaya, cantaloupe, peaches, prunes, squash, etc. It exhibits provitamin

A activity. (Provitamin is a substance that may be converted within the body to a vitamin.) Astaxanthin and capsanthin are other naturally occurring xanthophylls with potent antioxidant properties. Their antioxidant effects enable these compounds to play a vital role in protecting organisms against the damage of photo radiation during photosynthesis. They function as antioxidants by protecting blood and other body fluids from free-radical oxygen species. All-*trans* isomer of beta-carotene is the major source of retinol (a derivative of vitamin A) due to its high provitamin A activity. One molecule of it can theoretically provide two molecules of vitamin A. Its high levels in blood serum are correlated with low incidence of cancer.

Sources of carotenoids

Because plants are able to synthesise carotenoids, they are widely distributed in plant-derived foods and the composition is enriched by the presence of small amounts of biosynthetic precursors and derivatives of the major carotenoids. In general the level of carotenoids is directly proportional to the intensity of colour. Egg yolks, dairy products, fruits, vegetables, legumes, grains and seeds are their major food sources. In green leafy vegetables, beta-carotene is predominant while in the orange-coloured fruits and vegetables such as carrots, apricots, mangoes, yams, winter-squash, other carotenoids typically predominate. Yellow vegetables have higher concentrations of xanthophylls with a low provitamin A activity, but some of these compounds, such as lutein, may have significant health benefits. The red and purple vegetables and fruits such as tomatoes, red cabbage, berries and plums contain a large portion of non-vitamin A active carotenoids. Tomato and watermelon are main sources of lycopene.

Properties of carotenoids

The intrinsic antioxidant activity of carotenoids constitutes the basis for their protective action against oxidative stress and associated health problems. They inhibit lipid peroxidation, enhance eye health and immune systems and reduce the risk of certain cancers. Carotenoids are heat stable up to 50°C and degrade rapidly above this temperature. On heating, the naturally occurring *trans*-double bond configuration rearranges to *cis*-configuration. Common unit operations of food processing, blanching, retorting and freezing, etc., in general have either minor or no effect on their degradation. Frozen and heat-sterilised foods, with few exceptions, exhibit excellent stability of it. They are also stable in foods over a pH range of 2 to 7.

The best-known property of carotenoids is their ability to absorb light. Life on Earth is based on the energy of solar radiation, which is captured by higher plants, algae and photosynthetic bacteria. These organisms contain photosynthetic pigments such as chlorophylls, complex photoreceptor pigments called phycobilins, and carotenoids which absorb light in the wide range of wavelengths, covering the visible region and extending even to the near-infrared region. Finally, the energy is stored in the form of carbohydrates and other hydrogen containing organic compounds.

Carotenoids as antioxidants

Free radicals can damage the body's DNA, RNA, enzymes, carbohydrates, proteins, lipids, and cell membranes and thus weaken the natural defences. DNA damage can cause cancer while damage in arteries may cause hardening and increased the risk of heart attack, several other diseases, premature ageing, and death. Antioxidants significantly delay or prevent oxidation. Antioxidants, such as carotenoids, polyphenols, and vitamins C and E are known to have synergistic interactions (that is, they work together so the total effect is greater than their sum) through their recycling mechanisms. Antioxidants help to control free-radicals by donating electrons to molecules before they damage other cells. Antioxidants may have additional activities, such as reducing the energy of a free-radical or stopping it from forming by interrupting an oxidising chain reaction. They may also trap free-radicals and lipid peroxides, delaying the onset of lipid peroxidation, stopping production of further free-radicals and inhibiting the damaging effects of certain enzymes that can degrade connective tissues. Research has been focussed upon manipulation of carotenoids content and their composition in crop plants through biotechnological techniques to improve their nutritional value for human consumption.

Human health benefits and concerns about carotenoids

Carotenoids are generally regarded as safe, based primarily on studies with beta-carotene. But increased consumption of carotenoids may cause the skin to turn orange or yellow, a condition known as carotenodermia due to the presence of excess carotene in the blood. This occurrence is completely benign and is unrelated to jaundice that can result from liver disease or other causes. Vitamin A plays an important role in vision, bone growth, reproduction, cell division and differentiation. It maintains the surface linings of eye and respiratory, urinary and intestinal tracts. When those linings break down, bacteria can enter the body and cause infection. However, unlike beta-carotene, high doses of vitamin A have a negative impact on bone health and increases levels of retinoic acid. It can also affect the ability of vitamin D to maintain normal calcium levels in the body resulting in weakened bone structure. Hyper-vitaminosis due to excess consumption of vitamin A can lead to dry, itchy skin, headache, fatigue, vomiting, liver damage, and loss of hair and appetite.

Vitamin A deficiency is still a major public health problem in the developing world. It is most often associated with protein/calorie malnutrition and affects over 120 million children worldwide. In countries where immunisation programs are not effectively monitored, its deficiency is common leading to death of millions of children each year from complications of childhood blindness, infectious diseases such as measles, xerophthalmia (a condition in which the eye fails to produce tears), pneumonia, etc. As a result of the significance of vitamin A deficiency in children, the WHO and the UNICEF have recommend its administration for all children diagnosed with measles in communities where its deficiency is a serious problem and death from measles are greater than 1%.

Lycopene, alpha- and beta-carotenes help prevent heart disease by inhibiting the formation of harmful LDL cholesterol. Cataracts are caused, at least in part, by long-term free-radical damage to eyes. Carotenoids may delay that risk by scavenging free-radicals. Mixed carotenoids supplement along with vitamin C and E reduces the risk of developing diabetes and to fight against Alzheimer's disease by protecting nerve cells in the brain from deterioration.

Carrots are a rich source of antioxidant nutrient that was actually named for them: beta-carotene

They may protect sperm from damage by free-radicals so can be used as treatment for male infertility. Beta-carotene may also protect against chromosome abnormalities and/or their damage. It suppresses the activity of a gene involved in inflammation and reddening of skin, which is a marker for oxidative stress. Lower intakes of carotenoids in the body are associated with a higher risk of colorectal cancer. It has been found that high supplemental intakes of lutein, zeaxanthin, cryptoxanthin, alpha- and beta-carotene, etc., reduced the risk of breast, cervical and lung cancer. Lycopene appears to be particularly effective against cancers of the prostate, digestive tract, and lungs and may also protect the body against the effects of chemotherapy or radiation. They protect against sun damage because of their effect on the immune system, scavenger role towards oxidative substances and shield-like influence on the skin.

