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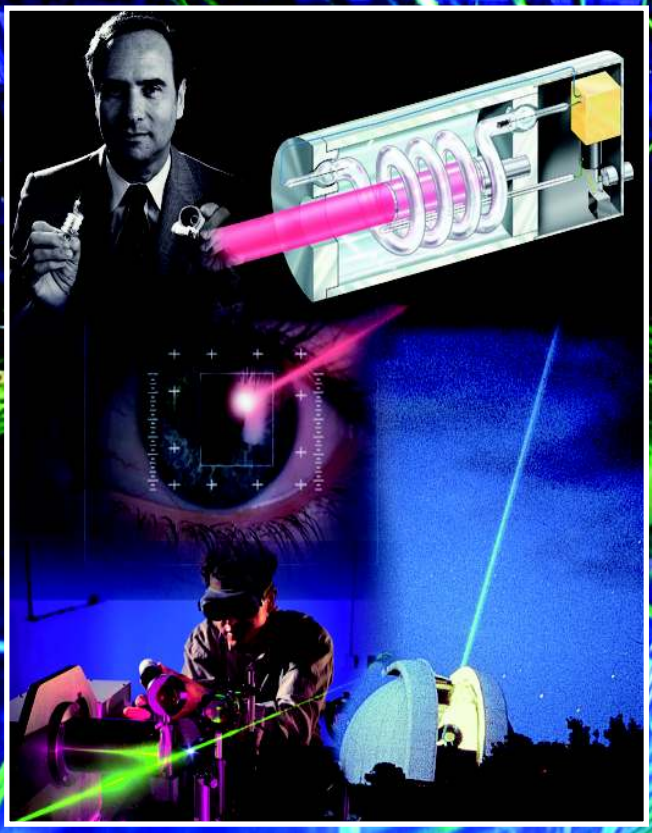
The story of laser

Robert Wilhelm Bunsen
(Pioneer of chemical spectroscopy and the inventor of the Bunsen burner)

(1811-1899)



Inside

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

Can Hindi Make a Difference?

Indian engineers and scientists can be justifiably proud of their achievements in sectors as complex as space, agriculture, nuclear energy and defence. There were controls imposed on transfer of knowhow and developments were required to meet difficult time schedules and severe cost constraints. The success in the IT sector is just as spectacular with supercomputing power now available to meteorologists and other researchers developed indigenously.

Of course there are challenges, often cross-sectoral, requiring scientists to work with sociologists and economists to be able to find acceptable solutions. These are issues of rural employment, urban dwellings, energy efficiency in generation and utilisation and many more. New problems are emerging including reduction of carbon dioxide emissions from industries and transport, water and energy conservation, and adaptation of agriculture practices even as climate change impacts forcefully on the small farmer.

One is optimistic that a new generation of scientists and engineers will address these issues more effectively. They will require high levels of problem solving skills and a well-developed capacity for critical and logical thinking. The best minds will need deep understanding of their chosen field of science or engineering from world class institutions. They will also have to be equipped with imagination, intuition and capacity for team work.

Inventive thinking, semi-guided exploration, entrepreneurship and creativity need to be nurtured and these are likely to best develop if students learn to work and think in their mother tongue. Mind games, puzzles, team games and projects are used by leading corporations (Xerox, Motorola, Kodak, GM and others) for their most creative teams to hone their skills in the above faculties.

Can higher education in science and engineering be transformed from English to Hindi? What will be the challenges and implications? Is it desirable? These questions were examined at a discussion recently and some of these questions were viewed in a new light.

Students who enter leading universities and colleges represent a national spectrum with mother tongues from across several regions. Their medium of instruction in schools also varies. The first few months in college are spent in improving social skills, staying abreast with the subjects and learning English language that is the medium of instruction. When they graduate, these youngsters are ready for a career in research, teaching, or industry in India or abroad. They meet their and the societies' aspirations as they spread their wings.

Have they lost the edge that they would have if their instruction was in Hindi? Small European nations have demonstrated that teaching and research at any level in the national language is feasible and equips the students with skill sets needed and expected by the employers. They use English as a link language and often do so without the fluency that our scholars demonstrate.

Books, notes, assignments and other curriculum based work may continue as per agreed standards and in the accepted medium of instruction. Can some topics in the existing curriculum be delivered in Hindi? Is it possible to encourage 'Solutions Research' as a skill set in the mother tongue? Would it be possible to provide societal exposure and comparisons in the local language? After all medical internees learn to interact with patients from third year onwards and this has to be in the local language. Would this be beneficial to the desired skill development?

Popular magazines in science and engineering need encouragement to help in developing vocabulary and interest in these subjects. Articles in newspapers and features on radio and television will help in creating dialogue on local, national and international issues. The opportunities on the digital medium are mind boggling. Science and engineering communicators have an important responsibility to fulfill if Hindi has to find place as a instruction medium in institutions of higher learning and research. They will have to move away from rituals that are witnessed in several institutions at present. Higher skill sets for creative thinking and problem solving in the new generation are worthwhile goals.

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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Robert Wilhelm Bunsen

Pioneer of chemical spectroscopy and the inventor of the Bunsen burner

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

"Each of the physical and natural sciences will probably always be likened to an unfinished structure. But in the case of chemistry we have good reason to think that the structure has at least reached the point where its foundations have been completed. If these foundations were begun by Lavoisier and Dalton, then Bunsen may be thought of as the last of that remarkable group of men, including Wohler, Liebig, and Dumas, by whom this structure was completed."

Henry Crew in *"The Astrophysical Journal"*

"The Bunsen burner, simple, inexpensive, and effective, immediately displaced its predecessors. The easily adjusted flame burned hot and clean, and was perfectly suited to laboratory operations. The present form of the Bunsen burner, familiar to every science student today, has scarcely changed from the original of 1855."

A.J. Rocke in *The Oxford Companion to the Modern History of Science*

"Bunsen was a great experimentalist, an expert in gas analysis and glass blowing, and a pioneer of photochemistry and spectroscopy. He also worked in electrochemistry, devising an improved version of the Grove cell."

A Dictionary of Scientists, Oxford University Press, 1999

Robert Wilhelm Bunsen was one of the most versatile chemists of the nineteenth century. He was pre-eminently an experimentalist with little interest in theory. He was a pioneer of chemical spectroscopy. Bunsen, jointly with Gustav Robert Kirchhoff (1824-1887), discovered the use of spectroscopy in chemical analysis in 1859 and within two years they discovered two new elements, viz., caesium and rubidium with its aid. His first major research helped establish the radical theory developed largely by Jean Baptiste Andre Dumas (1800-1884) and Justus von Liebig (1803-1873), a theory according to which organic groups or compound radicals correspond, in part, to the simple atoms of inorganic compounds. He devised the Bunsen cell, a zinc-carbon primary cell. This invention made it possible to replace the expensive platinum plate of the Grove cell by a cheap carbon rod. He was a master of gas analysis. His studies of Icelandic volcanoes led to explaining the phenomenon of geyser. He helped improve the English blast-furnaces. He invented many laboratory devices, including the filter pump and Bunsen burner. The burner which has immortalized the name of Bunsen was not actually invented by him but an improvement was made on the burner devised by Michael Faraday at the suggestion made by Bunsen. It was Bunsen's concept to premix the gas and air prior to combustion in order to yield the necessary high temperature, non-luminous flame. It was Bunsen's thorough understanding of the principles of combustion that enabled him to suggest the improvement. The actual design and manufacture of the burner was made by his technician Peter Desaga. Even today Bunsen burner can be found everywhere from the kitchen to laboratory.

Robert Wilhelm Bunsen

Bunsen was a pioneer in photochemistry and jointly with British chemist Henry Roscoe devised a photometer and an actinometer. Bunsen was a great teacher and his lecture courses were famous. He attracted students from all over the world to study in his laboratory. Bunsen was greatly devoted to his students. Among his students was Dimtri Ivanovich Mendeleef.

Bunsen was born at Gottingen, Germany, on 13 March 1811. His father Christian Bunsen was Chief Librarian and Professor of Modern Philology at the University of Gottingen. After completing his school education in the city of Holzminden, Bunsen entered the Gottingen University in 1828. He received his PhD at the age of 20. For his PhD he produced a Latin dissertation on hygrometers. After his PhD, he went on a long study tour (1830-33); first he visited different cities of Germany and then went to Paris and Vienna. This helped him to establish a network of contacts with well-known chemists of the time and he cultivated these contacts throughout his professional life.

