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Catalysts
The agents that make chemical reactions faster

Jöns Jacob Berzelius (1779–1848) | Geoffrey Wilkinson (1921-1996) | Wilhelm Friedrich Kühne (1837-1900)

Inside

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

Editorial

Science and Technology Communication: Way to Go

Vigyan Prasar crosses a landmark even as you read this piece. The institution enters its twenty-first year of active functioning. All anniversaries are opportunities to take stock and plan ahead. What can be expected from Vigyan Prasar?

In human terms this would signify a period when a role full of social responsibilities would be expected beyond the phase of higher education and skill building. Also we are on the threshold of a new five-year plan and proposing many initiatives in science and technology communication for the next five years.

This period should be witness to:

1. a higher level of public understanding of science and technology,
2. a significant increase in science literacy,
3. empowerment of the people based on capacity for critical analyses of development issues,
4. dynamic movements for conserving and building on our traditional sciences, and
5. a thrust to nurture an ambience for creativity and innovation.

Vigyan Prasar has established itself as a competent arm for effective science outreach in the last two decades. It needs to grow to serve the development agenda of the government while conducting research on emerging facets of science and technology communication. It should be housed in proper premises with necessary facilities to ensure effective operation for the next decade. For the uninitiated we function from two premises, one largely focussed on developing TV programmes and housing the EduSat studio (hub). The rest of the activities are organised at the main campus in NOIDA.

Vigyan Prasar is on Lok Sabha TV, DD National, Gyan Darshan and several regional channels with about 30 minutes of fresh programme daily on each. Other national and regional channels also require engaging and interesting software. We need efficient processes and higher level of in-house capacity for this to become a reality and to start making any impact on the society.

EduSat has 50 terminals linked to Vigyan Prasar for daily science programmes with two-way connectivity. This very powerful set-up helps improve training of resource persons. The present time utilisation is not optimal. Several centres operate very formally and with lack of enthusiasm. We need self-motivated coordinators and a ten-fold increase in the number of interactive terminals. The level of professionalism at the hub has vast potential for improvement, and finally, the hours of uptime need to go up for each centre.

AIR has been broadcasting weekly science programmes in 18 languages over 120 stations. These are well received because Vigyan Prasar has ensured high-quality programmes, gifts for listeners who respond to end-of-episode questions, frequent bridge porganmmes and phone-in opportunities. Prasar Bharati is willing to offer more slots and more stations. We will shortly commence a response service so that no question remains unattended. A database of questions will yield insights for developing new programmes. The challenge is to retain the interest of the community with interactive formats and interesting content both for AIR broadcasts and with community radios. We are developing capsules that can be used to trigger programmes for 30 minutes using a 5-minute pre-recorded input in Hindi and/or regional language.

The web space is expanding with easy accessibility and better connectivity. E-magazines, podcasts and webcasts and many other features are being used and have the potential for reaching specific target groups. Our portal is attractive with many features. There is need to improve the presentation and navigation even as accessibility to digital formats is growing exponentially.

Community Science Centres have a mixed history of effectivness. Vigyan Prasar should start a partnership scheme of working with these centres and nurture them into effective arms for science popularisation. The concepts of 'exploratories' need to be infused in these centres to make every visit by children memorable.

Emphasis on environment and climate change, gender empowerment, and technology popularisation and communication has helped in evolving a new image of the institution while reaching new target audiences. Scientists in Vigyan Prasar and of partnering institutions including national science and engineering academies and universities has raised the level of discourse.

International cooperation in S&T communication will yield significant benefits for the country. Many societies in similar stages of development have much to share and learn from experiments in science outreach. Vigyan Prasar may be the node for such collaboration and develop schemes for meaningful interaction between experts in India and abroad.

The mandate of the institution is empowering every citizen by developing capacity for informed decision making. Will we come up to your expectations?

☐ Anuj Sinha
E-mail: sanuj@vigyanprasar.gov.in

Editor	:	Er Anuj Sinha
Address for correspondence	:	Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016 Tel : 011-26967532; Fax : 0120-2404437 e-mail : info@vigyanprasar.gov.in website : http://www.vigyanprasar.gov.in

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Catalysts
The agents that make chemical reactions faster

Dr. Subodh Mahanti
E-mail: smahanti@vigyanprasar.gov.in

"As far as the processes of life are concerned, the most important role is played by proteins called enzymes, all of which are globular proteins. They are molecules which encourage other molecules to interact in certain ways — in chemical terminology, they act as catalysts."
John Gribbin in *Almost Everyone's Guide to Science*, Universities Press (India) Ltd., Hyderabad, 1998.

"In the presence of a catalyst a reaction proceeds through other intermediate stages than without it, and these stages are more accessible from the energy viewpoint. In other words, other activated complexes appear in the presence of a catalyst, and less energy is needed for their formation of the activated complexes appearing without a catalyst."
N. L. Glinka in *General Chemistry*, Vol.1, Mir Publishers, Moscow, 1981

Catalysts are very important for our existence. It is estimated that 90 percent of commercial chemical products involve catalysts at some stage in the processes of their manufacture. Catalysts play an important role in the production of most of the industrially important chemicals. The foodstuff industry is also largely dependent on catalysts. Modern detergents carry enzymes, the biochemical catalysts. Catalysts can also play an important role in environmental protection. In environmentally friendly green chemistry catalysed reactions are preferred because the waste generated is the minimum. Most of the important biochemical reactions occurring in living organisms involve catalysts. The study of catalysts is an important branch of applied chemistry.

What is a catalyst?

In the general context the term "catalyst" refers to anything which creates a situation in which change can occur or make something important to happen. However, the term has a specific meaning in the context of science specifically chemistry or biology with which we are mainly concerned here. In science catalyst may be defined as a substance that alters the speed of, or makes possible a chemical or biochemical reaction, but remains unchanged at the end of the reaction. The fact that a catalyst remains unchanged at the end of reaction does not mean that it does not take part at some stage of the reaction. We should remember that most of the chemical reactions happen in many stages. A catalyst usually reacts with one or more reactants to form intermediates that eventually give the final product and in the process regenerate the catalyst. Hence, the catalyst can be recovered unchanged at the end of the reaction and it can be reused again. The term "catalyst" was coined by the Swedish chemist Johns Jacob Berzelius (1779-1848) in 1846. It is derived from the Greek word *katalein* meaning "to annul", or "to unite" or "to pick up".

Johns Jacob Berzelius

The phenomenon of the change in the rate of a chemical reaction under the action of catalysts is called catalysis. The reactions which, proceeds under the action of catalysts, are called catalytic.

The function of a catalyst can be understood better with an example. In laboratory, one of the methods that are used for making oxygen is by decomposing the aqueous solution of hydrogen peroxide (H_2O_2) into water and oxygen.

$$2H_2O_2\,(aq) \rightarrow 2H_2O\,(l) + O_2\,(g)$$

Hydrogen peroxide — Water — Oxygen

Under normal circumstances the rate of decomposition of hydrogen peroxide is very slow. In fact the rate of decomposition is so slow that hydrogen peroxide solutions are commercially available. The rate can be increased by increasing the concentration of the hydrogen peroxide solution or by increasing the temperature. However, the rate can be increased easily under normal conditions by adding Mn_2O_4 [manganese (IV) oxide] in powder form to the solution. The rate is increased manifold. While Mn_2O_4 increases the rate of reaction, it does not get consumed in the process. It can be seen in its original form at the end of the reaction. Manganese (IV) oxide is an example of a catalyst.

Catalysts accelerate the reaction rates millions of times or more. There are reactions which can be initiated only under the action of a catalyst and not otherwise; such reactions do not proceed at all under ordinary conditions. A catalyst can be in any state — solid, liquid or gas. Most catalysts are also highly specific in the type of reaction they catalyse.

Catalytic activity

The property of a catalyst in terms of catalytic activity is measured by the catalysed rate of conversion. It is the measure of the increase in the rate of a chemical reaction caused by a catalyst under specified conditions. The SI derived unit for measuring catalytic activity is 'katal' and is expressed in moles per second. The productivity of a catalyst can be described by the turn over number (TON) and the catalytic activity by the turn of frequency (TOF); that is, TON per unit time.

Positive and negative catalyst

In practice, most catalysts are used to speed up reactions. Usually when someone refers to the term "catalyst", they mean positive

Geoffrey Wilkinson

catalysts meaning substances which speed up chemical reactions. However, there are negative catalysts too, which slow down the rate of catalysed reactions or make them less likely to occur. They are also called inhibitors, which work by inactivating catalysts for the reaction or by removing free radicals in a chain reaction.

There are pre-catalysts – substances which convert to catalysts in the reaction. A catalytic reaction using a pre-catalyst involves an induction period because of the time needed for pre-activating the catalyst. Wilkinson's catalyst chlorotris (triphenylphosphine) rhodium (I) $[RhCl(PPh_3)_3]$ developed by the British chemist Geoffrey Wilkinson (1921-1996) is an example of proto-catalyst, it loses one triphenyl phosphine (PPh_3) ligand before entering the true catalytic cycle.

Chemical nature of catalysts

There is a wide variety of substances which act as catalysts. The most widely used catalysts are proton acids. They catalyse many reactions involving water, including hydrolysis and the reverse. Transition metals and their complexes are often used as catalysts. Multifunctional solids like zeolites, alumina, higher-order oxides, graphite, and nanoparticles are often catalytically active. A large number of proteins called enzymes act as catalysts.