Most oxidation reactions in foods are deleterious and lead to degradation of vitamins, pigments and lipids, with consequent loss of nutritional value and development of off-flavours. Antioxidants, which are already present in or deliberately added to foods, can inhibit oxidation or slow down initiation by free alkyl radicals, as well as interrupt propagation of such free-radical chains. On the other hand, carotenoids are particularly strong dyes, even at levels of parts per million. Specifically, canthaxanthin, astaxanthin and lutein from the green algae *Chlorella* have been in regular use as pigments, and have accordingly been included as ingredients of feed for salmon fish and trout, as well as poultry to enhance the reddish colour of said fish or the yellowish colour of egg yolk.

Carotenoids have also the ability to stimulate the immune-system, thus being potentially involved in preventing more than 60 life-threatening diseases including various forms of cancer, coronary heart diseases, premature ageing and arthritis. This is specifically true of canthaxanthin and astaxanthin, and other non-provitamin A carotenoids.

Dr. Charu Gupta is a gold medallist and is specialised in microbiology. She has filed around 25 patents related to nutraceuticals, cosmeceuticals, functional foods, probiotics and utilisation of agro-horticultural wastes for production of value added products.

Prof. Dhan Prakash has 35 years of research experience in life sciences, has worked as guest scientist at several universities abroad, and has filed 35 patents.

Everyday Chemistry in the Kitchen-II

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Nutritional changes during cooking

A few legumes contain a kind of proteins known as trypsin inhibitors, which inhibit the enzyme trypsin that helps in the digestion of proteins in our stomach. Cooking of legumes effectively destroys these trypsin inhibitors, thus contributing to the increased bioavailability of proteins inherent in legumes. The availability of lysine (an essential amino acid) is compromised as a result of cooking. Nutrients like vitamins and minerals in fruits and vegetables can be destroyed or leached out by cooking. Vitamin C is especially prone to oxidation during cooking and may be completely destroyed by protracted cooking. Thiamine, a vitamin of the B group, is also partially lost during cooking. However, the bioavailability of some vitamins such as vitamin B6, niacin, folate, and carotenoids are increased with cooking by being freed from the food microstructure. These micronutrients naturally dissolve into the cooking water. Flavours can be lost during cooking when flavour compounds evaporate into the air. Short cooking methods such as stir-frying and blanching help reduce the heat degradation of vitamins, compared to longer cooking methods such as roasting. Minerals tend to have higher heat stability and are less affected by cooking methods which involve heating foods for longer time.

Colour appeal in food preparations and loss of pigmentation during cooking

Food is primarily attracted by its preferred colour and flavour. For example, chutney prepared with green chillies/mint leaves has a greenish tinge due to chlorophyll present in them and may be attractive to some, while the same item prepared with dry chillies which appears reddish due to carotenoids would be attractive to others. Similarly, dishes prepared with carrots, beetroots, ripe mangoes, etc., with their natural colours are very attractive (Table-3). There are three families of pigments found in fruits and vegetables: chlorophyll (green pigment), carotenoids (yellow-deep red pigments), and the flavonoids-anthocyanins (red, blue or purple pigments depending on the pH). Fruits and vegetables are prone to lose colour during cooking. Chlorophyll and carotenoids are fat-soluble pigments and thus may leach from vegetables if they are cooked in a medium containing fat. Also, carotenoids can undergo oxidation, which occurs when

the carotenoids come into direct contact with air and react with oxygen molecules leading to the degradation of the pigment. Open-pan boiling which exposes the food to the atmosphere for long periods of time, therefore, cause depletion of the pigment, resulting in paler coloured food. Both anthocyanins and anthoxanthins are water-soluble pigments and thus may leach into cooking water during soaking or prolonged heating. Cooking methods avoiding water (e.g., stir-frying) thus minimise the loss of these flavonoids during cooking.

Green vegetables containing chlorophyll when cooked initially become bright green eventually fading to an olive hue upon further cooking. Heat expands the cellular structure of the vegetable which enables gases to escape and expose the green chlorophyll. When cooked longer, chlorophyll becomes water soluble and leaches out. The magnesium in the centre of the chlorophyll molecule is displaced, causing conversion of chlorophyll to compounds with change in the colour (olive green and eventually, yellowish). This happens most often in acidic water, so a simple way to prevent it from occurring is to add a small amount of baking soda during cooking or to reduce cooking duration and add an acidic dressing at the end.

Enzymatic browning of vegetables and fruits upon cutting

Often, a food item which is primarily colourless or white may turn coloured during processing. For example, apple, potato, brinjal, avocado, etc., would darken

Enzymatic browning of Banana

Table-3. Colouring compounds present in fruits/ vegetables and other food items

Natural food item	Colouring compound	Natural food item	Colouring compound
Beetroot	Betanin	Meat	Myoglobin
Black/Blue grapes	Anthocyanins	Ripe papaya	Carotenes
Carrot	Carotenes	Red chilli	Capsanthin
Green vegetables	Chlorophyll	Tomato	Lycopene
Ripe Mango	Carotenes	Turmeric	Curcumin

Table-4. Chemicals in spice ingredient responsible for food flavour

Spice ingredient in food		Chemical responsible for flavour
	Ajowan	Thymol
	Asafoetida	Butyl propenyl disulphide
	Cardamom	Cineole, Pinene, Terpinene
	Cinnamon	Cinnamaldehyde, Cineole
	Clove	Eugenol
	Cumin	Cuminaldehyde
	Garlic	Diallyl disulphide
	Ginger	Gingerol, Zingerone
	Mustard	Allyl isothiocyanate
	Onion	Allyl propyl disulfide

and become unattractive upon slicing. This is due to enzymatic browning which is a chemical process, involving polyphenol oxidase and other enzymes that create melanin and benzoquinone from natural phenols present in them, resulting in a brown colour. In general, enzymatic browning requires exposure to oxygen. We also see how our mothers prevent the darkening of these cut vegetables by dipping them in water thus preventing the exposure to oxygen. Another technique for preventing enzymatic browning is to add lemon juice that lowers the pH and removes the copper cofactor necessary for the enzymes to function, or use of chemicals such as sodium bisulphite and citrates. Blanching or roasting is also adopted to denature enzymes that function in enzymatic browning.