In 1834, he became a Privatdozent at the University of Gottingen. At Gottingen, while investigating the insolubility of metal salts of arsenious acid he discovered the use of iron oxide hydrate as precipitating agent, which remains the best known antidote against arsenic poisoning till today.

In 1836, he joined the Polytechnic School of Cassel as a teacher of chemistry, where he succeeded the famous German chemist Friedrich Wohler (1800-1882). In 1839, he became a professor of chemistry at the University of Marburg and where he remained until 1851. At Marburg Bunsen undertook studies of the highly toxic organometallic compounds known as cacodyl

Gustav Robert Kirchhoff

compounds. He discovered the first member of cacodyls. Cacodyl is tetramethylarsine $(CH_3)_2As_2(CH_3)_2$.The name cacodyl was derived from the Greek *"kakodhs"* meaning "stinking". Describing one of the cacodyl compounds Bunsen wrote: "the smell of this body produces instantaneous tingling of the hands and feet, and even giddiness and insensibility…It is remarkable that when one is exposed to the smell of these compounds the tongue becomes covered with a black coating, even when no further evil effects are noticeable."

Bunsen prepared various derivatives of cacodyls including the chloride, iodide, fluoride and cyanide. Bunsen demonstrated that cacodyl was an oxide of arsenic that contained a methyl radical. Bunsen's work was a significant contribution towards the confirmation of the theory of radicals and also the idea put forward by Henri Berzelius that the concept of radical in inorganic chemistry is equally applicable to organic chemistry. Before the work of Bunsen, Gay-Lussac isolated the radical cyan in 1815 and Liebig and Wohler had published their work on the radical of benzoic acid. During his investigations on cacodyls compounds Bunsen lost one eye in an explosion and twice he nearly killed himself through arsenic poisoning.

To concentrate on his work on spectral analysis Bunsen took a sudden decision to discontinue his work on quantitative photochemistry in collaboration with the British chemist Henry Roscoe (1833-1915). Explaining the reason for terminating his almost ten-year-long collaboration He wrote to Roscoe: "At present Kirchhoff and I are engaged in a common work which doesn't let us sleep…Kirchhoff has made a wonderful, entirely unexpected discovery in finding the cause of the dark lines in the solar spectrum…thus a means has been found to determine the composition of the Sun and the fixed stars with the same accuracy as we determine sulphuric acid, chlorine, etc., with our chemical reagents. Substances on the earth can be determined just as early as on the Sun, so that, for example, I have been able to detect lithium in twenty grams of sea water."

The origin of spectral analysis could be traced to the work of the German physicist and optician Josef von Fraunhofer (1787-1826). While breaking the Sun's white light into the colours of the spectrum by using a prism, Fraunhofer noticed some strange black lines that seemed to punctuate the solar spectrum. Fraunhofer marked the position of the prominent lines in the spectrum, labeled them A through K. He calculated the wavelength of each line and he found out that the positions of these lines in the spectrum remained the same, as if these lines represented a kind of code. Fraunhofer worked with different sources of light, the direct light of the Sun, reflected light of the Moon and the planets and starlight. He found that each different light source leave a different pattern of the lines in its spectrum, a different code or a different thumbprint. These lines are named Fraunhofer lines.

Henry Roscoe

Jean Baptiste Andre Dumas

Fraunhofer died in 1826 at an early age of 39 without cracking the code or finding out the significance of unique pattern of lines in the spectrum of a light source.

Bunsen and Kirchhoff finally understood the significance of the spectral pattern. They developed an instrument, what they called spectroscope, which passed light through a narrow slit before passing it through a prism. The slit controlled the source of the light and in this way it was possible to display different wavelengths differently, and viewing against a scale it became easier to differentiate and interpret. They used the burner devised by Bunsen to heat various chemicals to incandescence or glowing heat, the heat at which the chemicals gave off light. The Bunsen burner itself gave off very little light. Bunsen and Kirchhoff observed that each chemical gave off its own distinctive pattern of coloured lines. For example sodium vapour produced a double yellow line, as its thumbprint. Today we know the thumbprints of all the known elements and the components of any substance could be analysed by analysing its chemical spectrum. The classic paper of Bunsen and Kirchhoff titled 'Chemical analysis through observation of the spectrum' published in 1860 ushered in era of chemical spectroscopy.

Commenting on Bunsen's contribution to the field of spectroscopy American physicist Henry Crew wrote: "The peculiar merit of Bunsen in the field of spectroscopy is then that he perfected a simple method which is capable of detecting the presence

Paul Emile Lecoq de Boisbaudran

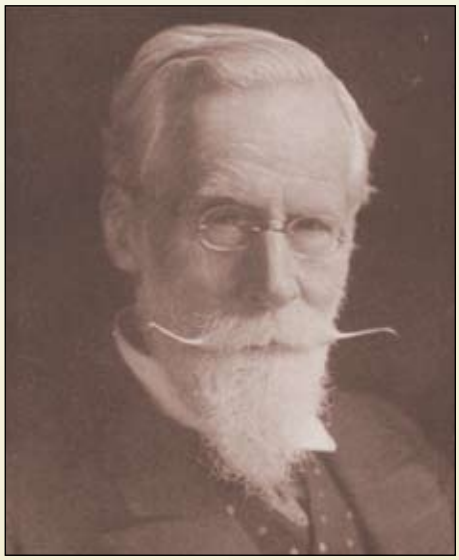
of an element by the use of quantities vastly smaller than are required by any other known method. It opened to chemists, therefore, an entirely new field of investigation and one which, as the sequel has proved, is not confined to our own planet or even to the solar system.

Bunsen and Kirchhoff, by using the technique of spectral analysis, discovered two alkali metals. Their first discovery was caesium, named after its distinctive blue spectral line. They announced their discovery in the following way: "Supported by unambiguous results of the spectral-analytical method, we believe we can state right now that there is a fourth metal in the alkali group besides potassium, sodium, and lithium, and it has a simple characteristic spectrum like lithium; a metal that shows only two lines in our apparatus: a faint blue one, almost coinciding with Srd, and another blue one a little further to the violet end of the spectrum and as strong as clearly defined as the lithium one." After a few months they discovered rubidium, another alkali metal, named after the red line that announced its existence. Following their footsteps five new elements were discovered by others—thallium (the name "thallium" was derived from the Greek word *"thallos"*, which means "a new green branch") by the British chemist William Crookes (1832-1919) in 1861, indium (named after indigo, a bright blue dye) by F. Reich and his assistant Th. Richter in 1863; gallium by Paul Emile Lecoq de Boisbaudran in 1875 (named after its inventor, Lecoq means "rooster" in French and which is "gallus" in Latin), scandium (named after Scandinavia) by L. Nilson in 1879 and germanium (named after Germany) by C. Winkler in 1886.

Bunsen liked to travel. In fact travelling was one of his favourite relaxations. It was this pastime which led him to explain the phenomenon of geyser. In 1846, he visited Iceland where he came across geysers. He investigated the composition of the gases coming off from the fumaroles and their action on the rocks with which they came in contact among other things.

Bunsen's outstanding contributions were given due recognition by the scientific world. He was elected to the Chemical Society of London (1842) and the Academie des Sciences of France (1853). He was elected a foreign Fellow of the Royal Society of London (1858). Bunsen was elected a foreign member of the Royal Swedish Academy of Sciences (1860). Awards received by Bunsen included the Copley Medal (1860) and the first Davy Medal (1877) of the Royal Society of London, the Albert Medal (1898). Bunsen was too modest to be influenced by awards and once he remarked: "Such things (recognitions) had value for me only because they pleased my mother, she is now dead."

Bunsen died at Heidelberg on 16 August 1899.



William Crookes

Josef von Fraunhofer

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(The article is a popular presentation of the important points of the life and work of Robert Wilhelm Bunsen available in the literature. The idea is to inspire the younger generation to know more about Bunsen. 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.)

The story of laser

Dr. P.K. Mukherjee
E-mail: pkm_du@rediffmail.com

The laser, considered to be one of the greatest inventions of the 20th century, has now virtually permeated almost all walks of life. For instance, scanning of bar codes on packets of food items and consumer products or recording and playing of audio/video contents on CDs and DVDs is done with the help of a laser. The hologram stickers used for security purposes on credit/debit cards, books, mobile batteries, etc. are recorded with the help of a holographic technique that uses laser. A laser printer can print data fast with excellent print quality. Laser has other applications too in a plethora of fields like communication, industry, medicine, defence, space science and so on. Laser has indeed changed our lives in a dramatic manner.