Classification of catalysts

Catalysts can be broadly divided into two groups:

i. Homogeneous catalysts
ii. Heterogeneous catalysts

Enzymes (biocatalysts) are homogeneous catalysts, but they are often seen as a separate group.

Homogeneous catalysts: Catalytic processes involving homogeneous catalysts are called homogeneous catalyses in which the catalyst, the reactants and the products remain in the same phase, or in other words, form a single phase. Usually homogeneous catalysts are in the liquid state and are dispersed or dissolved in the reactants. The catalytic decomposition of hydrogen peroxide into water and oxygen is an example homogeneous catalysis. The ions $Cr_2O_7^{2-}$, WO_4^{2-}, MoO_4^{3-} catalyse the reaction. Catalysis of the transformation of organic molecules by acids or bases constitutes one of the most widespread types of homogeneous catalysis. The catalysis of organic reactions by metal complexes in solution, which is of much industrial importance, also falls under homogeneous catalysis.

Heterogeneous catalysts: In heterogeneous catalysis the catalyst forms an independent phase, usually solid. Usually the catalyst is present in solid phase and the reactants and products are in gaseous or liquid phases. Heterogeneous catalysis proceeds by the formation and subsequent reaction of chemisorbed complexes or surface chemical compounds.

The reaction between ethene and hydrogen under the influence nickel as catalyst is an example of heterogeneous catalysis. $C_2H_4\,(g) + H_2\,(g) \rightarrow C_2H_6\,(g)$. Other examples of heterogeneous catalytic reactions are the oxidation of sulphur dioxide into trioxide in the contact method of producing sulphuric acid; the synthesis of ammonia; and the oxidation of ammonia in the production of nitric acid. In fact, the oxidation of sulphur dioxide into trioxide in the contact method of producing sulphuric acid was the first important heterogeneous catalytic process to be used in chemical industry. It was developed in 1875.

The total surface area of solid catalyst has important effect on the reaction rate. The effectiveness of heterogeneous or solid catalyst is increased when it is used in powder form because a powder has a much larger surface area than a large lump. The catalytic activity is usually proportional to the surface area. Finely divided metal powders are often used for liquid-phase reactions in batch reactors. In the manufacture of margarine from vegetable oils, finely divided nickel is used for the hydrogenation of unsaturated glycerides.

Usually heterogeneous catalysts are dispersed on a second material (or a support) that enhances the effectiveness of their functioning or minimises their cost. A mere surface, sometimes used as a support helps to spread the catalyst so that surface area is increased. But most supports used, like alumina or various kinds of carbon, interact with the catalyst and affect the catalytic reaction. Silicon dioxide, titanium dioxide, calcium carbonate, and barium sulphate are examples of specialised supports.

Enzymes

In human body, as in any other living organism, hundreds of chemical reactions are taking place all the time. These reactions take place in individual cells. Many of these reactions need to be fast. As we know, by increasing the temperature the reaction rate can be increased to some extent; but in the living organism temperature cannot be raised too high because high temperature would kill the cells of the body. Fortunately there is a special class of substances called enzymes which act as catalysts to speed up reactions in living organisms. The term "enzyme" was coined by the German physiologist Wilhelm Kuhne (1837-1900) in 1878.

Enzymes are highly efficient biologically active catalysts. They are homogeneous

Wilhelm Friedrich Kühne

catalysts and they act in solution in body fluids. Enzymes are proteins. Every enzyme usually has an active site that is a region into which only molecules of a very particular shape and size will fit. In fact only one type of molecule fits the active site and this quality of enzymes make them more specific than any other catalysts. In laboratory, as discussed above, the rate of decomposition of hydrogen peroxide can be made faster by manganese (IV) oxide, an inorganic catalyst. In human body the catalyst used for decomposition of hydrogen peroxide is an enzyme called catalase. In human body hydrogen peroxide is produced as a by-product of reactions undergoing in cells. However, our body needs to decompose hydrogen peroxide immediately after its production because otherwise it may cause damage to other tissues. The active site of catalase only fits hydrogen peroxide and no other molecule.

Like other catalysts, enzymes can also be easily poisoned or inhibited. A catalyst becomes inhibited when its active site is occupied by an unwanted molecule. For metal catalysts hydrogen sulphide is an effective inhibitor. Metal ions play the role of poison for enzymes. Enzymes cannot function at temperatures much above body temperature, that is, 37 degrees Celsius. This is because the rise of temperature changes the three-dimensional structure of proteins. With the increase of temperature the changes become irreversible, that is, geometry of the protein molecule cannot be restored again. This process is called denaturation. With the destruction of the three-dimensional structure of protein molecule its active site, which holds the substrate in position, loses its ability to do so.

The rate of a reaction catalysed by an enzyme increases with the increase of enzyme concentration. The rate also increases with increase in substrate concentration, but there is a limit to such increase. This is because once the active sites of enzyme molecules become saturated with substrate molecules, the reaction cannot be speeded up farther.

Like other catalysts, enzymes too can also be poisoned. We say an enzyme is poisoned when its active sites are clogged by other undesired molecules. Metal ions are capable of poisoning enzymes. To avoid poisoning it becomes necessary to ensure that reactants are free of poisons before they are put in the reaction chamber containing a catalyst.

How catalysts function

According to the transition state theory of chemical reaction, the reactants form a transition state or activated complex before they are converted into products. To reach the activation state the reactants require excess energy over the ground state energy. This excess energy is called activation energy. Activation energy is the minimum energy that the reactants must have before they can change into products. A transition state or activated complex is an energetically excited state which is intermediate between reactants and products in a chemical reaction. In the process of the conversion of reactant(s) into product(s), some of the old bonds of the reactant(s) are broken and new bonds are formed. The slowest step in the bond rearrangement produces the activated complex, which is neither the reactant(s) nor the product(s).

A catalyst increases the rate of a chemical reaction by providing an alternative mechanism involving a different transition state and lower activation energy. The alternative pathway makes it possible for more molecular collisions to have the energy needed to reach the transition state. It may also be stated that an activated complex does not always change into products; it can equally change into reactants. An activated complex may change into an intermediate that is more stable than the activated complex. It may be possible, though very rarely, to isolate an intermediate. It may also be possible that intermediate may turn into another activated complex before it is finally converted into products.

A catalyst does not affect the chemical equilibrium of a reaction because both the forward and reverse reactions are equally affected by the catalyst.

Catalytic converter

A catalytic converter is a device fitted to the exhaust system of a motor vehicle in order to reduce toxic emissions from the engine by converting harmful exhaust products to relatively harmless ones. It does so by passing the exhaust gasses over a mixture of catalysts coated on a metallic or ceramic honeycomb. The purpose of using a honeycomb structure is to increase the surface area. Three harmful exhaust products released by a petrol engine are: unburnt hydrocarbons, carbon monoxide produced by incomplete combustion of hydrocarbons, and nitrogen oxides produced by nitrogen in the air reacting with oxygen at high engine temperature. Metals like palladium, platinum and rhodium acting as catalysts convert hydrocarbons and carbon monoxide into carbon dioxide and water, and nitrogen oxides into nitrogen and oxygen. While a catalytic converter can significantly reduce the emission of hydrocarbons, carbon monoxide and nitrogen oxides, it slightly increases the emission of carbon dioxide.

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(The article is a popular presentation of salient features of catalysts available in existing literature. The idea is to inspire young generation to know more about catalysts. The author has given the sources consulted for writing this article. However, the sources on the Internet are numerous and have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article and the sources of the pictures reproduced here.) ■

Nutrigenomics: relationship between diet, genes and our health

Ashutosh Debata**

Darshan Panda*

E-mail: ashutoshdebata@yahoo.co.in; darshan.panda216@gmail.com

Introduction

We eat a complex mixture of foods, which contain a host of different nutrients and other bioactive compounds including some nutritional constituents that typically occur in small quantities. From the very dawn of scientific era we have known that our food decides our health and mind. But does how does it happen? From our genetics lesson we know that every biological trait is controlled by a gene or group of genes. So if our food decides our health then there must be some sort of nutrient-gene interaction at molecular level ultimately determining our gross phenotype (the set of observable characteristics of an individual resulting from the interaction of its genetic constituent with the environment). This is what is illustrated and explained by nutrigenomics – the study of interaction between dietary components and the genome. Various clinical trials dealing with nutritional research have proved the relationship between diet, health, disease and reproduction. For example, eating a diet rich in foods containing plant polyphenols (e.g., apples, onions, etc.) reduces the risk of developing gastrointestinal tract cancers; consumption of cooked tomato sauces reduces likelihood of developing prostate cancer in men; and a high folate intake reduces plasma homocysteine, which is an independent risk factor for cardiovascular disease (CVD), and also prevents neural tube defects in the developing foetus in pregnant women. New areas of study like genomics, *transcriptomics,* proteomics, metabolomics, and bioinformatics are now helping to solve the intervening puzzle between nutrients and genes. It is the flood of data from these researches which are updating our knowledge in understanding the relationship between nutrition and genes.