Browning of food by caramelisation and Maillard reaction

Brown colour in foods is also produced by non-enzymatic browning by two chemical processes, viz., caramelisation and the Maillard reaction. Caramelisation is the process of pyrolysis of sugar during which, volatile chemicals are released, producing the characteristic caramel or nutty flavour. The caramelisation reaction occurs when foods containing a high concentration of carbohydrates are cooked at high temperatures using a dry-heat. Caramelisation produces the flavours and colours that are characteristic of many food products such as dark beer, coffee, confectionery and roasted peanuts. Once the caramelisation temperature has been reached, sucrose in the food begins to decompose into its component monomer molecules, glucose and fructose. A further series of complex chemical reactions take place between the molecules, which ultimately results in the generation of flavour compounds. One of the most important flavour compounds produced is diacetyl, which provides one of the characteristic flavours of caramelised foods. Other important flavour compounds produced during the caramelisation reaction include furans and maltol from disaccharides and hydroxymaltol from monosaccharides, which together contribute to give the sweet, slightly burnt flavour of the caramelisation reaction.

Browing of food by Caramelisation and Maillard reaction

Along with caramelisation, the Maillard reaction is another browning process in foods. The Maillard reaction is a chemical reaction between an amino acid and a reducing sugar, in presence of heat. This complex chemical reaction produces brown coloured melanoidins (high–molecular-weight heterogeneous polymers) which impart many foods their characteristic colouring. The complex Maillard reaction occurs during heating of foods containing sugars and proteins together and is responsible for generating many of the flavours and colours. Similar to caramelisation, hundreds of different flavour compounds are generated during the Maillard reaction, such as many sulphur containing compounds, that contribute to the savoury, meaty, flavour characteristics of cooked meat.

Generation of undesirable compounds during cooking

Cooking of foods can lead to the generation of undesirable compounds, especially, potential cancer producing compounds. Nitrosamines are generated during cooking of meat when sodium nitrite is used for the curing of meat. They are found in some smoked, grilled or fried foods, such as charred meat. Acrylamide and heterocyclic amines, formed as a result of the Maillard reaction, furan, polycyclic aromatic hydrocarbons such as pyrene and benzo (α) pyrene (produced during incomplete combustion from roasting and frying) are considered as carcinogenic.

(*Concluded*)

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Vitamin C : an amazing chemical

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Vitamin C is an essential vitamin for human health. Chemically it is L-ascorbic acid. Vitamin C is an excellent antioxidant. It has a very interesting and inspiring history. Ascorbic acid derives its name from the Latin word *scorbutus*, which is the Latin name for the disease called scurvy. As scurvy can be treated with this vitamin, the letter 'a' (meaning no) was prefixed to mean that it is caused by a deficiency of the vitamin. In olden times sailors, especially those who used to set out for long voyages, used to suffer extensively from scurvy, the chief reason for this disease is incomplete synthesis of collagen, a fibrous protein, in the body. As a result the body parts start getting slackened because it is collagen that binds them like cement and provides structural support to them. Vitamin C deficiency weakens the cartilage present in the joints. The main symptoms of scurvy are internal bleeding, muscle weakness, bleeding and painful gums, loosening of teeth, pain and inflammation in joints, slow healing of wounds, etc. In 1497, when Vasco da Gama set out for his sea voyage from Portugal to India, the curative effects of citrus fruits were known at that time. The Portuguese, therefore, set up fruit and vegetable plantations at many places. In Saint Helena, a stopping point for homebound voyages, they used to leave the sick sailors, suffering from scurry and other sea ailments, to recuperate by consuming citrus fruits. The sailors were subsequently taken home by the next ship.

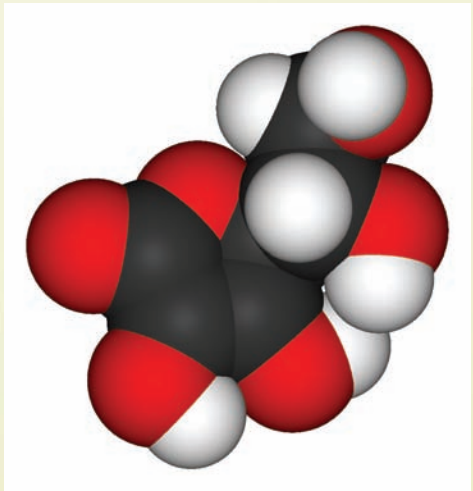
Albert Szent-Szent-Györgyi

According to an estimate, between 1500 AD and 1800 AD, scurvy killed at least two million sailors. Jonathan Lamb wrote: "In 1499, Vaso da Gama lost 116 of his crew of 170; in 1520, Magellan lost 208 out of 230… all mainly to scurvy. One can gauge from this how hazardous sea voyages used to be in the olden days. However, scurvy by any count is not a new disease. It has also been mentioned by Hippocrates (460 BC-380 BC) who is regarded as the father of Western medicine. According to some references, the use of herbs to treat scurvy was made by some local communities of prehistoric age.

The credit for discovering vitamin C goes to the Hungarian scientist Albert Szent- Szent-Györgyi (16 September 1893-22 October 1986). He was awarded the Nobel Prize in Physiology or Medicine in 1937 for his discoveries in connection with the citric acid cycle, that is, biological combustion process with special reference to vitamin C and the catalysis of fumaric acid. The importance of vitamin C can be gauged from the fact that in the same year (1937), Walter Norman Haworth was also awarded the Nobel Prize in Chemistry for unveiling its chemical structure. It sounds quite incredible that two Nobel Prizes were awarded in the same year for work on a chemical compound.

Walter Norman Haworth

Vitamin C is a water-soluble white crystalline substance, which is sour in taste. Earlier, ascorbic acid was known by the name of hexuronic acid, Due to its high solubility in water, vitamin C is easily absorbed by the small intestine. It directly reaches the liver from blood and from the liver it then reaches different parts of the body. If taken in excess, it easily excreted from the body through urine.



Vitamin C molecule

Of all vitamins, vitamin C is the most unstable vitamin. When taken with other nutrients such as vitamin A and iron, it boosts the immune system of the body and keeps it healthy. The melting point of vitamin C is 190°C.

Main sources of vitamin C

Humans get vitamin C only through food products because the human body is not able to synthesise it. As vitamin C gets easily oxidised, storing it in aerobic condition and cutting and cooking of vegetables containing it lead to its oxidation. On average, an adult requires 60 mg of vitamin C per day. Pregnant and lactating mothers need an additional of 10-30 mg per day. The main sources of vitamin C are sour and juicy fruits and all kinds of citrus fruits, such as, gooseberry, orange, lemon, grapes, tomatoes, pineapple, strawberry, etc. Cantaloupe, kiwi, mango, guava, water melon, apple, bananas, berries, and green leafy vegetables, etc., are also good sources of this vitamin. In addition, spinach, fresh peas, wood apple jackfruit, turnip, mint radish leaves *munakka* (black raisins) milk, beetroot, amaranth, cabbage, green coriander, green and red chilli, broccoli, cauliflower, sweet and white potatoes and pumpkin one also considered to be good sources of vitamin C. Ascorbic acid is found in scant quantity in milk, eggs, mutton and chicken; sometimes it may not be present in these food items at all. The table below shows the amount of vitamin C present in different food items.