What is laser?

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. It is a powerful source of light having some unique characteristics not found in the normal light sources like tungsten bulbs, mercury lamps, etc. A unique property of laser is that it contains waves of a single colour or wavelength. This property is known as monochromaticity or spectral purity. The ordinary light has many colours or wavelengths and is, therefore, not monochromatic.

Another unique property of laser is that it has high degree of directionality; i.e., it can travel very long distances with very little divergence, which can be less than 10-5 radians. In contrast, a beam of ordinary light spreads out very quickly; in fact, it spreads to about a kilometer across for every kilometre traversed. Hypothetically, if a narrow beam ordinary light could travel to the Moon, which is at a distance of 3,84,400 km from Earth, it would have spread to such an extent that the diameter of the light on the Moon would be about 3,84,400 km. In contrast, the spread of a laser beam would be hardly a few kilometres. This unique characteristic of laser was used for measuring the distance of the Moon from Earth when astronauts of Apollo-11 mission of 1969 mounted a retro-reflector (a special kind of reflecting mirror that sends the light back to the source along the same direction) on the surface of the Moon. When a laser beam was sent from the Earth to the retro-reflector on the Moon, it was reflected back to Earth. By measuring the time taken by the laser beam to travel from Earth to the mirror and back, the distance of the Moon from Earth was calculated with an accuracy of 15cm.

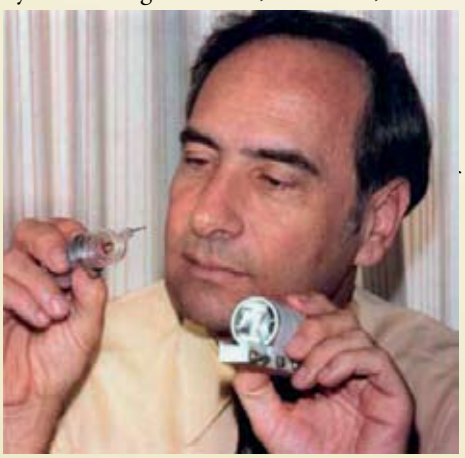
Laser light is highly coherent; i.e., its waves are exactly in step with each other and thus have a fixed phase relationship. In fact, the high degree of directionality and monochromaticity of laser is responsible for its coherence. The high monochromaticity of laser light endows it with a property called 'temporal coherence' while the high degree of directionality of laser endows it with another property called 'spatial coherence'. Thus, high degree of both temporal and spatial coherence exists simultaneously in laser light.

Another remarkable feature of laser is its high intensity. This means that a large amount of energy can be focused on to a very small spot. This has important applications in industry for cutting, welding, etc., and in the field of laser fusion.

Thus, laser light has high degree of directionality, is monochromatic and coherent and has high intensity. Laser light can be compared to a group of soldiers wearing uniforms of the same colour and marching together in step in the same direction. Ordinary light, on the other hand, is like a crowd of people wearing clothes of different colours, walking generally out of step with one another in different directions.

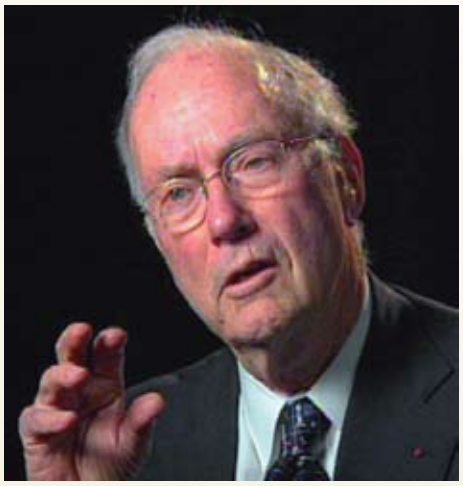
Invention of laser

Laser was invented by Theodore Harold Maiman on 16 May 1960. He obtained it by stimulating the atoms, molecules, or ions



Theodore Maiman with a ruby laser

Emission of Radiation). The idea for the invention of maser is said to have struck Charles Hard Townes while he was sitting on the bench of a park. Townes, who was with Columbia University in USA, was working in the field of microwave spectroscopy. He was trying to build a short-wave oscillator which could work at frequencies as high as the infrared.



Charles Townes

Townes had tried several ideas. However, none seemed to work. He was also chairman of a committee for navy that was examining ways to develop very short-wave oscillators. In 1951, the committee was having its meetings in Washington. The members of the committee could not come out even with a single plausible idea for the development of short-wave oscillator. This had greatly disappointed Townes. Only the last meeting of the committee was due which was to be held the next day.

Next morning Townes got up early. He got dressed and moved out of his hotel. Plenty of time was left for the meeting to start. Being too early in the morning, no café or restaurant was open. Moving ahead, Townes suddenly found himself outside the entrance gate of the famous Franklin Park. As if guided by some inner instinct, he entered

the park and sat on a bench. The beautiful flowers of azaleas caught his attention.

While admiring the natural beauty of the park his mind was also focussing on the problem that had bogged him down for quite some time. Suddenly, as if by flash, an idea struck him. Earlier also he had considered molecules that oscillate at high frequencies. However, he had dismissed them because in equilibrium such molecules are bound by certain laws of thermodynamics. "But, molecules do not have to obey such laws if they are not in equilibrium," thought Townes. This was precisely the idea that struck Townes while sitting on the bench. He immediately took out a piece of paper from his pocket and started writing some equations on it. He wanted to see if selection of excited molecules by molecular beam methods could produce enough molecules to provide a feedback oscillator. "It very much looks possible," sighed Townes. He seemed to have got a solution to the problem that was hankering him.

Using the principle of stimulated emission proposed by Einstein, Townes in 1954 succeeded in constructing a microwave amplifier device called master. It is a mere coincidence that two Russian scientists, Alexender Mikhailovich Prokhorov and Nicolai Gennedieyevich Basov, working in Lebedev Institute in Moscow were also simultaneously and independently thinking along the same lines. However, Townes was the first to produce the maser. For the invention of maser Townes, Basov and Prokhorov shared the 1964 Nobel Prize in Physics; half of the prize was awarded to Townes and the other half jointly to Basov and Prokhorov.

The development of laser

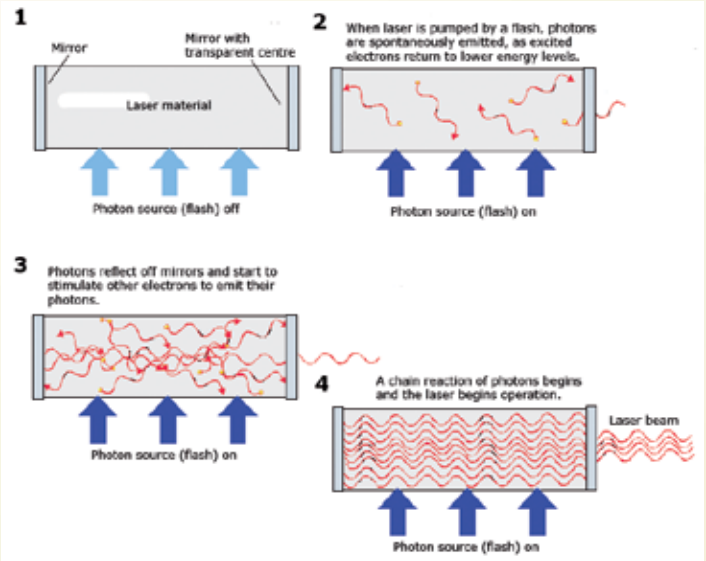
In 1958, Townes jointly with (his sister's husband) Arthur Leonard Schawlow published a paper in *Physical Review* wherein they presented the idea that the maser principle could be extended to optical frequencies. In effect, this meant that like microwaves, light waves could also be amplified using a device which they called optical maser (later to be named laser).

Arthur Leonard Schawlow

About the same time, Gordon Gould was also working on the same problem. He is supposed to be the first to have introduced to the public the term laser in his 1959 conference paper. However, Theodore Harold Maiman, working with the Hughes Research Laboratory in California, USA, was the one who made the first laser operate on 16 May 1960. For this, Maiman used a cylindrical rod of ruby crystal that produced laser light in the visible red region.

Principle of laser action

In order to understand the principle of laser action we first need to clearly understand the concepts of stimulated emission and population inversion. These are technical concepts which we will try to explain in simple terms.



Principle of laser

According to quantum theory, emission or absorption of radiation is not a continuous process. Rather, it takes place in the form of discrete packets or bundles of energy, each packet or bundle being called a quantum. A quantum of light radiation is called photon.