Nutrigenomics concept

The science of nutrigenomics is the study of how naturally occurring chemicals in foods alter molecular expression of genetic information in each individual. According to Mexican nutritionists Chavez, nutrigenomics is the study of molecular relationships between nutritional stimuli and the response of the genes. From a nutrigenomics perspective, nutrients are dietary signals that influence gene expression and, subsequently, metabolite production. These metabolites have significance in different types of biochemical reactions taking place in the cell and ultimately decided the gross phenotypes of our body. Furthermore, nutrigenomics aims at identifying the genes that influence the risk of diet-related diseases on a genome-wide scale, and to understand the mechanisms that underlie these genetic predispositions.

Nutrient-gene interaction

Nutrients as environmental factors can interact with the genetic material. Nutrigenomics states that in every individual human being nutrients and genes interact with each other in a unique manner ultimately determining the metabolic efficiency, physiological capacity and the strength of immunity of a person. All these factors as a whole decide the physical and mental wellbeing of a person in particular.

In all human beings 99.9% of genomic sequences are same. This small variation of 0.1% in the nitrogen base sequences in our genome creates a total difference between us. We get this small variation due to a phenomenon called as single nucleotide polymorphism (SNP). SNP is the variation in sequence between individuals caused by a change in a single nucleotide. Many human studies have demonstrated the evidence for interaction between SNPs in various genes and metabolic response to diets. Moreover, analysis of SNPs provides a potential molecular tool for investigating the role of nutrition in human health, diseases and identification of optimal diets.

Nutrients and genome interact at two levels:

1) Nutrients can induce or repress gene expression thereby altering individual phenotype.
2) Conversely, single nucleotide polymorphisms can alter the bioactivity of important metabolic pathways and mediators and influence the ability of nutrients to interact with them.

The conceptual basis for nutrigenomic research can be summarised with the following four principles:

1) Common dietary chemicals act on the human genome, either directly or indirectly, to alter gene expression.
2) Under certain circumstances and in some individuals, diet can be a serious risk factor for a number of diseases.
3) Some diet-regulated genes are likely to play a role in the onset, incidence, progression, or severity of chronic diseases.
4) The degree to which diet influences the balance between healthy and disease states may depend on an individual's genetic background.

There is ample evidence from researches carried out around the world to prove the role of nutrients in the maintenance of genomic stability. An unstable genome is likely to be more susceptible to various anomalies; for instance, cancer. It has been clearly demonstrated that DNA metabolism and repair depend on a wide range of dietary factors that act as cofactors or substrates in metabolic pathway, but much less is known about the impact of the deficiency or excess of cofactors and/or micronutrients on the fidelity of DNA replication and repair.

Genes and diet related diseases

Can an individual's risk of common diet-related diseases such as heart disease and diabetes be predicted from their genes, and is this likely to be possible in future? Is this type of testing useful to decide an individual's diet? We get answers to these questions from the science of nutrigenomics. There are several diseases which are directly controlled by genes and have been profoundly influenced by diet. The following are some of them:

a) Diet and cancer

In 2009, there were 10 million new cases, 6 million deaths, and 22 million people living with cancer in the world. Inherited mutations in genes that could be important in causing susceptibility to cancer include genes involved in the metabolism of carcinogens, or genes involved in nutrient metabolism. Although at the cellular level, cancer is recognised as a disease of genes, there is good epidemiological evidence that this is substantially modulated by environmental factors such as diet. In the Japanese population, for example, the incidence of colon cancer was low in the 1960s, but since then rates have increased rapidly and now exceed UK rates. This is thought to have been associated with adoption by the Japanese population of a westernised diet, and, possibly, increased susceptibility to it. When the amount of fat eaten and breast cancer incidence are compared in various populations worldwide, there is a strong interrelationship. High alcohol consumption is also clearly related to an increased risk of cancers of the mouth and throat, gullet, liver and breast.

Eating large quantities of Chinese-style salted fish (in some Asian populations) also increases the risk of throat cancer. Food contaminated with aflatoxin (due to a fungus growing on peanuts and other foods) increases the risk of liver cancer, but possibly only in regions where infection with hepatitis (the main cause) is common. There is evidence that fruit and vegetables probably reduce the risk of cancers of the mouth, gullet, stomach and bowel. There is also evidence that preserved meat and red meat increase the risk of bowel cancer and that fish may be protective; salt preserved foods and salt increase the risk of stomach cancer; and that very hot drinks increase the risk of cancers of the mouth, throat and gullet. There is evidence from some studies that dietary fibre protects against bowel cancer.

b) Diet and heart diseases

Are some geneticists right to argue that genetic testing will improve predictions of heart disease in individual patients and is it possible that specific dietary advice for individuals at greatest cardiovascular risk will really help to reduce the incidence of this disease? Nutrigenomics provide us a better picture. Heart disease is the leading cause of death in developed countries, and also India. It is expected to become the leading *global* cause of death by 2020. Atherosclerosis (the deposit of fatty substances inside the walls of the arteries) is the main cause of heart disease and stroke. Because of the high incidence of heart disease throughout the world, and the evidence for the role of cholesterol, interactions between genes and dietary fats (lipids) has been one of the main areas of research in nutrigenomics.

The fatty substances in our diet chiefly include the cholesterol and other lipid-rich fatty substances. There are two types of cholesterol – high density lipoproteins (HDL), also called as 'good' cholesterol and low density lipoproteins (LDL), also known as 'bad' cholesterol. Raised levels of bad (LDL) cholesterol can be linked with increased risk of heart disease whereas high levels of good (HDL) cholesterol appear to have a protective effect. In our blood we always have a marginal concentration of LDL. This is possible due to the presence of a protein receptor called LDL receptors, on the outer surface of our nucleated cells, especially hepatocytes (liver cells). When blood comes in contact with LDL receptors, LDL binds to it, takes it into the cell and neutralises it. Mutation in the LDL receptor gene increases the level of LDL level in the blood. This abnormal state causes a disease called familial hypercholesterolaemia (FH) in which there is an excess of cholesterol in the bloodstream. People with FH are advised not to smoke and to eat a healthy diet, and are given cholesterol-lowering medication (statins) to lower their risk.

Another important gene involved in lipid metabolism is the apolipoprotein E (APOE) gene. It codes for a protein receptor expressed on the outer surface of hepatocytes called APOE receptor. This protein receptor plays an important role in the breakdown of triglyceride-rich lipoprotein constituents. The APOE gene has three common forms, known as APOE2, APOE3, and APOE4, leading to six different genotypes (because every individual has two copies). People with the E4 form have the highest cholesterol levels and people with the E2 form the lowest; but the E3 form is the most common. In addition to this, experimental studies also have shown that some people's cholesterol levels increase more than others when they eat a high-fat diet. This variability in response to a high-cholesterol diet has led many researchers to conclude that genetic differences explain why some people (called 'hypo-responders') can eat high-cholesterol foods with very little adverse effect, but others (called 'hyper-responders') find that their cholesterol levels increase significantly, potentially threatening their health.

c) Genes, diet and diabetes

Diabetes is a group of disorders that result in high blood sugar levels (hyperglycaemia). Diabetes also increases the risk of other diseases such as heart disease, blindness, nerve damage and kidney damage. There have been very few studies of gene-diet interactions in diabetes. There is evidence from various studies to suggest that the basis of diabetes is fundamentally an interaction between genes and the environment. Research has provided direct evidence to prove that a high-cholesterol and fat-rich diet can cause mutations in a gene that code for a protein that plays an important role in the regulation of fatty acid storage and glucose metabolism in our body and can lead to type-II diabetes.

d) Brain disease and neurodegenerative disorders

There is some evidence that diet may be important in the decline in brain function which occurs as people age, including in the major neurodegenerative disorders such as Alzheimer disease (the commonest form of dementia) and Parkinson's disease. Various research works have established a link between APOE genotype (discussed earlier) and risk of Alzheimer disease. It has been found that a high LDL level in the blood may aggravate the disease. One recent study has found a gene-environment interaction between the APOE4 gene and drinking alcohol in middle-age (but not old age): risk of dementia increased with increasing alcohol consumption, but only in those individuals with at least one copy of the APOE4 genetic Variation.

e) Gene diet and obesity

Obesity is a disorder affected by multiple genetic and environmental factors, in particular nutrients and their interrelationships. Increasing knowledge of the genes and molecules involved in the development of obesity is paving the way for new methods of controlling obesity. In this sense, nutrigenomics may help develop new functional foods for controlling obesity based on the scientific knowledge

of the impact of specific nutrients on the mammalian body weight control system and their mechanisms of action. As we all know, there are several metabolic syndromes that are linked to obesity, like hypertension, low HDL cholesterol, abdominal obesity, high fasting glucose, and many others. Recent studies have shown that obesity is not only directly caused by our environment but is also influenced by our genetic makeup. According to a recent discovery we have energy-thrifty genes that helped our ancestors survive in the past, when food was scarce and unpredictable. These genes were helpful in the past, but are now the cause of obesity in an environment where food is plentiful. However, it can also be observed that not all people in this kind of environment are obese. People of the same race, background and even living in the same environment as in a family have different response or reaction to a certain environment condition. Thus, we can safely say that genetic variations also play a big role in the development of obesity.

From these observations and studies, nutrition specialists believe that obesity can be prevented through customised diet and lifestyle prescription. To an obese person, losing 5%-10% of weight can delay or prevent the onset of the metabolic disorders associated to obesity, which he or she is prone to Nutrigenomics focusses on identifying the influence of nutrition to the gene expressions and diet-related diseases. Though it is still at an early stage of development, nutrition specialists have recognised the potential of nutrigenomics in the eradication of obesity epidemic in the near future. Understanding how some components in food interacts with certain genes, which can heighten the risk of metabolic diseases, could help us avoid the foods that would induce those reactions. Moreover, choosing the right amount of specific nutrients our body needs would help optimise and maintain our health. Nutrigenomics enables us to be aware of the risks of obesity to our health and it also gives us a gateway to prevent an obesity epidemic. With the development of research and studies about personalised nutrition, solution for obesity problem could soon be available.