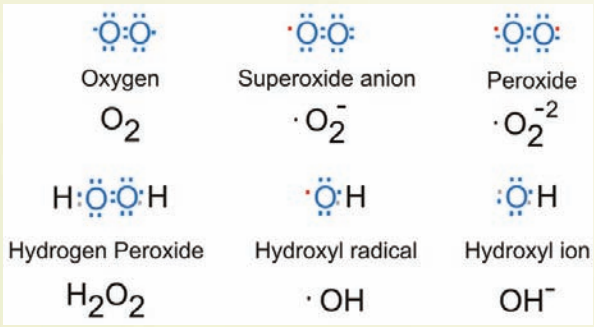
Free radical and reactive oxygen species

Free radicals are generated due to the oxidation of the body cells. Atoms or

Table: The amount of vitamin C (ascorbic acid) in some food products

Food product	Ascorbic acid (mg/100 g)
Grapes	200
Cabbage	100
Cauliflower	70
Spinach	60
Orange	50
Lemon	50
Potatoes	30
Peas	25
Tomatoes	20
Lettuce	15
Carrot	6
Apple	5
Milk	2.1-2.7

groups of atoms heaving an odd (unpaired) number of electronic are called free radicals.



Free radical and reactive oxygen species

They have a deleterious effect on the body. Increased formation of free radicals in the body invites host of diseases. The process of the formation of free radicals increases with advancing age and due to free radicals wrinkles start appearing on the skin and there is a drop in the efficiency of the functioning of body parts.

Due to the presence of an odd or unpaired electron in free radicals, they have a strong affinity to get paired by attracting an electron. So they rapidly get paired by pulling and electron from neighbouring molecules. But, in this process the stable molecule from which one electron has been detached gets converted into a free radical. Now, this newly formed free radical pulls an electron from another stable molecule. In this way, a chain reaction for the formation of free radicals starts. These free radicals are highly reactive. If their formation rate becomes uncontrolled, cell death may occur.

Vitamin C has antioxidant properties which fights with the free radicals produced in the body and replenishes the supply of vitamin E in our body cells. Side by side, it also increases the capacity for iron absorption in the body. It also works as an anti allergic and antioxidant. Therefore, humans must take sufficient quantity of fruits and vegetables in their diet. Like free radicals there are some other kinds of molecules which have identical nature and are equally injurious to the body. Such molecules are dubbed as reactive oxygen species. Their formation takes place in the body due to a variety of reasons such as oxidation of food products, infection, mental stress, excessive exertion, and consumption of diet loaded with fats. Little or no consumption of fibrous fruits and vegetables also triggers their generation. Some environmental factors like pollution, ultraviolet and ionising radiation might also be the cause of their formation. Reactive oxygen species damage the nucleic acids DNA and RNA by reacting with them and may give rise to such changes in the cells of the organisms as may lead to untimely ageing and the dreaded cancer in due course of time.. They also damage protein, lipids, etc. This raises the possibility of getting afflicted with the age-related diseases, such as cataract, diabetes, Parkinson's disease, Alzheimer's disease, gout, hypertension, insomnia, osteoporosis, cancer, depression, etc.

Vitamin C: An excellent antioxidant and free radical neutraliser

Antioxidants are those chemical compounds which prevent the oxidation of other substances. They get rid of the reactive oxygen species by reacting with them. By reacting with the free radicals found in the body due to oxidation, antioxidants neutralise them. Situated top on the list of antioxidants in vitamin C. Gooseberries are considered to be an excellent source of vitamin C. The vitamin C present in gooseberry in relatively stable and is not easily destroyed on heating. Extensive research has been carried out on properties of vitamin C. The most interesting property of vitamin C., as found by the researchers, is that it increases the antioxidant properties of other vitamins manifold. By donating an electron to the free radicals, the activity of vitamin E gets neutralised and in the process, vitamin E itself gets converted into a free radical. In such a scenario, vitamin C, by constantly offering its electron to vitamin E, helps maintain the latter's reactivity. Vitamin C also has the property of replenishing the loss of its electron through recycling.

Vitamin C can offer improvement in the skin health and also some other benefits. Although, as found by researchers, daily consumption of 60 mg of vitamin C is good for health, its quantity in the blood of those who smoke is 25 percent less compared to the quantity in non-smokers. So, smokers, alcoholics and those having greater intake of caffeine need comparatively larger quantities of vitamin C. In addition, in cases of excessive mental tension, fever, infection, pregnancy and old age the requirement of vitamin C goes up proportionately.

Mood-setting role of Vitamin C

Vitamin C has a role in setting our mood. It helps formation of serotonin in the human brain. Serotonin, which is a neurotransmitter, regulates our mood. Chemically, it is 5-hydroxytrptamine (5-HT). It is biochemically derived from tryptophan. Good level of serotonin in the blood has the effect of increasing the level of happiness of a person. It also regulates sleep and appetite of a person. In persons suffering from worries and depression, the level of serotonin in blood is found to be low. To increase the level of serotonin, therefore, chemicals in the form of antidepressants are prescribed. Serotonin also has cognitive importance. It influences the memory and learning process. Therefore, a good level of serotonin increases the possibility of better learning and understanding by students. Vitamin C is also beneficial for our eyes. It protects us for glaucoma, which can make a person go blind.

Some biological roles of vitamin C

In the fundamental chemical reactions and in the formation of compounds in the body, vitamin C has a definite role. It helps in the metabolic processes of the cells. Vitamin C is helpful in carrying out various chemical reactions in the body, such as, communicating messages to the nerves ensuring energy flow

Continued on page 22

Low Blood Pressure – More secrets and ways to cope with it

Dr. Yatish Agarwal
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The malady of low blood pressure can bug any person at any stage in life, yet studies indicate that the fairer sex suffers from its ills more often! While blood pressure is counted as normal if its numbers hover around 120/80 points of mercury or lower, no such crisp demarcation exists to call it too low. In general, you may think of blood pressure as too low when it causes you difficulties. Usually, this happens when the blood pressure is less than 90/60 points.