An atom can both absorb and emit energy. When an atom absorbs energy it gets excited. The process is known as 'absorption'. The excited state of the atom, however, lasts for a very short duration of 10^{-8} seconds after which it returns to its original (unexcited) state. This process, which is accompanied by the emission of radiation by the atom, is known as 'spontaneous emission'.

Besides the above two processes, a third process is also possible. An outside photon interacting with an excited atom may stimulate it to emit a photon. This process is known as 'stimulated emission'. However, a necessary condition for this to happen is that the outside photon should have energy that is equal to the difference between the energies of the atom in its excited and the lowest energy state (ground state).

An important characteristic of stimulated emission is that the emitted photon has exactly the same wavelength (or frequency) as the outside photon and that the two photons are in the same phase.

If the process is repeated, more and more atoms will be forced to emit photons thereby initiating a chain reaction. This would result in rapid buildup of radiation of one particular wavelength travelling coherently in a precise, fixed direction. This process is called amplification by stimulated emission which is fundamental for laser action.

However, besides stimulated emission another condition, called population inversion, is also necessary for laser action. Under the normal circumstances, the number of atoms in the lowest energy state (ground state) is greater than that of the excited energy state. If somehow the situation could be reversed, it would be possible to achieve what is known as population inversion.

If an intermediate state, called metastable state having a lifetime higher than that of the excited state, is present between the ground state and excited state then the atoms could pause at the metastable state for more time. This would result into a higher population of atoms in the upper energy (metastable) state relative to that in the ground state, leading to population inversion which is an essential condition for laser action. The lifetime of the metastable state may be about a millisecond (10^{-3}s),

which is fairly large compared to the lifetime of the excited state of the atom (10^{-8}s).

Main components of a laser

A laser generally requires three main components for its operation: (i) the active medium, (ii) the pumping source; and (iii) the optical or cavity resonator. The active medium may be a solid, liquid, gas, or semiconductor. The pumping source may be a xenon or krypton flash lamp; electrical energy or energy obtained from chemical reactions may also be used as pumping source. The optical or cavity resonator consists of two mirrors one having full reflectivity while the other having 90% or less reflectivity. It may be noted that different types of lasers can have different configurations of the optical resonator. While some cavity resonators may use plane mirrors (as used by Maiman) others may use spherical, hemispherical, confocal, or concave-convex mirrors.

The pumping source pumps energy into the active medium to achieve the state of population inversion. The radiation emitted in the form of photons as a result of stimulated emission multiplies by bouncing back and forth between the two mirrors and passing through the active medium. As a result, the radiation gets amplified and finally the laser light comes out in the form of a narrow beam through the partially transparent mirror.

Different types of laser

Maiman used ruby crystal for developing the first laser. Subsequently, gas, liquid, semiconductor, etc., have also been used as materials for production of laser. Although innumerable types of laser are now available, based on their production technology seven broad categories of lasers have been identified. These are solid-state lasers, gas lasers, liquid or dye lasers, semiconductor lasers, chemical lasers, gas dynamic lasers, and free electron lasers.

The ruby laser developed by Maiman emits red light which lies in the visible range of the spectrum. However, besides visible light some lasers emit light in the ultraviolet region while others emit light in the infrared region also.

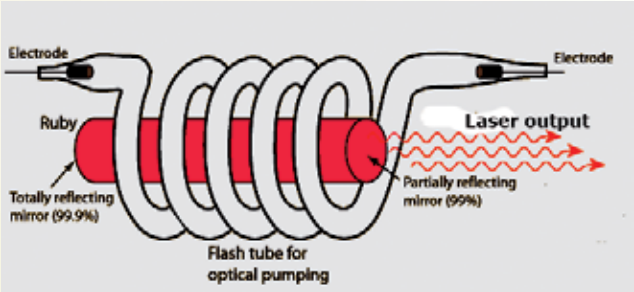
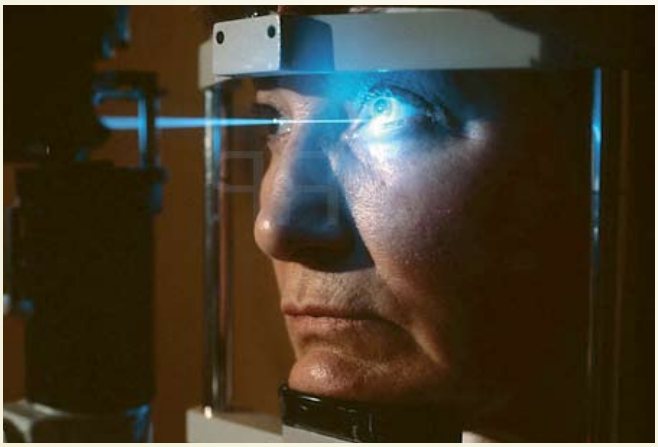


Diagram of a ruby laser

Scientists have also succeeded in producing X-ray lasers that produce radiation in the X-ray region. Raman lasers, based on the Raman Effect discovered by the Indian Nobel laureate physicist C.V. Raman, have also been developed. It may be noted that Raman lasers are different from the conventional lasers as laser action is possible in them even without population inversion. Scientists are currently busy in developing state-of-the-art lasers such as nano lasers, quantum dot lasers etc. Some success has already been achieved in this direction.



A patient undergoing laser eye surgery

Applications of laser

Lasers have wide ranging applications in various fields. In the field of medicine, laser is used for performing cataract operations and in the Lasik surgery for correcting the refractive errors of eyes. Laser is also used for welding of detached retina. It also finds application in dentistry and for clearing of the blocked arteries by way of a procedure called laser angioplasty. Also, it is used for the treatment of various kinds of cancer.

In fibre-optic communication, laser is used for transfer of vast amounts of data with faster speed. It has applications in industry for cutting of metals and for welding of even dissimilar metals. Laser is also used for drilling of holes in such hard material as diamond.

Laser has important application in metrology, surveying and seismology. It is also used for the study of environmental pollution. In defence and warfare too, laser has important applications. Laser systems can be used to track down and destroy enemy missiles. Underwater ranging using laser makes possible detection of submerged submarines.

Lasers are being used for testing the validity of some basic scientific theories. For instance, the validity of Einstein's special theory of relativity has been tested using helium-neon laser. Lasers can also be used for isotopic separation, measurement of impurities present in materials and study of ultrafast chemical reactions in chemistry. In physics, lasers play a significant role in the fields of spectroscopy and thermonuclear fusion. Applications of laser even extend to agriculture. Using laser the rate of sprouting of seeds can be increased and even the crops can be reaped relatively early. Many more applications of laser are expected to emerge in the near future. Today, laser is greatly benefitting the human society at large.

A scientist experimenting with laser

Dr. Prakasam Tata,

a pioneer in transformation of waste

Dr. Prakasam Tata, a well known civil engineer and environmental scientist is associated with the Centre for Transformation of Waste Technology (CTWT) as Executive Director since its inception and he is the man behind the success of this Centre which attracts policy makers and environmentalists.

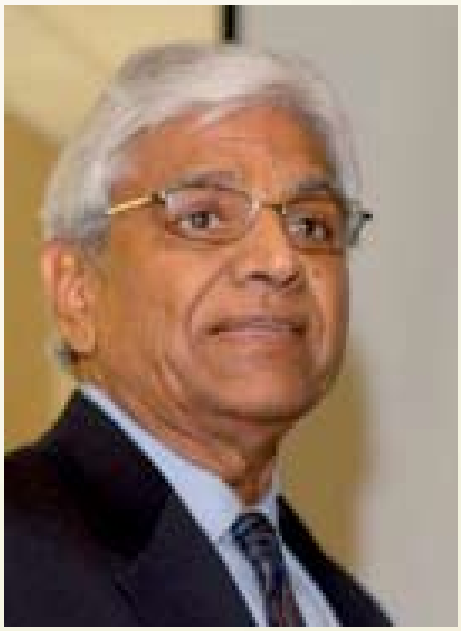
The primary mission of the CTWT is to use wastes as a resource to generate revenue on a sustainable basis. The revenue is to be used to finance water reclamation and reuse projects and other environmental improvements. The Centre explores opportunities to implement waste transformation technologies and participate in the process of commercialising commodities, products and energy converted from municipal wastes and the residuals of industrial and agricultural activities, and the emerging "green" industries.