Apart from all these health disorders a direct relationship has been found between gene and diet in other health anomalies like metabolic syndrome, food intolerances, allergies and inflammatory diseases, osteoporosis, and fractures.

Conclusion

Humans, their food, and their illnesses are complex. Food may affect our health via interaction with our DNA, regulation of genes, post-translational modification of proteins, or metabolic perturbation. Molecular nutrition in terms of nutrigenomics could serve as a new tool for nutritional research in mitigating the problems related to human health. In the coming years, innovations in nutrition research with use of various molecular technologies will indubitably update our basic understanding of nutrient-gene interrelationship and help to define new methods for curing deadly human diseases like cancer, Parkinsonism and Alzheimer's disease.

** Principal Stewart Science College, Cuttack, Odisha,
* Lecturer, Dept. Of Biological Sciences, Tutorvista Global Pvt.Ltd, Domlur, Bangalore,

5Es - Energy, Environment, Efficiency, Economy and Ethics are great challenges for the society: Prof. Pramod K. Verma

Well known geologist and science and technology policy maker Prof. Pramod K. Verma is Scientific Advisor, Government of Madhya Pradesh and Director General, Madhya Pradesh Council of Science & Technology, Bhopal. With a long experience of 25 years in teaching and research and scientific and academic administration Prof. Verma has been associated as Director, Remote Sensing Applications Centre (MPCST, Bhopal); Professor of Applied Geology, School of Studies in Earth Science, Vikram University, Ujjain; Nodal Officer, Association for Madhya Pradesh Inter-University Cooperation; Officer-In-Charge, University Science Research Promotion Cell; Director, University Information Centre and Advisor, University Computer Centre; Officer on Special Duty, (Academic Development and Planning); and Coordinator, University Examinations.

Recipient of gold medals during his M.Sc. and M.Phill, Prof. Verma has been awarded with prestigious awards and fellowships including FTIYS Fellowship; DAAD (Germany) Post-doc Fellowship; SERC (DST) Visiting Fellowship; INSA Visiting Fellowship; and GTZ (Germany) Special Award. Prof. Verma completed his Ph.D. from Vikram University, Ujjain and Post-doc from Heidelberg (Germany).

Prof. Verma is actively associated with many national and international professional bodies and has special interest and involvement in the area of Active Tectonics, Structural Geology, Geoinformatics, and Rural Technology.

Recently Er Anuj Sinha, Director, Vigyan Prasar and Consultant, Department of Science and Technology, Govt. of India, interacted with Prof. Pramod K. Verma on a variety of important issues like the universe, Earth and atmospheric sciences, ecological footprint of S&T, and remote sensing interpretation, etc. Some other issues like role of science communicators in directing research agendas, Vigyan Prasar's involvement in supporting science outreach in M.P. and other challenges were also discussed during the interaction. This full-length interaction is published here:

Er Anuj Sinha: How do we understand the universe? Are scientists sure of their discoveries and theories?

Prof. Pramod K. Verma: The universe is commonly defined as the totality of everything that exists, including all physical matter and energy, the planets, stars, galaxies, and the contents of intergalactic space. More customarily, the universe is defined as everything that exists, has existed, and will exist. According to this definition and our present understanding, the universe consists of three elements: space and time, collectively known as space-time or the vacuum; matter and various forms of energy and momentum occupying space-time; and the physical laws that govern the first two. The universe is immensely large and possibly infinite in volume. A 2010 study by astronomers resulted in a figure of 300 sextillion (3×10^{23}) stars in the universe.

Prof. Pramod K.Verma (left) along with Er Anuj Sinha releasing a CD of radio science programme produced by Vigyan Prasar during July 2011 at Bhopal; after the release function Er Sinha interviewed Prof. Verma which is published here

The universe is believed to be mostly composed of dark energy and dark matter. Less than 5% of the universe is ordinary matter, a relatively small contribution. The universe is also bathed in a highly isotropic microwave radiation that corresponds to a thermal equilibrium blackbody spectrum of roughly 2.725 kelvin. The present overall density of the universe is very low, roughly 9.9×10^{-30} grams per cubic centimetre. This mass-energy appears to consist of 73% dark energy, 23% cold dark matter, and 4% ordinary matter. Thus the density of atoms is on the order of a single hydrogen atom for every four cubic metres of volume. The properties of dark energy and dark matter are largely unknown. Dark matter gravitates as ordinary matter, and thus works to slow the expansion of the universe; by contrast, dark energy accelerates its expansion.

Theories of an impersonal universe governed by physical laws were first proposed by the Greeks and Indians. Over the centuries, improvements in astronomical observations and theories of motion and gravitation led to ever more accurate descriptions of the universe. The modern era of cosmology began with Albert Einstein's 1915 general theory of relativity, which made it possible to quantitatively predict the origin, evolution, and conclusion of the universe as a whole. Most modern, accepted theories of cosmology are based on general relativity and, more specifically, the predicted Big Bang. However, still more careful measurements are required to determine which theory is correct. The prevailing Big Bang model accounts for many of the experimental observations

It is difficult to imagine that the next 100 years will reveal as many fundamentally new concepts as what we have already encountered. The last 100 years uncovered the existence of galaxies, the chemistry of stars, the evolution of stars, the expansion of the universe, the existence of extra-solar planets, the nature of the surfaces of the planets in the solar system, and the universe through the various electromagnetic windows from gamma rays to radio waves. This period is absolutely unique in human history, and

this pace of discovery will not repeat itself again. The next 100 years will be a period of refining what we already know, but there is still much to be done in that arena, although it is not going to rival anything like the previous 100 years of excitement.

The wild card is, of course, the nature of dark matter and dark energy. They constitute more than 96% of the contents of the universe. Even though we may understand the visible content completely, this larger invisible arena in which they operate is truly the biggest mystery of 21st century astronomy and physics!

A second wild card is the search for life beyond Earth. We have the intriguing mysteries of extra-solar planets which we are discovering at a very brisk clip. Each of these new worlds is an enigma waiting to be explored and 'solved'.

A.S.: Where is current research in Earth and atmospheric science leading us?

P.K.V.: Over the years, our understanding of the processes operating in the Earth and its atmosphere has increased considerably. With inclusion of mathematical calculations and models including interdisciplinary approach through different science/engineering disciplines, the Earth and atmospheric sciences have transgressed all boundaries. This has led to a variety of new questions and new avenues of research as well. Earthquake prediction and understanding processes operating at deep crustal level; search for new mineral deposits including hydrocarbons; role of microorganisms in regular monsoonal system including artificial rain processes; effective and efficient use of alternative sources of energy, particularly geothermal energy; efficient water management for making rivers perennial and keeping Earth green, etc., are some of the areas of prime concern. Very high-resolution satellite data along with powerful hardware and specially designed software, data available from deep bore holes both on land and under ocean, dynamic climatic data available through automatic weather stations and doppler radars, and many other similar high quality data have opened new vistas for high-level research and modelling in Earth and atmospheric sciences. Extra-terrestrial geologic and climatic investigations are yet another avenue in this field. Moreover, science must translate into benefit of society. So, as President of the Earth System Sciences Section of the 99th Indian Science Congress to be held at Bhubaneswar during 3-7 January 2012, I have kept theme as "Innovative Earth Sciences for People's Prosperity".

A.S.: Do costs of science teaching and research outweigh the benefits?

P.K.V.: Despite strong commitment of government to science teaching and research, India compares poorly with other major Asian countries. In Japan, for example, nearly 3 percent of GDP goes to research and development; in South Korea and Taiwan, the figure is nearly 2 percent. In India, research and development receives only 0.8 percent of GDP. Though India's share of GDP expenditure on research and development has increased from 0.5 percent in 1975 to 0.8 percent at present, a lot has to be done in this direction. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), India has the lowest public expenditure on higher education per student in the Budget. The bulk of government research and development expenditures go to government agencies like DRDO, CSIR, ICAR, Atomic Energy, DoS, etc. Consequently, a very small budget is normally available to university laboratories where a large number of future scientists get training under supervision of scientific think tanks.

A recent survey of Indian scientific contributions measured through impact factor of journals has yielded good hope. However, numbers of patents, particularly those that have been/can be translated into commercial production, are finger countable. This is mainly because Indian scientific research is mostly academic oriented rather than industry oriented. As a consequence, the academia-industry interaction in India is still at infancy, reflected in meagre funds available from industry for this purpose. We need to have harmony between fundamental research and research with techno-commercial value.

A.S.: What is the ecological footprint of S&T? How can we reduce this?

P.K.V.: Ecological footprint measures the extent to which demand of human economies exceeds the capacity of biosphere to provide goods and services. Ecological footprint takes into account the amount of land surface required for growth of fruits, vegetables, biofuels, water surface required to sustain fishes, growth of plants for absorption of CO_2 emitted at present level of consumption and technological development. India is clubbed together with nations whose ecological footprint is between 100-150% larger than their bio-capacity. Scientific and technological development has brought a revolution which has increased the overall standard of living. However, at the same time, it has contributed manifold to the ecological footprint of S&T. As we know, adopting green technology while producing/practising/using energy, infrastructure, farming, etc., can do wonders in this direction. Economic and judicious use of bio resources in a green way to tackle the problem of ecological footprint of S&T can be best achieved by educating our people over this issue.