Types of low blood pressure

Depending on the causes and other factors, low blood pressure can be broadly grouped into different categories. Some common types of low blood pressure include:

Postural hypotension (Low blood pressure on standing up)

Some people record a sudden drop in blood pressure when they stand up from a sitting position or if they stand up after lying down. This category of low blood pressure, which specifically occurs on change of posture or standing up is called the orthostatic, or postural, hypotension.

The mechanism of this sudden change in pressure is simple. Ordinarily, gravity causes blood to pool in our legs whenever we stand. The body compensates for this by increasing the heart rate and constricting blood vessels, thereby ensuring that enough blood returns to the brain. However, in people with orthostatic hypotension, this compensating mechanism fails and blood pressure falls, leading to symptoms of dizziness, lightheadedness, blurred vision, and even fainting.

This type of hypotension is especially common in older adults, with as many as 20 per cent of those older than age 65 experiencing postural hypotension. But postural hypotension can also affect young, otherwise healthy people who stand up suddenly after sitting with their legs crossed for long periods or after working for a time in a squatting position.

A variety of reasons can produce postural hypotension. This can happen due to dehydration, prolonged bed rest, pregnancy, diabetes, heart problems, burns, excessive heat, large varicose veins and certain neurological disorders.

A number of medications also can cause postural hypotension, particularly drugs used to treat high blood pressure – diuretics, beta blockers, calcium channel blockers and angiotensin-converting enzyme (ACE) inhibitors – as well as antidepressants and drugs used to treat Parkinson's disease and erectile dysfunction.

Postprandial hypotension (Low blood pressure after eating)

Postprandial hypotension is a sudden drop in blood pressure after eating. It affects mostly older adults. When we have eaten, a large amount of blood flows to the digestive tract. Ordinarily, the body counteracts this by increasing the heart rate and constricting certain blood vessels to help maintain normal blood pressure. However, in some people these mechanisms fail, leading to dizziness, faintness and falls.

Postprandial hypotension is more likely to affect people with high blood pressure or autonomic nervous system disorders such as Parkinson's disease.

Lowering the dose of blood pressure drugs and eating small, low-carbohydrate meals may help reduce symptoms.

Neurally mediated hypotension (Low blood pressure from faulty brain signals)

This disorder mostly affects young people, and it seems to occur because of a miscommunication between the heart and the brain. It causes blood pressure to drop after standing for long periods, leading to signs and symptoms such as dizziness, nausea and fainting.

When a person stands for extended periods, his/her blood pressure falls as blood pools in the legs. Normally, the body then makes adjustments to normalise the blood pressure. However, in people with neurally-mediated hypotension, nerves in the heart's left ventricle actually signal the brain that blood pressure is too high, rather than too low. As a result, the brain lessens the heart rate, decreasing blood pressure even further. This causes more blood to pool in the legs and less blood to reach the brain, leading to light-headedness and fainting.

Low blood pressure in Shy-Drager syndrome

Shy-Drager syndrome is a rare disorder that causes progressive damage to the autonomic nervous system, which controls the involuntary bodily functions such as blood pressure, heart rate, breathing and digestion.

Although this condition can be associated with muscle tremors, slowed movement, problems with coordination and speech, and incontinence, its main characteristic is severe orthostatic hypotension

in combination with very high blood pressure when lying down.

Diagnostic tests

Often people come to know that they have low blood pressure when their doctor checks the pressure. Or they may find that they have low blood pressure when they check it at home.

If you feel you're having health-related difficulties, you should consult your family doctor. To check for the causes of your low blood pressure, your doctor will look into your past health, your symptoms, and the medicines you take. He or she will do a physical exam and may do other tests.

The goal of doing diagnostic tests is to find the underlying cause. This helps determine the correct treatment and identify any heart, brain or nervous system problems that may cause lower than normal readings. You may be asked to undergo one or more of the following tests to reach a diagnosis.

24-h blood pressure test

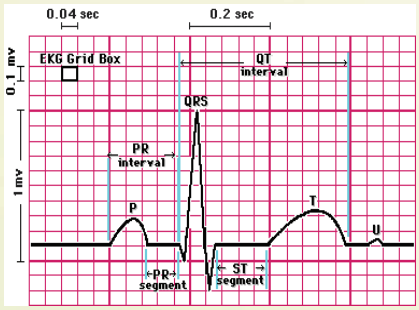
If you have symptoms that are highly suggestive of low blood pressure, yet the readings in a doctor's office do not support the diagnosis, s/he may recommend a 24-hour monitoring of your blood pressure. A device is taped to your body, which continues to measure your blood pressure with an inflatable arm cuff and a pressure-measuring gauge and record the numbers over a period of 24 hours.

Blood tests

These can provide information about your overall health as well as whether you have low blood sugar (hypoglycemia), high blood sugar (diabetes) or a low number of red blood cells (anaemia), all of which can cause lower than normal blood pressure.

Electrocardiogram (ECG)

During this painless, noninvasive test, soft, sticky patches (electrodes) are attached to the skin of your chest, arms and legs. The patches detect your heart's electrical signals while a machine records them on graph paper or displays them on a screen.

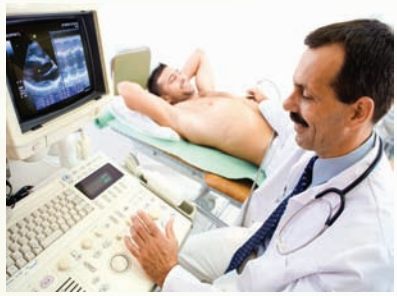


An ECG, which can be performed in your doctor's office, detects irregularities in your heart rhythm, structural abnormalities in your heart, and problems with the supply of blood and oxygen to your heart muscle. It can also tell if you're having a heart attack or if you've had a heart attack in the past.

Sometimes, heart rhythm abnormalities come and go, and an ECG won't find any problems. If this happens, you may be asked to wear a 24-hour Holter monitor to record your heart's electrical activity as you go about your daily routine.

Echocardiogram

This noninvasive test, which includes an ultrasound of your chest, shows detailed images of your heart's structure and function. Ultrasound waves are transmitted, and their echoes are recorded with



a device called a transducer, which is held outside your body. A computer uses the information from the transducer to create moving images on a video monitor.

This test can help identify people with a weakened heart. When the heart muscle weakens, the heart is not able to pump sufficient blood into the circulation.

Stress test

Some heart problems that can cause low blood pressure are easier to diagnose when your heart is working harder than when it's at rest. During a stress test, you'll exercise, such as walking on a treadmill. You may be given medication to make your heart work harder if you're unable to exercise.