Dr. Prakasham Tata persued his professional interests at the State University of New Jersy and has been outstanding teacher and researcher in Chicago for the past five decades. His empathy for the downtrodden has drawn him to The Rotary International Movement and he is active in Naperville, USA. He resurrected Bharathi Teertha to promote Indian Culture and continues to give it leadership & vision.

Dr. Prakasham Tata who was born in Vizianagaram, Andhra Pradesh, is also working for his childhood dream of doing something to improve public health in Vizianagaram to provide the city a better environment. He played an important role in the construction of a wastewater treatment system in Vizianagaram, to bring into focus the whole gamut of issues relating to clean water availability, conservation, management, waste water disposal and recycling. According to Dr Tata, "modern living was leading to more water toxicity levels and more energy consumption for water management. Urban areas faced an increasing sewage disposal problem, and water was being increasingly polluted".

Recently Er Anuj Sinha, Director, Vigyan Prasar and Consultant, Department of Science & Technology, Government of India interacted with Dr. Prakasam Tata on challenges faced by him to create a success story of Vizianagaram.

Prof Ashok Lal, a well known author, also joined in the discussion. Prof Ashok Lal began his career as an executive in State Trading Corporation and specialized in International Marketing. He moved over to academics and found his true calling in



Dr. Prakasam Tata

interpreting the works of Galib and reflecting thoughts of the Buddha. His interest spans from radio scripting to street plays and other forms of direct communication on developmental issues. Prof Lal was at Vizianagaram to release his book on Galib and Buddha which was published by Bharathi Teertha Trust.

Here are excerpts of the conversation.

Er Anuj Sinha: In any social engineering project it is not only the technology that determines the success or failure but it is also factored by the commitment of the people the users of a particular service and the promoters. So what are the lessons that one learns from this experiment that could be useful to others who may be equally committed to try and see whether they can make contribution to a project of that type the you took up and completed in Vizianagaram?

Dr. Prakasam Tata: There is nothing that cannot be done. I have been living in the United States for last 48 years and I could complete the project in my home town in 2003-04, with the cooperation of some local people I found that majority of the masses were not interested in doing it. It is a sense of apathy that I observed because there is no support from the government or from activists concerned about the environment. They talk about all kinds of different things but they rarely discuss local problems or try to identify a solution. Even if I offered a solution they said it cannot be done, unless the government is involved. So what lessons did I learn from it? The government supported the project. Almost Rs. 2.5 crores was spent on this project and it was tax payers' money. But once the regime changes the priorities change.

I must comment on the toilet complex that was completed recently. I have seen the frustration of villagers there and as per my scientific estimations I know this project has potential benefit of about Rs. 1.5 to 2 lakh per year after paying for the arrangements and also the salaries of four people working in this complex. But what I heard from the villagers is a little bit disappointing. This project was not funded by the government; rather and it is a project of the Rotary International. But, by motivating the masses, by sitting with them and telling them that this is their project, they agreed to pitch in.

Now I am not happy over the money spent over there simply because it is the money of the people being spent and nobody seems to be caring about that money. It has been happening for last 3.5 to 4 years. Every year I come and ask the authorities why they are not taking interest. I have documented it in films and articles also. This is a real story and you can see my frustration.

AS: May I draw a parallel from Punjab which has had a different outcome? There was a religious leader in Punjab who was convinced that the stream of river flowing next to his ashram was really neglected with sewer discharges from neighbouring villages. He managed to raise this issue among the devotees and they jumped in on the offer and over a period of five weeks they had constructed aeration ponds for all discharges

in to the river and made it alive again. Perhaps the people of Punjab do kar-seva - as a matter of faith and religion, whereas the people of this community here are not that socially inclined and ask the government to do everything!!

Prof Ashok Lal: Can I interrupt you? What Er Sinha is saying is of great significance but there is a problem here of attaching religion. I am very glad that it worked in Punjab. But, what will work here is some kind of symbology, because we know what we mean by religion in the present time. So, I personally I am very much for promoting spirituality only. But iconic representation in terms of a religion where problems would arise is another story.

PT: Anuj ji, you raise a very good point. I am not talking about religion, about spirituality. We do not have to deal with religion per se. All the Hindus, ashrams, must act together; must say to their devotees "unless you act, things will never change". They should urge the people not to spread pollution. There are religious leaders who have lots of followers; when they say something their followers would implement it. In the same manner, when some mullah calls upon his followers to clean the mushy river, they would be keen to do it.

There are common good things for the entire population to share for livelihood and sustainability of the region. So we can bring all the mullahs, all Buddhist priests and Hindu pundits and also scientists together to demand service to society for the common goal. So finally we have an obligation to save the planet Earth for the coming generations.

AS: May I come back to the experiment you carried out in Vizianagaram. How could we have done the things differently? Now you go back 9-10 years; could it happen in a different form so that it would have been more successful?

PT: I think it is very difficult for administrators posted every 6 months or one year, taking charge and trying to understand the problems that had been previously tried to be rectified. One problem I see is that by the time they understand the problem and come to a stage where they try to think of solving the problem their tenure is over. At least this is what I found in the few years of my exposure of solving the problem in Vizianagaram! I don't blame them because the system is so inefficient, any new person will take time to understand what the problem is.

So we have to create awareness among the public and actually demonstrate that they can solve the problems, without depending on the government, because governments cannot do much. This is a kind of feeling that is needed to be developed in society.

AS: Coming to other functioning of Bharathi Teertha, where you have been promoting art music, and traditional culture. Of course we admire the commitment and generosity that you donated your ancestral home. How and what sort of vision or change you see in the future?

Dr. Prakasam Tata delivering a talk.

AL: This is of great interest to me, but before that I want to ask a question. I want to know your trigger, what made you take up this endeavour in spite of your profession, and in spite of your several concerns that you may have in Chicago and elsewhere?

PT: Well I think it's a personal element of mine because, when I made a commitment that I promised to somebody I wanted to make sure that I have tried my best to make it happen. I sincerely believe, whatever I said to anybody in my life I have tried my best to fulfill that commitment.

I know my limits; I also know my weaknesses. But if I made a commitment, that always keeps bothering me in some respect and compels me to do something. So that when I retired from my active job, I could take other opportunities. Now I will go to the question of Er Sinha; I will tell you the best way, when I went to the first lecture in the college, my professor told me, an engineer who knows the history can do a better job. So I know the history of Bharathi Teertha - which had its glorious days in Andhra Research University, this is what they called it at that time. When the University Grants Commission came, it lost its status as a research university and it has become Bharathi Teertha! And the benevolence of the maharaja is diminished; only passionate people like Suryanarayana Murti were left. Mr Murti passed away in 1999, but I made a promise to him that I will do something for our place. So when I retired in 2002, I wanted to do something and to work for the benefit of Vizianagaram.

After many years of professional career one can become a good orator and can give good lectures. But what is next? Is there a transformation of people there? I think music is such a medium. Many people want to sing and dance and hence I want to give them a platform where music and culture will go hand in hand.

AS: My point here is that Prof Prakasam Tata is in a unique position to try and integrate these two great human endeavors… science and culture. Can that commitment to development and integration of science with art happen because of the Bharathi Teertha?

PT: I am 75 years old. Let me be pragmatic about it. I do not know, but if at all anything will happen. I always tell two things, one is committed people and the other is finances. I am now finding more committed people. While giving demonstrations I say you are right people who can do it. In doing this, I requested many people and one of them is you Anuj. While undertaking the Vizianagaram project I met administrators in India and also in the United States. After sharing my views people have started to believe and started to support me. We have reached the fifth year now of celebrating the World Water Day.

AS: Can I take you back to your formative years when you were in Nagpur, spending time in LIT campus? I spent five years there after you left. How did it shape your personality?

PT: There are several people who have made my life. Prof A. Nath, Head, Department of Bio Chemistry was a great philosopher. I believe in the Vedas and Ayurvedas and he pulled out so many slokas which motivated me to do the best. Before that there were many teachers who impressed me in a way.

I was 17 years old when I was admitted to Nagpur. I did not know Hindi or English well. I just had Rs 10 with me and I went with the hold-all that time. At the station the rikshawala asked me three rupees. That time I did not know what is he saying. I said Oh God, why I am here! By hearing me he said, 'are you a Telugu man?' At the same moment I recognised God. Because I know God will not come with 10 hands and all. I said yes, and then he gave me such a treatment that he even carried my hold-all. After reaching to the hostel I was giving him 3 rupees and one extra for the efforts but he refused to take the money. It is great that I have met so many different people. Even in the United States I met many good people.