A large majority of the population is living without proper sanitation, water supply and electricity and without having two square meals a day. Progress can be sustained in the long run only if there is equitable distribution of income, and consumption of basic amenities, irrespective of gender, class, religion. Thus, human needs, development and sustainability should progress hands in hands. The need of the hour is inculcating moral values and love for nature and humanity amongst school-going children. Environmental consciousness amongst children can be developed through experiential learning in close interaction with nature. Every citizen need to be made aware and educated about how, by taking smalls steps in incorporating environmentally friendly products and lifestyles for their need fulfilment, they can assure a better future for themselves and their descendants.

A.S.: Adapting to climate change is like developing resistance to environmental filth in rag pickers. Your comments?

P.K.V.: As per the available records, climate change has occurred several times. Origin, evolution, and extinction of life forms on Earth often relate to these changes. It is a universal process that has its own cycle. The only way to reduce the vulnerability is mitigation and adaptation measures. Climate change mitigation means implementing policies to reduce the effect (viz., to reduce greenhouse gas emissions and enhance sinks) while adaptations are initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Degree of climate change impact felt by a nation depends on available wealth, technology and infrastructure to cope the problem.

To achieve the millennium development goal, a developing nation like India can reduce the vulnerability by taking suitable adaptive measures using optimum resource base, energy and infrastructure on sustainable basis. As the nation has to develop despite the inevitable climate change, we need to make long-term strategies of adaptation for our society through government policies, concentrated efforts of NGO's and active participation of people at national, regional and local level.

A.S.: What role can science communicators have for directing research agendas?

P.K.V.: Often it is said that science is the way of life. Each and every process, activity, event, etc., that we observe in everyday life has its scientific answer. The science behind these short-term and long-term processes, activities, events, etc., is communicated by science communicators. Science communicators spread messages of science to non-scientific audiences, who have little or no knowledge of science, and may be literate/illiterate or uneducated. Many of the ancient and traditional knowledge related to farming, medicine, water harvesting systems, metallurgy, etc., possessed by our rural/tribal people are undocumented and have been propagated generation after generation by practising. There are many societal problems like superstitions, malnutrition, sanitation, health, and hygiene prevailing in rural areas. These are known to public either through media or through communicators who have larger reach to the masses/society. The necessity and requirement of common people can only be brought to the researchers and innovators though science communicators.

A.S.: How would *Panchayats* benefit if there was a tool for calculating local environmental analysis of their projects?

P.K.V.: Within the Indian Government decentralised administrative system, *Gram Panchayats* – institutions of local self-governance – are responsible for identifying and prioritising development projects within their areas of jurisdiction for economic development and social justice. They undertake projects on development of watershed areas, afforestation/plantation and other projects according to the local needs. We know that Environment Impact Analysis or EIA is a study to predict the effect of a proposed activity/project on the environment. It is a decision-making tool and compares various alternatives for a project and seeks to identify the one which represents the best combination of economic and environmental costs and benefits. EIA systematically examines both beneficial and adverse consequences of a project and ensures that these effects are taken into account during project design. It helps to identify possible environmental effects of the proposed project, proposes measures to mitigate adverse effects, and predicts whether there will be significant adverse environmental effects, even after the mitigation is implemented. Thus, obviously the *Panchayats* will be enormously benefitted when they conduct EIA of the projects likely to be implemented in the area.

A.S.: Remote sensing interpretation is still in its infancy and expecting rugged results and planning data is premature. How do you react to this and what should the scientific community be doing to address this?

P.K.V.: I don't agree with this proposition. Remote sensing technology is an established science and engineering that has developed through visual interpretation to almost fully automatic interpretation. The processes and techniques involved in remote sensing interpretation include highly mathematical image analysis to several techniques of clustering, pattern recognition, peak analysis, temporal comparison and correlations, etc. Identification and interpretation of objects on images and their synchronisation with location data (GPS) is now forming the backbone of any planning and development process. In brief, the interpretation from satellite image has strong scientific bias and for applications of image interpretation, sky is the limit.

A.S.: Students of science and engineering in M.P. are competent to guide society to the next stage of development. How can they have a greater role in planning and development process?

P.K.V.: Yes, our students are competent enough to guide society to the next stage of development. However, they do not get ample chance to get involved in this activity/process. The only way a student gets involved in this activity is through his/her project/dissertation work where he/she has scope to forward ideas and suggestions. I remember during my primary education days, every Saturday my teacher used to take us for local visits to post office, railway station, local hat/bazar, museum/zoo, etc., to give us a chance to learn the functioning of these agencies/facilities. It used to have tremendous impact on our way of thinking how a society vis-à-vis nation is built up. With this in mind, we have unique program called 'Madhya Pradesh Mission Excellence Program' where every year we provide opportunity to selected approximately 600 school students to visit the national level academic/research institution and to interact with the eminent scientists at different places in the country. They are real brilliant students. I would suggest that these students must be given opportunity to interact with local government authorities, engineers, and social workers to help them understand planning, working and procedures; their feedback will be enormously useful. In essence, it is to be ensured that each student interacts with and contributes to local level planning and development processes. This is how we may be able to get benefit of our young and innovative brains in national development.

A.S.: Do we indulge through M.P. Council of Science & Technology to increase our conveniences, luxuries and desires? How can we address basic needs and necessities?

P.K.V.: The M.P. Council of Science & Technology is a role model for this kind of institutions. If you look at the objectives and ongoing/future programmes of this Council, it would be clear that it is operating at both the ends – providing R&D support to academic/research institution to innovate, research and produce technology that may lead to make people's life easy, healthy and comfortable, while at the other end it supports bamboo, honey, lac clusters in the tribal and other backward districts to address their basic needs and necessities, yet with scientific merit and temper. The basic needs and necessities may vary depending upon the level of economy and degree of urbanisation. Nevertheless, for a large part of the population it still remains bread, cloth and shelter ('*roti*', '*kapda*' *aur* '*makan*'). Promotion of organic farming, development of local resource based clusters, communicating the merits of scientific practices, deployment of low-cost technology, training on low-cost housing, etc., are some of the programmes through which the Council addresses the basic needs and necessities of underprivileged part of society. Additionally, we provide GIS based district resource maps to decision makers

and program implementing agencies that provides added support to achieve this humble goal. Further, a companion type handholding amongst different government and non-government agencies, with strong participatory approach focussed on inclusive growth of specific area/region, could do wonders. It would ensure a pool of resource and budget and, thus, would lead to optimal deliverables.

A.S.: How can Vigyan Prasar be involved more actively in supporting science outreach for a large state like M.P.?

P.K.V.: Madhya Pradesh is 2nd largest state of the country with rich biodiversity and dominant disadvantaged class population. With its large forest covered areas and widespread agro-climatic zones, the state plays vital role in maintaining healthy environment and wealthy economy of the nation. Vigyan Prasar has many good programs that range from educating teachers in effective science communication to providing scientific materials in local tribal languages. Additionally, it brings excellent resource materials including low-cost effective hands-on scientific experiment/ training kits for science learners and educators as well. We, at our Council, have been frequently using all these materials for inculcating science awareness in the state.

However, there remains a wide gap between urban and rural sector learners and educators mainly due to non-availability of teaching/learning materials in local/regional language. Vigyan Prasar itself or through the Council, may take up such projects to develop common scientific educational materials in local languages. The effort must not be limited to print media but audio-video technology should also be used extensively to fight against scientific illiteracy and superstitions widespread in tribal and other backward districts. Vigyan Prasar may also target budding journalists in educating them in science communication and science reporting. Training one or two persons at each *Panchayat* to hold *Vigyan chaupal* in local language may also be a good idea. These *Vigyan choupals* may target rural women, farmers and even students to inculcate science awareness and scientific practices in them. In this way, superstitious beliefs could be wiped out from society and a scientific environment can be created at the grassroots level. Folk media –such as puppet shows, street plays, stage performances, and folk songs and dances – successfully reach these segments of society where other forms of media have limitations. Finally, I would say Vigyan Prasar has a vast task and enormous scope to create an ambience where every Indian will 'think scientifically and act locally'.

A.S.: What are the grand challenges of our society and how can we prepare to address these?

P.K.V.: I would like to put it in the form of 5Es: Energy, Environment, Efficiency, Economy, and Ethics. Each of these Es is putting great challenge before society. Energy being the foremost challenge demands not only wide-scale application of alternative sources but also needs to be used judiciously as well. While solar energy needs to be extensively used, the bio-energy needs to be equally promoted to get wealth out of waste. Apart from massive plantation and large-scale carbon sequestration strategies, the reworking and deployment of various technologies suggested for creating and maintaining green environment is need of the hour. We have a large manpower that needs to be converted to be efficient manpower.

Educating people and making them efficient in scientific and technological practices is a big challenge before us. Promotion of innovative brains and practices, identification of sectorial skills and mapping them, need based manpower requirement in different sectors and massive skill development programs to achieve it, etc., are some of the suggested measures to achieve target for required efficient manpower for the country. The people's smile can be measured by per capita income. Only intervention and deployment of appropriate technology based on local resource availability can make society economically strong. There needs to be perfect synchronisation amongst energy, environment and efficiency in building up economy.