When your heart is working harder, your heart will be monitored with electrocardiography or echocardiography. Your blood pressure is also monitored.

Valsalva manoeuvre

This non-invasive test checks the functioning of your autonomic nervous system by analysing your heart rate and blood pressure after several cycles of a type of deep breathing. You take a deep breath and then force the air out through your lips, as if you were trying to blow up a stiff balloon.

Tilt-table test

If you have low blood pressure on standing, or from faulty brain signals (neurally mediated hypotension), your doctor may suggest a tilt-table test, which evaluates how your body reacts to changes in position.

During the test, you lie on a table that's tilted to raise the upper part of your body, which simulates the movement from horizontal to a standing position.

Treatment

Low blood pressure that either doesn't cause signs or symptoms or causes only mild symptoms, such as brief episodes of dizziness when standing, rarely requires treatment.

If you have symptoms, the most appropriate treatment depends on the underlying cause, and doctors usually try to address the primary health problem – dehydration, heart failure, diabetes or hypothyroidism, for example – rather than the low blood pressure itself.

When low blood pressure is caused by medications, treatment usually involves changing the dose of the medication or stopping it entirely.

If it is not clear what's causing low blood pressure or no effective treatment exists, the goal is to raise your blood pressure and reduce signs and symptoms. Depending on the reason for your low blood pressure, you may be able to take certain steps to help reduce or even prevent symptoms. Some suggestions that may work well include:

Use more salt

Experts usually recommend limiting the amount of salt in your diet because sodium can raise blood pressure, sometimes noticeably. For people with low blood pressure, that can be a good thing. However, because excess sodium can sometimes lead to heart failure, especially in older adults, it's important to check with your doctor before increasing the salt in your diet.

Drink more water

Although nearly everyone can benefit from drinking enough water, this is especially true if you have low blood pressure. Fluids increase blood volume and help prevent dehydration, both of which are important in treating hypotension.

Wear compression stockings

The same elastic stockings commonly used to relieve the pain and swelling of varicose veins may help reduce the pooling of blood in your legs.

Stand up slowly

You may be able to reduce the dizziness and lightheadedness that occur with low blood pressure on standing by taking it easy when you move from a prone to a standing position. Before getting out of bed in the morning, breathe deeply for a few minutes and then slowly sit up before standing.

Simple maneuvers

If you begin to get symptoms while standing, cross your thighs in a scissors fashion and squeeze, or put one foot on a ledge or chair and lean as far forward as possible.

If you feel dizzy or lightheaded, sit down or lie down for a few minutes. Or you can sit down and put your head between your knees. This will help your blood pressure go back to normal and help your symptoms go away.

These simple maneuvers encourage blood to flow from your legs to your heart.

Medications

Several medications, either used alone or together, can be used to treat low blood pressure that occurs when you stand up. For example, the drug fludrocortisone is often used to treat this form of low blood pressure. This drug helps boost your blood volume, which raises blood pressure.

Doctors often use the drug midodrine to raise standing blood pressure levels in people with chronic orthostatic hypotension. It works by restricting the ability of your blood vessels to expand, which raises blood pressure.

Drink little or no alcohol

Alcohol is dehydrating and can lower blood pressure, even if you drink in moderation. Water, on the other hand, combats dehydration and increases blood volume.

Follow a healthy diet

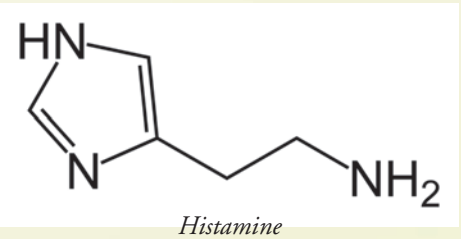
Get all the nutrients you need for good health by focusing on a variety of foods, including whole grains, fruits, vegetables, and, if you eat non-vegetarian food, lean chicken and fish.

Your doctor also may recommend drinking caffeinated coffee or tea with meals to temporarily raise blood pressure.

Vitamin C : an amazing chemical *(Continued from page 25)*

to cells, etc. They help keep various parts of the body in proper shape. Besides, vitamin C is required for the formation of collagen that cements the bones, blood vessels, ligaments, cartilage, etc. It also regulates the amount of cholesterol in the body. It acts as a co-agent for hydroxyphenylpyruvate, an oxydising enzyme that breaks up tyrosine and thus catalyses the bio-synthesis of catecholamines. Vitamin C is also instrumental in the conversion of folic acid to the active formyl tetrahydrofolic acid.

The absorption of iron in the body is increased by vitamin C. It converts the ferric ion into ferrous ion which makes the absorption of iron by the intestine easier. Vitamin C helps in strengthening the blood vessels of the body. Lack of vitamin C may lead of bleeding gums and dental pain. There may be loosening of the gums leading to untimely loss of teeth. Therefore, one must regularly include vitamin C in



Histamine

the diet. Those suffering from hypertension must take regular dose of vitamin C in their diet. It dilates the arteries and thus protects the person from the possible ill-effects of hypertension.

Due to its antihistaminic properties, vitamin C may act as a medicine to treat normal cough and cold. In biological system, superoxides or radicals produced as a result of chemical reactions damage the proteins or DNA of the body. By proper and regular intake of vitamin C, it may be possible to control the ageing process and the incidence of cancer. Vitamin C produces antibodies and thus boosts the immune system of the body. Besides, vitamin C deficiency may increase the possibility of ulcer, scars on the face, weak lungs, cough and cold, and eye, nose and ear diseases, allergies, etc. Due to the lack of vitamin C, excessive bleeding may also take place on getting hurt because it plays an important role in the coagulation of blood.

It is thus amply clear that vitamin C is indeed an amazing chemical which has multifarious roles in keeping us healthy and disease-free.