AS: In another aspect of your character, you spotted something in Prof Ashok Lal. And probably he did it like that. What is that you spotted? Was it an intuition only or logical type decision that this guy has that spark?

PT: I was told by my friend Prof Ajit Pant that he has a friend here and he is good. I said I want to listen to this man. Both of us along with his wife Kumkum had a good time talking to each other. I found that if any single man can change the way we perceive things it could be Ashok Lal. And that's it. I agreed to print his thesis on Buddha and Galib that was released yesterday.

AS: It has been a positive expression about a Bharathi Teertha. We have interacted in searching and locating unifying efforts in reducing tension, interpreting different change of thought.

PT: Definitely, that is one of the things to join more people in this effort and then have trust in Bharathi Teertha. As I have always said, I am finding myself in this effort. As an endeavour, as a consumer or producer, all that I can say.

AS: Thank you Sir.

Antibiotic effectiveness
What You Can Do to Safeguard it?

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

Hailed as the "wonder drugs" of the 20th century, antibiotics easily rate among the best of the miracles worked by modern medicine. Before their birth, teeny-weeny bacteria took such heavy toll of human lives that the average life expectancy of the human race on earth was less than 25 years. With the advent of these miracle drugs, it has nearly tripled in many parts of the world and several scourges caused by microorganisms stand decimated. Yet, today, the human race is on the verge of squandering this big advantage. Due to their widespread misuse, antibiotics are rapidly losing their efficacy. New microorganisms often referred to as "superbugs" are becoming resistant to them, and are threatening to kill, spread to others, and return us to the pre-antibiotic era. Unless quick measures are initiated both by individuals and society, the future generations may again be left exposed to the evil wrath of microorganisms. Recognising the threat, the World Health Organization (WHO) has decided to send out a clarion call to its member nations to intensify measures to safeguard these "wonder drugs" for future generations. The central theme of the World Health Day 2011 is to call on governments and stakeholders to implement the policies and practices needed to prevent and counter the emergence of highly resistant microorganisms.

Antimicrobials and antibiotics are the icons of modern medicine. Of the many proud sagas that colour the world of medicine, they easily rate among the biggest miracles. Yet, through their widespread misuse, today a stage has been reached when they are losing their efficacy. Antimicrobial resistance – also known as drug resistance – is rendering these pills ineffective. The threat is real.

Should you think antibiotic resistance isn't a problem or doesn't affect you, think again. Infections caused by resistant microorganisms – failing to respond to conventional treatment, resulting in prolonged illness and greater risk of death – are on a steep rise. About 440,000 new cases of multidrug-resistant tuberculosis (MDR-TB) are emerging annually, causing at least 150,000 deaths. Resistance to earlier generation antimalarials such as chloroquine and sulfadoxine-pyrimethamine combination is nearly global. The notorious methicillin-resistant Staphylococcus aureus (MRSA) – once a concern only for people in the hospital – is raising its ugly head and is causing infections among healthy people in the community. If this isn't alarming, think about this: resistance is on the rise against the antiretroviral drugs (ARV) used in the treatment of the human immunodeficiency virus (HIV).

The writing is clearly on the wall: inappropriate and irrational use of antimicrobial drugs has spawned the emergence of resistant microorganisms, which threaten to spread far and wide among the human race and turn into killer illnesses. Regular antibiotics no longer work against them. These infections are very difficult to treat, mean longer layoffs, extended hospital stays, and the need for more expensive and toxic medications. Some resistant infections can even cause death.

A global health concern, the only way to tide over the crisis would be to use antibiotics wisely.

What makes antimicrobials ineffective?

If antibiotics are used too often for conditions they can't treat — like colds, flu or other viral infections — they become less effective against the bacteria they're intended to treat. Not taking antibiotics exactly as prescribed also leads to problems. For example, if you take an antibiotic for only a few days — instead of the full course — the antibiotic may wipe out some but not all of the bacteria. The surviving bacteria become more resistant and can be spread to other people. When bacteria become resistant to first line treatments, the risk of complications and death is increased. Each year, thousands of people die each year of antibiotic-resistant infections they contracted in the hospital.

The failure of first-line antibiotics also means that doctors have to resort to less conventional medications, many of which are more costly and associated with more serious side effects. For instance, the drugs needed to treat drug-resistant forms of tuberculosis (TB) are much more expensive than are the drugs used to treat non-resistant TB. The course of treatment is long — up to two years — and the side effects can be severe.

Other consequences are the increased costs associated with

prolonged illnesses, including expenses for additional tests, treatments and hospitalisation, and indirect costs such as lost income.

What you can do to safeguard antibiotic effectiveness?

Repeated and improper use of antibiotics is the primary cause of the increase in the number of drug-resistant bacteria. Here's what you can do to promote proper use of antibiotics:

Understand when antibiotics should be used

Don't expect to take antibiotics every time you're sick. Antibiotics are effective in treating most bacterial infections, but they're not useful against viral infections, such as colds, acute bronchitis or the flu. And even some common bacterial ailments, such as mild ear infections, don't benefit much from antibiotics.

Don't pressure your doctor for antibiotics if you have a viral illness

Instead, talk with your doctor about ways to relieve your symptoms—for instance, a saline nasal spray to clear a stuffy nose or a mixture of warm water, lemon and honey to temporarily soothe a sore throat.

Take antibiotics exactly as prescribed

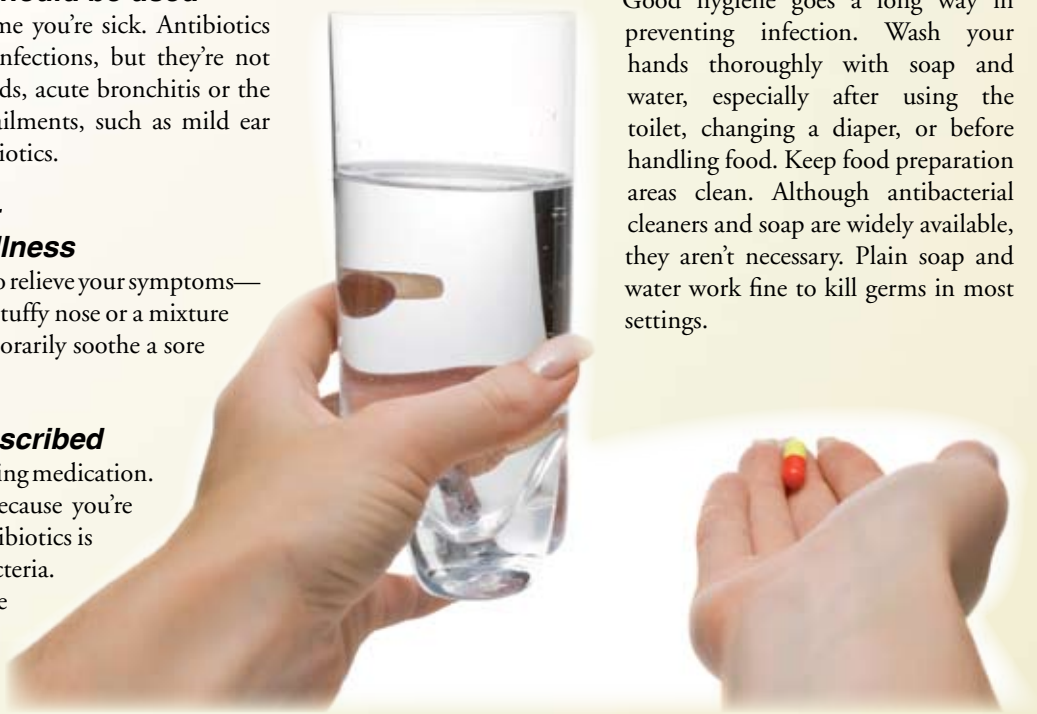
Follow your doctor's instructions when taking medication. Don't stop treatment a few days early because you're feeling better. Taking the full course of antibiotics is the only way to kill all of the harmful bacteria. A shortened course of antibiotics, on the other hand, often wipes out only the most vulnerable bacteria while allowing relatively resistant bacteria to survive.

Never take antibiotics without a prescription

If you didn't complete a full course of antibiotics, you might be tempted to use the leftover medication the next time you get sick or to pass it along to someone else. But this isn't a good idea. For one thing, the antibiotic might not be appropriate for a future illness. And even if it is, you're not likely to have enough pills to combat the germs making you sick, which can lead to more resistant bacteria.