Last but not the least, the 5th E, ethics, remains a virtue which needs to be essentially interwoven in first 4Es so that we Indians may always be proud of our tradition 'Live and let live'. In a nutshell, all the 5 Es (energy, environment, efficiency, economy, and ethics) should move together in perfect harmony, not as competitors but as companions. I am sure our youth will consider it and will lead India to be "world Guru" by 2047.

Letters to the editor

Science and the supernatural

The article 'Astrochemistry: The chemistry of space' by Utpal Mukhopadhyay in Dream 2047 (September 2011) was excellent, but I don't agree with the concluding lines of the article. The author says 'advancement of knowledge is a continuous process and human being is the sole creator of this progress and no supernatural entity is responsible for it'. This is not correct. Both human beings and supernatural entities like incarnations, prophets, seers, sages and saints have contributed to this advancement of knowledge.

Anirudh Kumar Satsangi
Dayalbagh, Agra

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Free-floating planets or KBOs?

In 'Recent Developments in Science and Technology' section of the July, 2011 issue of Dream 2047, the author has informed about a very interesting fact, viz., discovery of 10 free-floating, Jupiter-like planets without any parent star. According to the author, a possible explanation of this event is that these objects were ejected from their orbits, mainly due to their encounter with other planets. Moreover, these newly discovered celestial bodies are devoid of any parent star within a distance of 1.5 billion kilometres. This means that they may be residing at the outskirts of a stellar system from which they were driven out. Hence, they are more like Kuiper Belt Objects (KBOs) of our solar system rather than planets. This is quite interesting because in that case, it will signify the non-uniqueness of Kuiper Belt like regions and KBO type objects. So, this discovery may open up a new horizons in planetary astronomy.

Utpal Mukhopadhyay
Teacher, Satyabharati Vidyapith
P. O. – Barasat
Kolkata - 700 126
(West Bengal)

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Polycystic Ovary Syndrome

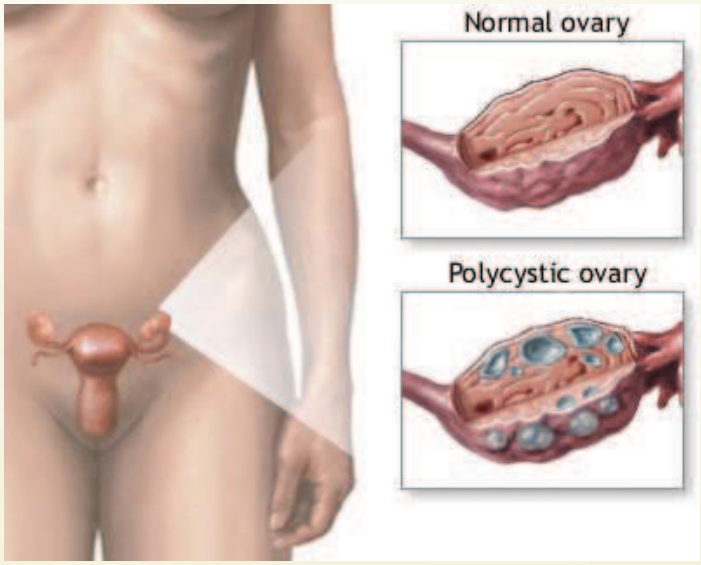
When a woman's femininity is under cloud

Dr Yatish Agarwal
e-mail: dryatish@yahoo.com

> Since art is the expression of beauty and beauty can be understood only in the form of the material elements of the true idea it contains, art has become almost uniquely feminine. Beauty is woman, and also art is woman.
>
> —Rémy de Gourmont
> The Dissociation of Ideas

Polycystic ovary syndrome is one of the most common hormonal disorders, which affects young women during the best years of life. The name of the condition relates to the typical appearance of the ovaries. In most, but not all, women with the disorder, both the ovaries are enlarged and contain numerous small cysts located along their outer edge, the so-called polycystic appearance.

The characteristic hallmarks of the disorder include menstrual disturbances in the form of infrequent or prolonged menstrual periods, excessive hair growth, severe acne and obesity. The condition may manifest itself in adolescence with menstrual abnormalities, or may become apparent some years later with abnormal weight gain, hirsutism and difficulty in getting pregnant.



The exact cause of the disorder — which doctors generally refer to by its acronym PCOS (polycystic ovary syndrome) — is unknown.

Women with polycystic ovary syndrome may have trouble becoming pregnant due to infrequent or lack of ovulation. Early diagnosis and treatment of polycystic ovary syndrome can help reduce the risk of long-term complications, such as type 2 diabetes, heart disease, and stroke.

Symptoms

Polycystic ovary syndrome signs and symptoms often begin soon after menarche, the time when an adolescent girl first begins having periods. In some cases, PCOS may develop a little later during the active reproductive years.

The signs and symptoms vary from one individual to another, in both type and severity. To be diagnosed with the condition, your doctor looks for at least two of the following:

Menstrual abnormality

This is the most common characteristic. Examples of menstrual abnormality include menstrual intervals longer than 35 days; fewer than eight menstrual cycles a year; failure to menstruate for four months or longer; and prolonged periods that may be scant or heavy.

Excess facial and body hair

Elevated levels of male hormones (androgens) may result in physical signs, such as excess facial and body hair (hirsutism); adult acne or severe adolescent acne; and male-pattern baldness or androgenic alopecia.

However, the physical signs of androgen excess vary with ethnicity, so depending on your genetic background you may or may not show signs of excess androgen.

Polycystic ovaries

Enlarged ovaries containing numerous small cysts can be detected by ultrasound. Despite the condition's name, polycystic ovaries alone do not confirm the diagnosis.

To be diagnosed with PCOS, a woman must also have abnormal menstrual cycles or signs of androgen excess. Some women with polycystic ovaries may not have PCOS, while a few women with the condition have ovaries that appear normal.

Infertility
Women with polycystic ovary syndrome may have trouble becoming pregnant because they experience infrequent ovulation or a lack of ovulation. PCOS is one of the most common causes of female infertility.

Obesity
About half the women with polycystic ovary syndrome are obese. Compared with women of a similar age who don't have polycystic ovary syndrome, women with PCOS are more likely to be overweight or obese.

Pre-diabetes or type 2 diabetes
Many women with polycystic ovary syndrome are insulin resistant, which impairs the body's ability to use insulin effectively to regulate blood sugar. This can result in high blood sugar and type-2 diabetes. Pre-diabetes is also called impaired glucose tolerance.

Darkening of the skin
The skin on the nape of the neck, armpits, inner thighs, and vulva and under the breasts becomes darkened and velvety. This skin condition is called a canthosis nigricans and is essentially a sign of insulin resistance.

Causes
A woman's normal reproductive cycle is regulated by changing levels of hormones produced by the pituitary gland in the brain and by the ovaries. The pituitary gland produces follicle-stimulating hormone (FSH) and luteinising hormone (LH), which control the growth and release of eggs (ovulation) in the ovaries. During a monthly cycle, ovulation occurs about two weeks before the menstrual period.

The ovaries secrete the hormones oestrogen and progesterone, which prepare the lining of the uterus to receive a fertilised egg. The ovaries also produce some male hormones (androgens), such as testosterone. If pregnancy does not occur, oestrogen and progesterone secretion decline, and the lining of the uterus is shed during menstruation.

In polycystic ovary syndrome, the pituitary gland may secrete high levels of luteinising hormone (LH) and the ovaries may make excess androgens. This disrupts the normal menstrual cycle and may lead to infertility, excess body hair and acne.

Medical researchers and doctors don't know the exact cause of polycystic ovary syndrome. They continue to explore possible causes for the disorder. Currently, the following factors are a subject of research and possibly may play a role:

Excess insulin
Insulin is the hormone produced in the pancreas that allows cells to use sugar (glucose) as the body's primary energy supply. If a woman has insulin resistance, the ability to use insulin effectively is impaired, and the pancreas has to secrete more insulin to make glucose available to cells. This excess insulin is thought to be a possible culprit that could boost the androgen production in the ovaries.

Low-grade inflammation
The human white blood cells produce substances to fight infection in a process called inflammation. Eating certain foods can trigger an inflammatory response in some predisposed people. When this happens, white blood cells produce substances that can lead to insulin resistance and cholesterol accumulation in blood vessels, a process called atherosclerosis.

Atherosclerosis causes cardiovascular disease. Research has shown that women with polycystic ovary syndrome have low-grade inflammation.

Heredity
If a woman's mother or sister has polycystic ovary syndrome, she might have a greater chance of having it, too. Researchers also are looking into the possibility that mutated genes may be linked to polycystic ovary syndrome.

Abnormal foetal development
New research has shown that excessive exposure to male hormones (androgens) in foetal life may permanently prevent normal genes from working the way they're supposed to — a process known as gene expression. This may promote a male pattern of abdominal fat distribution, which increases the risk of insulin resistance and low-grade inflammation. Research continues to establish to what extent these factors might contribute to polycystic ovary syndrome.