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(Translation: Abhas Mukherjee)

Recent Developments in Science and Technology

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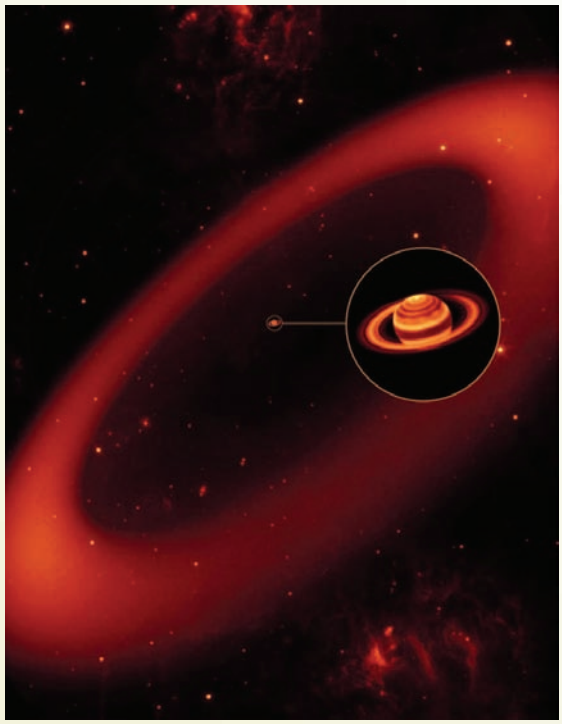
Saturn's Phoebe ring is really huge

For centuries after Galileo used his telescope to view its rings, Saturn was known to be the only planet of the solar system to have a coterie of rings till space probes discovered rings around Jupiter, Uranus and Neptune. But a recent discovery of a massive invisible ring around the planet again puts Saturn in the forefront. The ring is really huge – ranging in diameter from 14 million to 25 million kilometres and is about 10 times bigger than the planet's previously largest known ring, the E ring. (Saturn's diameter is 116,464 kilometres). The ring is not visible in optical telescopes because it emits only in infrared wavelengths. The ring was discovered by Anne Verbiscer and Michael Skrutskie of the University of Virginia and Douglas Hamilton of the University of Maryland in 2009 from data sent back by NASA's Spitzer Space Telescope, which imaged the ring in infrared, but only now has its real nature been deciphered. The Spitzer findings have been corroborated by data from NASA's Wide-field Infrared Survey Explorer (WISE) telescope (*Nature*, 11 June 2015 | doi:10.1038/nature14476).

According to the researchers, the ring is formed by tiny particles released from the planet's small moon Phoebe and that's why it has been dubbed the "Phoebe ring". The ring is made up mainly of dust particles about 10 to 20 microns in size, or about one-tenth to one-fifth the average width of a human hair, but also has some football-sized rocks. According to the researchers, rocks that are the size of footballs or larger with diameters of more than 20 centimetres) make up no more than about 10 percent of the ring.

The dark grains making up the Phoebe ring absorb sunlight, which makes the ring difficult to see in visible light but much easier to see in infrared wavelengths. The ring is very tenuous, consisting of widely-dispersed particles of ice and dust. A cubic kilometre of space in the Phoebe ring might have just a few dozen dust particles, maybe 100 at most. Spitzer's infrared eyes were able to spot the glow of the cool dust, which has a temperature of only about 80 kelvins (minus 193.14°C). The Phoebe ring is tilted 27° with respect to Saturn's equator in contrast with the planet's main ring system, which is lined up with the planet's equator. Part of the Phoebe ring crosses the orbit of another moon of Saturn, Iapetus.



The Phoebe ring loops around Saturn near the moon Phoebe. It is much bigger than Saturn's other rings. This is how an artist thinks the Phoebe ring might look if we could see it. Saturn and the other rings are just a tiny dot compared to the Phoebe ring. The inset picture shows Saturn magnified. (Credit: NASA/JPL-Caltech/Keck)

Named alphabetically A to F in the order they were discovered, Saturn's rings, except the Phoebe ring, are relatively close to each other. Working outward from the planet, the main rings are known as C, B and A. The Cassini Division measuring 4,700 kilometres is the largest gap in the rings and separates rings B and A. In addition, a number of fainter rings have been discovered more recently. The D ring is exceedingly faint and closest to the planet. The F ring is a narrow feature just outside the A ring. Beyond that are two far fainter rings named G and E.

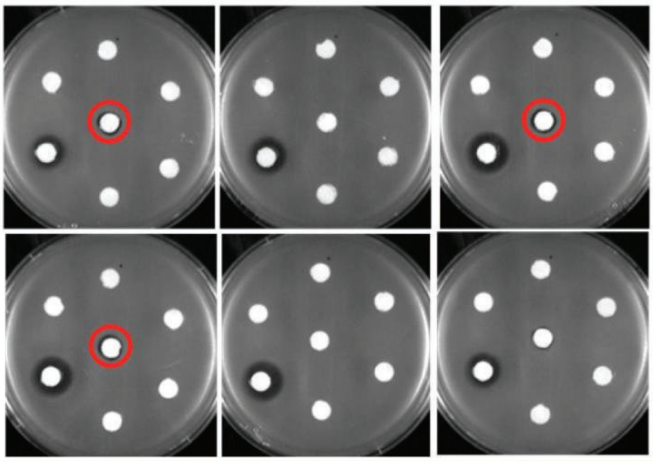
According to the researchers, the recent findings suggest that Saturn possesses three kinds of rings. The main rings are constantly changing, made of fast-moving house-size chunks of ice that gently collide, break apart and reform every hour or so. The E ring is filled with frozen water droplets from geysers on the icy moon Enceladus. The vast Phoebe ring has million- to billion-year-old dust particles and likely some larger objects as well.

E. coli turned into antibiotic factories

Escherichia coli or *E. coli* is a common bacterium found in the human gut. It is widely used in genetic engineering studies and genetically modified *E. coli* is being routinely used for producing human insulin and many other pharmaceuticals. In the latest success story, a team of researchers led by Blaine Pfeifer at the State University of New York at Buffalo, USA have managed to turn *E. coli* into tiny factories for producing new forms of the antibiotic erythromycin – including three that were shown in the lab to kill drug-resistant bacteria (*Science Advances*, 29 May 2015 |doi:10.1126/sciadv.1500077).

Erythromycin is used to treat a variety of illnesses, from pneumonia and whooping cough to skin and urinary tract infections.

Over the past 11 years, Pfeifer's research has focussed on manipulating *E. coli* so that the organism produces all of the materials necessary for creating erythromycin – the metabolic precursors. It is like stocking a factory with all the necessary parts and equipment for building a car or a plane. With that phase of the research complete, Pfeifer turned to the next goal – finely adjusting the way his engineered *E. coli* produce erythromycin so that the drug they make is slightly different than versions used in hospitals today. And they have succeeded,



The white filter disks holding antibiotics sit on petri dishes housing erythromycin-resistant Bacillus subtilis. The filter disks circled in red hold new forms of erythromycin created by University at Buffalo researchers, and the dark halo around them indicates that the drug has seeped out of the disk to kill the surrounding bacteria. (Credit: Guojian Zhang)

showing the way to harnessing *E. coli* to synthesise dozens of new forms of the drug which are structurally different from existing versions.