Prevent the spread of germs

Good hygiene goes a long way in preventing infection. Wash your hands thoroughly with soap and water, especially after using the toilet, changing a diaper, or before handling food. Keep food preparation areas clean. Although antibacterial cleaners and soap are widely available, they aren't necessary. Plain soap and water work fine to kill germs in most settings.



Understanding the new type of antibiotic resistance labelled as NDM1

- NDM1 is an enzyme that confers resistance to one of the most potent classes of antibiotics, known as carbapenems. Many different types of bacteria have now been reported to harbour this new resistance machinery. At least one in 10 of these NDM1-containing strains appear to be pan-resistant, which means that there is no known antibiotic that can treat it.
- This is ominous since this particular resistance machinery is governed by a set of genes that can move easily from one bacterium to another.
- Equally damning is the fact that NDM1 has been found in the most commonly encountered bacterium in the human population, E. coli, which is the most common cause of bladder and kidney infections. Of the two drugs potentially capable of treating an infection due to these new multi resistant strains, one of them, colistin, causes toxic effects to the kidney in about a third of people, and hence, is not safe.
- Currently, there is no significant new drug development which promises to offer a major breakthrough against this problem.

Protect yourself and others

Antibiotic resistance is a global health problem. Nearly all significant bacterial infections in the world are becoming resistant to commonly used antibiotics. When you misuse antibiotics, you help create resistant microorganisms that can cause new and hard-to-treat infections. That's why the decisions you make about using antibiotics — unlike almost any other medicine you take — have far-reaching consequences. Be responsible in how you use antibiotics to protect your health and that of your family, neighbours and community.

Recognise the ills of antimicrobial resistance

Antimicrobial resistance is a ruthless killer. Infections caused by resistant microorganisms often fail to respond to conventional treatment, resulting in prolonged illness and greater risk of death.

Antimicrobial resistance challenges control of infectious diseases. Antimicrobial resistance hampers the effectiveness of treatment because patients remain infectious for longer, thus potentially spreading resistant microorganisms to others.

Antimicrobial resistance threatens a return to the pre-antibiotic era. The risk of many infectious diseases is becoming uncontrollable and could derail progress made towards reaching the targets of the health-related United Nations Millennium Development Goals set for 2015.

Antimicrobial resistance increases the costs of health care. When infections become resistant to first-line medicines, more expensive therapies must be employed. The longer duration of illness and treatment, often in hospitals, also increases health-care costs and the financial burden to families and societies.

Antimicrobial resistance jeopardizes health-care gains to society. Antimicrobial resistance is threatening to jeopardize the achievements of modern medicine. Without effective antimicrobials for care and prevention, success rates for treatments such as organ transplantation, cancer chemotherapy and major surgery would be hampered.

Antimicrobial resistance is a compromise to health security, and can seriously damage trade and economies. The growth of global trade and travel allows resistant microorganisms to promptly spread to virtually any part of the world. Any society that fails to take adequate steps to safeguard against antibiotic resistance poses a threat to the entire human population.

50 years of human space flight

Fifty years ago, on 12 April 1961, the Russian air force pilot Yuri Gagarin became the first human to orbit the Earth. He went into space in a capsule called Vostok-1, which was lofted into orbit by a rocket from the Baikonur launch pad in Kazakhstan. The Vostok-1 spacecraft blasted off from the Baikonur launch site at 06:07 UTC (11.37 IST). The payload included life-support equipment and radio for communication and television cameras to relay information on the condition of the pilot. Gagarin's flight lasted 108 minutes, including 89 minutes in space. He completed one orbit of the Earth, travelling at 27,400 kilometres per hour. At the highest point, the spacecraft was 327 kilometres above mean sea level. Gagarin ejected after re-entry and descended under his own parachute, as was planned.

In his post-flight report, Gagarin recalled his experience of spaceflight, having been the first human in space:

"The feeling of weightlessness was somewhat unfamiliar compared with Earth conditions. Here, you feel as if you were hanging in a horizontal position in straps. You feel as if you are suspended."

Gagarin was killed in the crash of a two-seat jet aircraft on 27 March 1968, while on what was described as a routine training flight.

[A detailed article on Gagarin's historic flight will be published in a forthcoming issue of Dream 2047.]

Letters to the editor

A useful magazine

Dream 2047 is a very popular magazine in India. It is read everywhere in the country. I also aread it regularly and find it very useful. I think all youth and students should read this popular magazine.

Mukund Kumar
S/o Shri Ramjee Tiwari
P.O/Via – Piprahi, Distt. Sheohar, Bihar – 843334

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Creating scientific temperament

I belong to a backward area (Dist: Kulgam) of Jammu and Kashmir, facing much difficulty in getting comprehensive and basic study material for physics that could help remove my misconceptions. I thank you for your mission to create innovative and scientific temperament among the youth through Dream 2047. Your endeavour is going to bring about a scientific revolution throughout our country.

Nadeem Manzoor
S/o Shri Manzoor Ah. Naikoo
R/o Damidulla, Teh./Distt. : Kulgam
Post Office : Yaripora
Jammu & Kashmir – 192232

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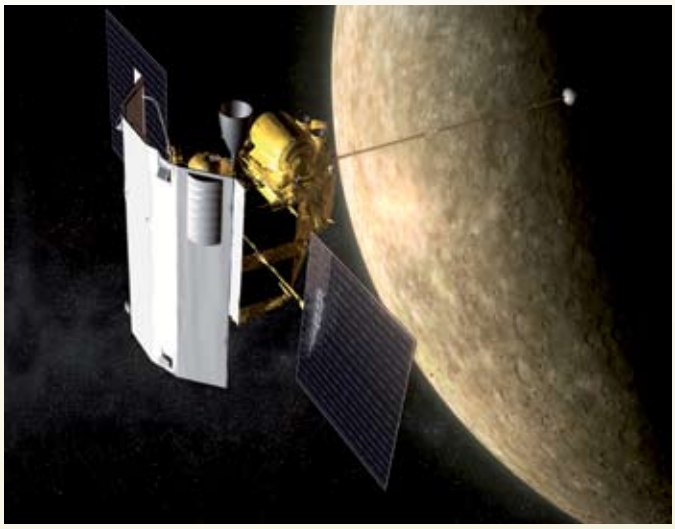
Recent developments in science and technology

Biman Basu
e-mail: bimanbasu@gmail.com

MESSENGER in orbit around Mercury

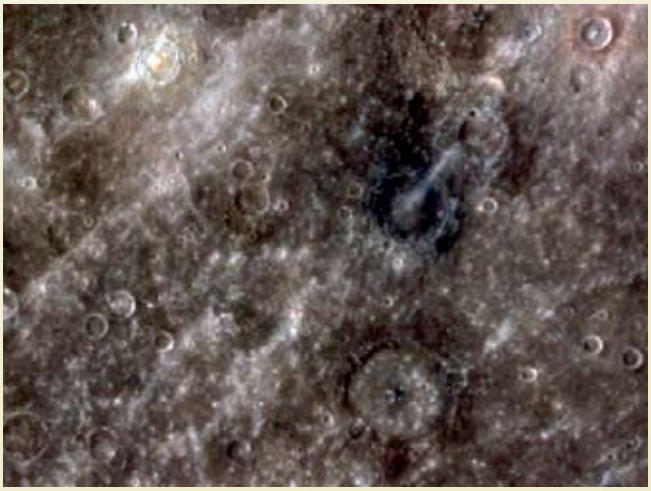
Of the planets visible to the naked eye, Mercury is probably the most elusive. Being closest to the Sun, it is almost always hidden in the glow of sunrise or sunset, being visible only when its orbit carries it furthest away from the Sun in the sky as seen from Earth. Even when Mercury is visible on the horizon just after sunset or before dawn, it is mostly obscured by the haze and dust in the atmosphere. For this reason little could be learnt about the planet through telescopic observation from Earth, although fly-bys by a spacecraft in the 1970s did reveal some surface feature. But it was too little. Now, for the first time history a spacecraft has gone into orbit around Mercury. NASA's *MESSENGER* spacecraft achieved the distinction on 18 March 2011 after a nearly seven-year journey from Earth.



Artist's impression of MESSENGER orbiting Mercury. The sun-shade can be seen on the left.

MESSENGER stands for *ME*rcury Surface, Space *EN*vironment, *GE*ochemistry, and *R*anging. Launched in August 2004 the spacecraft covered nearly eight billion kilometres and included a number of planetary flybys before reaching Mercury orbit. Before going into orbit, the spacecraft had made three fly-bys of Mercury in January and October 2008 and September 2009. *MESSENGER*'s orbit around Mercury is highly elliptical, 200 kilometres above the surface at the lowest point and 15,193 kilometres at the highest.