Complications
Having polycystic ovary syndrome makes the following conditions more likely, especially if obesity also is a factor:

- Type 2 diabetes
- High blood pressure
- Cholesterol abnormalities, such as high triglycerides or low high-density lipoprotein (HDL) cholesterol, the so-called "good" cholesterol
- Elevated levels of C-reactive protein, a cardiovascular disease marker
- Metabolic syndrome, a cluster of signs and symptoms that indicate a significantly increased risk of cardiovascular disease
- Non-alcoholic steatohepatitis – a severe liver inflammation caused by fat accumulation in the liver
- Sleep apnoea
- Abnormal uterine bleeding
- Cancer of the uterine lining (endometrial cancer), caused by exposure to continuous high levels of oestrogen
- Gestational diabetes or pregnancy-induced high blood pressure, if you do become pregnant

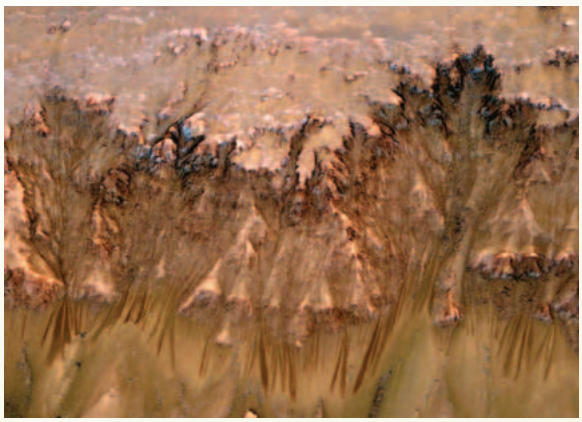
When to see a doctor
Early diagnosis and treatment of polycystic ovary syndrome may help reduce your risk of long-term complications, such as type 2 diabetes, high blood pressure, heart disease and stroke. Talk with your doctor if you have menstrual irregularities — such as infrequent periods, prolonged periods or no menstrual periods — and have excess hair on your face and body or acne. ■

Recent developments in science and technology

Biman Basu
e-mail: bimanbasu@gmail.com

Flowing water detected on Mars

Mars has been the planet of interest for astronomers for many reasons including speculations about the existence of life there. From Earth-based telescopic observation it was known that Mars has frozen polar ice caps comprising both solid carbon dioxide and water ice that appear to change with seasons. In 1976 two *Viking* spacecraft sent by NASA landed on the planet and carried out biochemical tests on its soil. But it found no evidence of life. Later studies by other space probes found dry channels and evidence of flow of large volumes of water on the planet in the distant past when Mars may have been warmer. But it was not known till recently whether liquid water is present on Mars or not.



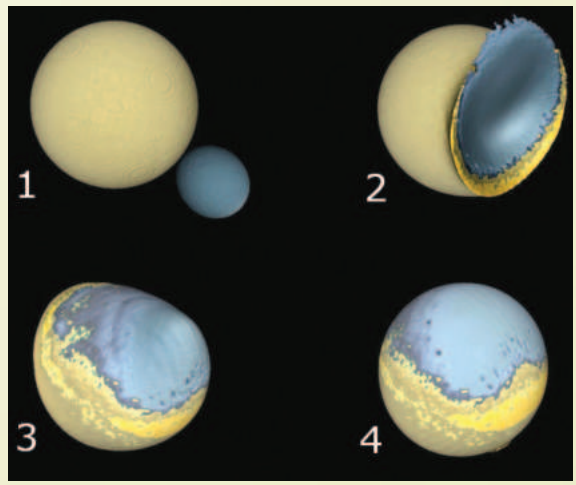
An image combining orbital imagery with 3-D modelling shows flows that appear in spring and summer on a slope inside the Newton crater on Mars. Sequences of observations recording the seasonal changes at this site and a few others with similar flows could be evidence of salty liquid water active on Mars today. (Credit: Science)

According to a recent report in *Science* (5 August 2011) liquid water may indeed be flowing on the red planet today. High-resolution photographs taken by NASA's *Mars Reconnaissance Orbiter*, which has been in orbit around Mars since 2006, show finger-like streaks up to five metres wide that appear on some steep slopes inside the Newton crater on Mars in the planet's late spring, which NASA scientists believe indicate flowing water. These streaks grow and shift during summer, reaching hundreds of metres in length before they fade in winter. One crater had about 1,000 streaks. Repeated observations have tracked the seasonal changes in these recurring features on several steep slopes in the middle latitudes of Mars' southern hemisphere at seven locations over the past three years. The observations show they extend ever farther downhill with time during the warm season. According to Alfred McEwen, the principal investigator for the orbiter's High Resolution Imaging Science Experiment (HiRISE) and lead author of the *Science* report, "The best explanation for these observations so far is the flow of briny water." This seems quite probable because salt, which is known to be widespread on Mars, lowers the freezing point of water, allowing it to exist in its liquid state at temperatures well below 0°C. Salt also alters the evaporation properties of water, making brine able to withstand the extremely dry conditions on Mars more readily than pure water. Salt deposits over much of Mars indicate brines were abundant in Mars' past.

According to the scientists, the streaks are the strongest evidence yet for the existence of liquid water on Mars today. It reaffirms Mars as an important future destination for exploration. Future robotic missions might also be able to hunt for signs of simple life forms, suggesting that unusual types of bacteria might conceivably live in brine water.

Did Earth once have two moons?

Earth's closest celestial neighbour Moon is a mysterious object. And perhaps the biggest mystery of them all is why the far side of the Moon appears so different than the side that we see every day. The familiar hemisphere facing Earth is covered by low, lava-filled plains (seen as the darker gray areas on the Moon's "face"), whereas the far side, which is never visible from Earth, is a collection of rugged, mountainous highlands, as revealed in images sent by space probes. The striking differences between the near and far sides of the Moon have been a longstanding puzzle. Till recently scientists did not have any definite clue as to why it is so, although researchers had long held that the Earth's gravity and impacts by foreign bodies were to blame for the variance. Now a study suggests that perhaps the reason the Moon appears so differently from one side to the next is because at one time it was two separate objects. According to a new study by planetary scientists at the University of California, Santa Cruz, USA, the mountainous region on the far side of the Moon, known as the lunar far side highlands, may be the solid remains of a collision with a smaller companion moon, which orbited the Earth along with the Moon we see today,



Four snapshots from the computer simulation of a collision between the Moon and a smaller companion moon show most of the companion moon is accreted as a pancake-shaped layer, forming a mountainous region on one side (far side) of the Moon. (Credit: M. Jutzi and E. Asphaug, Nature)

some 4.5 billion years ago, when the Earth was still forming (*Nature*, 4 August 2011 | doi:10.1038/nature10289).

The new study builds on the "giant impact" model for the origin of the Moon, according to which a Mars-sized object collided with Earth early in the history of the solar system and kicked up a ring of debris around Earth that later coalesced to form the Moon. This model adequately explains the similarity in composition of the Earth's crust and Moon rocks. The new study suggests that this giant impact also created another, smaller body, initially sharing an orbit with the Moon. These objects then individually orbited the Earth on a slow collision course toward each other. Eventually the smaller companion fell back onto the Moon and coated one side with an extra layer of solid crust tens of kilometres thick.

In the new study, astrophysicists M. Jutzi and E. Asphaug used computer simulations of an impact between the Moon and a smaller companion (about one-third the size of the Moon) to study the dynamics of the collision and track the evolution and distribution of lunar material in its aftermath. According to them, in such a low-velocity collision, the impact does not form a crater and does not cause much melting. Instead, most of the colliding material is piled onto the impacted hemisphere as a thick new layer of solid crust, forming a mountainous region comparable in extent to the lunar far side highlands.

One attractive feature of the new model is that it neatly explains why the near and far sides of the Moon are not only different in topography but also in composition. Several sites on the near side sampled by Apollo astronauts had rocks comparatively rich in KREEP – for potassium (K), rare earth elements (REE) and phosphorus (P). But KREEP is scarce on the lunar far side, as it would be if the colliding moonlet had pushed the cooling magma ocean and its KREEP on the still forming Moon to the lunar near side.

Dawn in orbit around asteroid Vesta

For the first time in space history a spacecraft has been placed in orbit around an asteroid. NASA's *Dawn* spacecraft went into orbit around the 530-km-wide asteroid Vesta on 15 July 2011 to map its surface and carry out in-depth analysis of the asteroid from orbit.

Artist's concept of NASA's Dawn spacecraft, which went into orbit around the huge asteroid Vesta on 15 July 2011. (Credit: NASA/JPL)

Close observations of Vesta are expected to help astronomers understand the early days of the solar system, as well as the processes that formed and shaped rocky planets like Earth. The *Dawn* spacecraft is powered by an ion propulsion system that provides enough thrust required to reach its target asteroids. The ion thrusters work by using an electrical charge to accelerate ions from xenon fuel to a speed 10 times that of chemical engines.

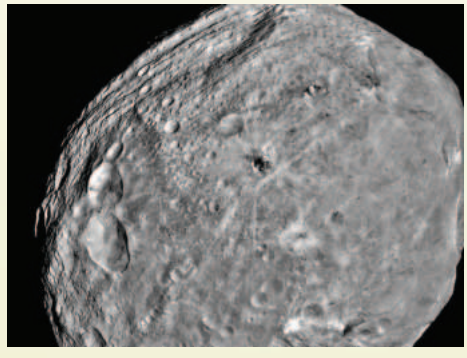
Vesta is the brightest object in the asteroid belt between Mars and Jupiter and is thought to be the source of a large number of meteorites that fall to Earth. *Dawn* arrived in the vicinity of the asteroid after travelling nearly 2.8 billion kilometres in four years and was captured by Vesta's gravity. At present the giant asteroid and the orbiting spacecraft are approximately 184 million kilometres away from Earth. *Dawn* will be spending a year at Vesta before moving on to the "dwarf planet" Ceres.