The process of creating erythromycin begins with three basic building blocks – chemical compounds that are combined and manipulated through an assembly line-like process to form the final product, erythromycin. To build new varieties of erythromycin with a slightly different shape, scientists can theoretically target any part of this assembly line, using various techniques to affix parts with structures that deviate slightly from the originals, and that is what Pfeifer's team did.

In the new study, Pfeifer's team focussed on a step in the building process that they say had previously received little attention from researchers, a step near the end. They focussed on using enzymes to attach 16 different shapes of sugar molecules to a specific molecule that led, at the end of the assembly line, to more than 40 new analogues of erythromycin – three of which showed an ability to fight erythromycin-resistant bacteria in lab experiments. Pfeifer says they have established a platform for using *E. coli* to produce erythromycin, and now they can start altering it in new ways to make other antibiotics different from the existing ones.

Dinosaurs were warm-blooded

Dinosaurs were a diverse group of animals that first appeared during the Triassic period, 231.4 million years ago. They dominated the Earth for 135 million years, from about 201 million years ago until about 65 million years ago, when a massive cosmic event led to the extinction of most dinosaur groups (along with some three-quarters of plant and animal species on Earth). Most dinosaurs were herbivores and grew to massive sizes and were believed to be sluggish and cold-blooded animals or occupied a unique intermediate category of animals that were neither fully cold nor warm-blooded. But recent research has shown that dinosaurs were probably warm-blooded animals that had many traits in common with mammals. The discovery came after re-analysis of data published in the journal *Science* last year (13 June 2014 | DOI: 10.1126/science.1253143). In that paper by John M. Grady, *et al.* had stated that dinosaurs were neither sluggish like lizards nor brisk like mammals, but something in between. This conclusion was arrived at by analysing a database of growth rates in 381 animal species, including 21 dinosaurs. But, according to Michael D'Emic of Stony Brook University, New York, USA, who did the re-analysis, "Upon re-analysis, it was apparent that dinosaurs weren't just somewhat like living mammals in their physiology – they fit right within our understanding of what it means to be a 'warm-blooded' mammal" (*Science*, 29 May 2015 | DOI: 10.1126/science.1260061). In fact, he says, dinosaurs grew as fast as your average living mammal.

D'Emic studying structures of dinosaur bones smaller than the width of a human hair. (Credit: SBU)

D'Emic is a specialist in bone microanatomy, or the study of the structure of bone on microscales that are just a fraction of the width of a human hair. Based on his knowledge of bone growth he re-analysed the earlier study, which led him to the strikingly different conclusion that dinosaurs were more like mammals than reptiles in their growth and metabolism. D'Emic re-analysed the data from two aspects. First, the original study had scaled yearly growth rates to daily ones in order to standardise comparisons, which according to him was not correct because "many animals do not grow continuously throughout the year, generally slowing or pausing growth during colder, drier, or otherwise more stressful seasons". Therefore, he says, the previous study underestimated dinosaur growth rates by failing to account for their uneven growth. "Like most animals, dinosaurs slowed or paused their growth annually, as shown by rings in their bones analogous to tree rings," he explains.

The second aspect of the re-analysis was the fact that in the original study dinosaurs were not statistically analysed within the same group as living birds, which, according to D'Emic, should have been done because birds are also warm-blooded and they are descendants of Mesozoic dinosaurs. "Separating what we commonly think of as 'dinosaurs' from birds in a statistical analysis is generally inappropriate, because birds are dinosaurs – they're just the dinosaurs that haven't gone extinct," he opines. "Re-analysing the data with birds as dinosaurs lends more support that dinosaurs were 'warm-blooded', and not occupants of a special, intermediate metabolic category", he says.

Science Fusion-2015
Science Activities for Children

Vigyan Prasar organised a five-day-long science activity-based programme *Science Fusion- 2015* exclusively for children up to 10th class during 17-22 June 2015, at Vigyan Prasar, A-50, Sector 62, Noida (UP). Several hands-on activities on science and technology were organised for enabling children to learn and understand science by doing things themselves. The objectives of the programme were i) to sensitise children about the activity-based science learning; ii) to induce an interdisciplinary integrated approach to science learning through experimentation; and iii) to inculcate scientific temper among children through hands-on activities.

The programme was inaugurated with a keynote address by Dr. E.N. Rajgopala, Head, NCMRWF, Noida on 17 June 2015, followed by special addresses by Ms Asheema Singh, Coordinator (AEP), NIOS, Noida and Dr. R. Gopichandran, Director, VP. On this occasion three books produced by VP for EduSat science festival were released. Shri Kapil Tripathi, Scientist E, VP made a presentation on overview of the programme. The session ended with a vote of thanks by Dr. Irfana Begum, Project officer, EduSat, VP.

The main programme included an interactive "Meet with Scientist" session followed by science movie show on both days. Dr. T.V.Venkateswaran, Scientist 'F', Smt Kinkini Dasgupta Mishra, Scientist 'F', Shri B.K. Tyagi Scientist 'E', and Dr. Bharat Bhushan, Scientist 'C' from Vigyan Prasar interacted with the children on different themes related to Astronomy, Health and Hygiene, Innovation, Agriculture, etc. Award-winning films of Rashtriya Vigyan Chalchitra Mela were screened daily.

The main attraction of this event was the various Hands-on sessions on *Origami - Fun with mathematics* by Smt Shandhya Bansal; Low cost Science Experiments by Shri Kapil Tripathi, Scientist 'E', VP; Science of Flying by Shri Madhav Khare; Robotics by Shri Vivek Yaday; Science Behind Miracles by Mr Zia Khan; Astronomy and Night Sky Watching by Dr. Arvind Ranade, Scientist E and his team, *Wonder of Chemistry* by Shri Sachin Narwadiya, Scientist 'B', VP; Science Games by Shri Rakesh Thakur; Photography & Videography *by* Neelum Kala Kendra.



Hands on activities session

Dr. Irfana Begum, Project Officer and Shri Navneet Gupta, Project officer assisted in all activity-based session.

The event *Science Fusion-2015* concluded with the valedictory session on 22 June 2015. Major S.C. Jhighan, Registrar, VP, delivered the keynote address on this occasion. Dr. R. Gopichandran, Director, VP was also present. Shri Manish Mohan Gore, VP, delivered welcome address and coordinated this session. A total 67 children from NCR region participated in the programme. Resource materials developed by VP were provided to the children and certificates were also given to the participants.