The importance of the *Dawn* mission stems from the fact that Vesta and Ceres are baby planets (protoplanets) whose growth was interrupted by the formation of Jupiter. They were chosen for investigating in detail as they are the two most massive protoplanets remaining intact since their formation and because of their contrasting constitution. While asteroid Vesta and the recently categorised dwarf planet Ceres both formed under the same conditions and by the same processes early in the formation of the solar system, they developed into two different kinds of bodies. Ceres is very primitive and wet (icy), while Vesta is evolved and dry (rocky); so examining both should help scientists understand the formation of both rocky planets and icy bodies in our solar system and also under what conditions a rocky planet can hold water.

Launched in 2007, the nearly decade-long *Dawn* mission will try to characterise the conditions of the early solar system and the processes that dominated its formation. When our solar system was forming, the materials in the solar nebula varied with their distance from the Sun. The temperature dropped with distance, with terrestrial bodies forming closer to the Sun, and icy bodies forming farther away.

Dawn carries a wide range of instruments. The framing camera is designed to acquire detailed optical images for scientific purposes as well as for navigation in the vicinities of the two asteroids. The gamma ray and neutron detector would be used to for measuring the elemental composition of both Vesta and Ceres. This instrument uses a total of 21 sensors with a very wide field of view to measure the energy from gamma rays and neutrons that either bounce off or are emitted by a celestial body.

Dawn will make another set of scientific measurements at Vesta and Ceres using the spacecraft's radio transmitter and sensitive antennas on Earth. Monitoring signals from *Dawn*, scientists would be able to detect subtle variations in the gravity fields



This image of the giant asteroid Vesta was obtained by the Dawn spacecraft with its framing camera on 24 July 2011. It was taken from a distance of about 5,200 kilometres. (Credit: JPL/NASA)

of the two asteroids, from which planetary scientists would be able to find out how mass is distributed in each body. This information, in turn, will provide clues about the interior structure of Vesta and Ceres. ■

Nationwide sensitisation Programme for Chemistry Teachers

International Year of Chemistry (IYC 2011) is a worldwide celebration of achievements of chemistry and its contribution to the well-being of humankind. Under the focal theme 'Chemistry-Our Life Our Future', IYC offers a range of interactive, entertaining and educational activities. Public participation at local, regional and national level is a major objective of activities slated for observing the year of chemistry in India. One of the main objectives of IYC is also to attract young minds towards the chemistry. This can be done only if teaching of chemistry in schools is made interesting. It is also realised that we need to interact with school teachers to understand present problems and to make them familiar with the material developed by VP.

Keeping the above in view, Vigyan Prasar (VP), jointly with Vigyan Parishad Prayag, Allahabad and National Academy of Sciences, India (NASI), Allahabad, organised a three-day sensitisation programme for chemistry teachers at Allahabad from 6 to 8 August 2011. Fifty-five school teachers from Allahabad and neighbouring areas were invited for the workshop. The objective of the programme was to sensitise teachers towards the importance of chemistry in day-to-day life, including awareness on latest developments in the field of chemistry. The components of programme were (i) discussion on the IYC 2011 and lectures on different facets of chemistry; (ii) demonstration of innovative teaching materials; (iii) presentation by teachers; (iv) discussion on global experiment "Water: A Chemical Solution"; and v) interaction with media for larger publicity of this campaign.

The sensitisation programme was inaugurated by Er. Anuj Sinha, Director, Vigyan Prasar, Noida. Dr. Shiv Gopal Mishra, General Secretary, Vigyan Parishad Prayag, Allahabad, Dr. S Mahanti, Scientist 'F', Vigyan Prasar, Dr. K. K. Bhutani, Vice-President, Vigyan Parishad, Prayag, Allahabad, Dr. S K Mitra retired from NCSM, Kolkata, and Ms Swati Bedekar, from Vadodara, were present at the inaugural session.

(R-L:) Dr S Mahanti, Scientist 'F', VP., Er Anuj Sinha, Director, VP, Dr Shiv Gopal Mishra, General Secretary, Vigyan Parishad Prayag, Prof (Mrs) Krishna Mishra, General Secretary, NASI, Allhabad interacting with media persons

Book released function during inaugural session

In his inaugural remarks Er. Anuj Sinha emphasised on the future trends in chemistry and focussed on green technology and related issues. He urged the participants to make themselves up-to-date in their field so that the information could be transferred to end users, i.e., students, in a stipulated time. Dr. Shiv Gopal Mishra, said that chemistry is involved in all aspects of life and we should recognise the role of chemistry in our daily activities and must tell to students about them. Dr. S. Mahanti, gave a lecture on "International Year for Chemistry 2011" and its activities and emphasised on the reasons for celebrating IYC 2011 and urged participants to be a part of this occasion and carry on the message to grassroots level. During the inaugural function the book "*Hindi mein vigyan lekhan: Vyaktigat evam sansthagat prayas*", published by Vigyan Prasar, was released. In his opening remarks Dr. K K Bhutani discussed about the importance of this year and gave a detailed briefing about the book. Shri Kapil Tripathi, Scientist 'D', Vigyan Prasar gave a vote of thanks. This session were anchored by Dr. Deo Vrat Dwivedi of Vigyan Parishad Prayag, Allahbad. After this session, the poster exhibition was inaugurated. These posters were the result of a poster competition which was organised by HBCSE, TIFR, Mumbai.

First session of the programme started with the lecture on "Teaching chemistry: an approach" by Prof. Sudha Jain, Head, Department. of Chemistry, Lucknow University, and President All India Chemistry Teachers' Association. During the lecture she raised several issues related to appropriate methods while teaching chemistry. The second session after the lunch break was mainly devoted to the demonstration of an activity kit on chemistry developed by VP. This demonstration was conducted by Ms Swati Bedekar of Vadodara, Gujarat and included several activities on

Shri S.K.Mitra demonstrating innovative experiments in chemistry at Department of Chemistry at Allahabad University, Allahabad

A view of an exhibition organised during the programme

chemistry. The third session of the day was organised at the Department of Chemistry, Allahabad University, where Dr S K Mitra of Kolkata gave a hands-on demonstration to the teachers. He demonstrated more than 15 experiments related to chemistry in an interesting manner. In the evening, there was a press meet where experts in the field of chemistry interacted with media persons to popularise this campaign. Er. Anuj Sinha; Prof. S G Mishra; Prof. (Mrs.) Krishna Mishra, General Secretary, NASI, Allahabad; Dr. Niraj, Executive Secretary, NASI, Allahabad; Dr. S. Mahanti; and Shri Nimish Kapoor, Scientist 'C', VP were present at the press meet. Annual 15 media proposed from different newspapers, TV and Radio participants in this session.

Second day's programme was organised at National Academy of Science India, Allahabad with a lecture on "Chemistry today and tomorrow" by Prof. Krishna Mishra. In her lecture she touched upon the recent advancements in the field of chemistry and also presented a future scenario.

In the second session, two lectures were organised. First was on "Global experiment: Water - a chemical solution by Shri Kapil Tripathi. These global experiments are being conducted throughout the world by students. In his lecture, he discussed about the methods of doing the experiments and also discussed the future plans of Vigyan Prasar related to this activity. A lecture on "Wonder drugs" was delivered by Dr. Archna Pandey, Professor of CNP Degree College, Allahabad University. In the third session there was a open house discussion where the teachers shared their experiences and gave several suggestions for the further improvement of the programme. After this session, participants visited the Ganga Gallery situated at NASI, Allahabad and the Planetarium at Anand Bhawan, Allahabad.

On the third day, a lecture on "Water" was organised and same was given by Dr. K K Mishra, HBCSE, TIFR, Mumbai. In his lecture, he showed various properties of water which was well appreciated by the audience. After this there was a session on chemistry behind miracles. This was organised by Dr S.K. Singh, Shri Promod and Shri Raguvanshi of VIKAS, Allahabad. During the session the chemistry behind so-called miracles was discussed and explained. In the second session a presentation on 'Chemistry of Semiconductors' was delivered by Dr Ashutosh Mishra working in Texas, USA. After this Shri S K Mitra demonstrated 15 hands-on experiments in chemistry.

In the concluding session teachers participated in a discussion where they shared their experience about the programme. Vigyan Prasar gave participation certificates to all the participants along with books, CD on Innovative Experiments in Chemistry, wall planners of IYC 2011, and desk calendar developed by VP.

This was the first outreach programme as part of the International Year for Chemistry 2011, which provided the platform for testing resource material developed by VP. Similar programme will be organised in other parts of India during the year. ■

Books released on science and technology writing in Marathi

A two-volume monograph titled *Science and Technology Writing in Marathi between 1830 and 1950* has been published as part of Vigyan Prasar's efforts in documenting popular science writings in different Indian languages. The work will be of significance to science writers, linguists, historians and scholars. The project in Marathi was implemented by Marathi Vidnyan Parishad (MVP), Mumbai, which has been engaged in science popularisation work in Maharashtra for decades. The research for this monograph covers the period 1830-1950. Earlier, similar projects were completed in Hindi, Bengali, and Odiya. Efforts are on to take up such projects in other languages.