Before *MESSENGER*, *Mariner*-10 was the only spacecraft to have visited Mercury. It did not go into orbit, but successfully flew by the planet on three different occasions: 29 March 1974, 21 September 1974, and 16 March 1975. *Mariner* 10 took a total of 3,500 images. Unfortunately, Mariner-10 ended up capturing images of the same side of Mercury each time. *MESSENGER* is intended to explore the sides never seen before. *MESSENGER*'s tasks during its one-year primary science mission include making topographic maps of the entire surface of Mercury and characterising the planet's magnetic field and geologic history, including the role of volcanism in its relatively recent past.



One of the first colour images of Mercury sent back by MESSENGER. (Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)

There are six key questions NASA hopes to answer during *MESSENGER*'s year-long orbit of Mercury: why is Mercury so dense; what is the planet's geological history; what is the nature of Mercury's magnetic field; what is the structure of Mercury's core; what are the unusual materials at Mercury's poles; and what volatiles are important at Mercury? It will also attempt to confirm radar studies that hint at the presence of ice within permanently shadowed craters near the north and south poles of the planet.

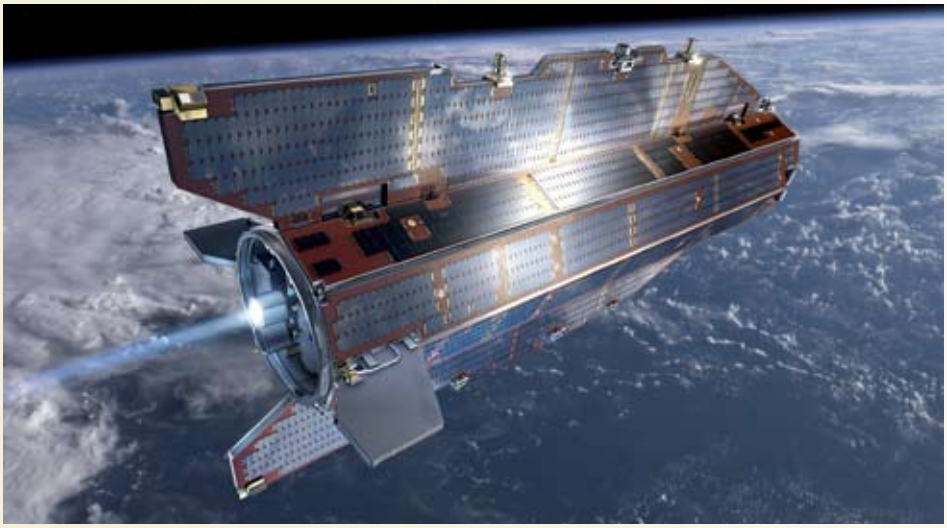
MESSENGER carries seven different science instruments as well as a radio science experiment. The equipment includes cameras, a laser altimeter, a magnetometer and a variety of spectrometers. Using these instruments, the spacecraft will be able to do many things, such as map the planet's entire surface in great detail, gather data on the composition of Mercury's crust and investigate the nature of its magnetic field and thin atmosphere.

Because Mercury is so close to the Sun, any spacecraft orbiting the planet must be able to withstand intense heat and solar radiation. To protect it from the searing heat of the Sun *MESSENGER* is fitted with a sun-shade. The heat-resistant, highly reflective sun-shade sits on a titanium frame fixed to the front of the spacecraft.

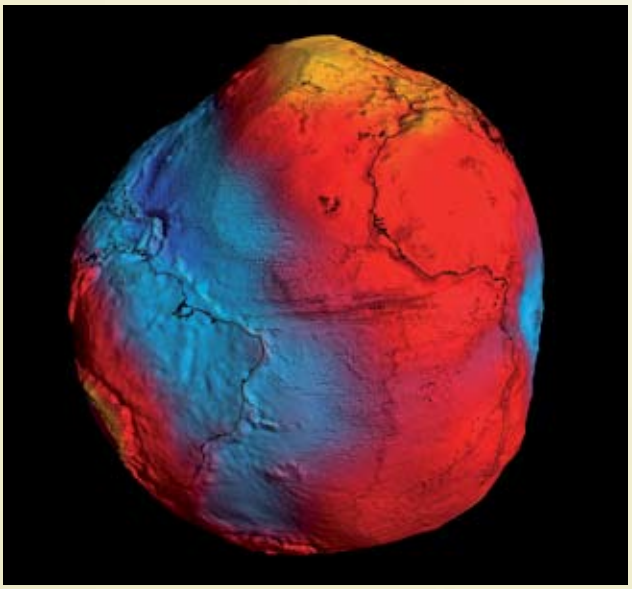
Interestingly, *MESSENGER*'s mission will last only two Mercury days. This is because Mercury rotates on its axis so slowly that one Mercury day is equivalent to about 176 days here on Earth. Mercury speeds around the Sun very fast, taking just 88 days to complete one orbit. So during *MESSENGER*'s 12 Earth-months of orbital observations, the spacecraft will experience just two Mercury days, but more than four Mercury years.

Earth's gravity revealed with utmost precision

That the Earth does not have a geometrically perfect shape is well established, and the geoid is used to describe the unique and irregular shape of the Earth. A geoid is defined as the surface within or around the Earth that is everywhere normal to the direction of gravity and coincides with mean sea level in the oceans. However, only recently have the more substantial irregularities in the surface created by the global mean sea level been observed. These irregularities are an order of magnitude greater than experts had predicted. Controlled by the gravitational potential of the Earth, these irregularities form very gentle but massive "hills" and "valleys." Recently, a new 3D map of Earth's gravity with unrivalled precision has been prepared from the data gathered by ESA's *GOCE* satellite. The new map shows the most accurate model of the geoid ever produced to further our understanding of how Earth works. The new geoid was unveiled on 1 April 2011 at the Fourth International *GOCE* User Workshop hosted at the Technische Universitat Munchen in Munich, Germany.



The GOEC satellite



ESA's GOCE mission has delivered the most accurate model of the 'geoid' ever produced, which will be used to further our understanding of how Earth works.

The 'Gravity field and steady-state Ocean Circulation Explorer' (*GOCE*) is a unique satellite designed to measure gravity. The five-metre-long arrow-shaped satellite has none of the moving parts often seen in other spacecraft. Therefore, the satellite together with its instrumentation actually forms a single composite gravity-measuring device. The spacecraft structure is built largely of carbon-fibre reinforced plastic sandwich panels to guarantee stable conditions under varying temperatures and at the same time to limit mass.

Launched on 17 March 2009 the satellite orbits Earth as low as possible to observe the strongest possible gravity-field signal – hence *GOCE* has been designed to skim above Earth at a height of just 250 km. Its slim elongated form enables it to cut through the wisps of atmosphere that are still present at this height. An electric ion thruster at the back continuously generates tiny forces to compensate for any drag that *GOCE* experiences along its orbit. *GOCE* has now collected more than 12-months of gravity data. Scientists hope *GOCE* will provide dynamic topography and circulation patterns of the oceans with unprecedented quality and resolution, which will help improve our understanding of the dynamics of world oceans.

According earth scientists the *GOCE* geoid will help make advances in ocean and climate studies, and improve our understanding of Earth's internal structure. For example, the gravity data from *GOCE* are helping to develop a deeper knowledge of the processes that cause earthquakes, such as the event that recently devastated Japan. Since this earthquake was caused by tectonic plate movement under the ocean, the motion cannot be observed directly from space. However, earthquakes create signatures in gravity data, which could be used to understand the processes leading to these natural disasters and ultimately help to predict them.

India's tiger population rises

For the first time in decades, the tiger population in India has shown a 20 percent increase in their numbers in the wild over the last five years, as evident from a survey, released by the Ministry of Environment and Forests. According to the survey, India's current tiger population is 1,706, compared with 1,411 in 2006. India is home to about half of the world's wild tigers.

There were estimated to be around 40,000 tigers in India at the time of independence from Britain in 1947. Their numbers had declined sharply for decades, largely because of poaching and the pressures of development encroaching on their natural habitat. However, even though tiger numbers have increased, the area occupied by tigers has shrunk dramatically over the past four years, from 93,000 hectares to just 72,800 hectares, which is a cause of worry. With economy growing at nearly 9 percent a year, mining, forestry and other types of development are affecting wild habitats.

The Royal Bengal tiger

A majority of India's tigers live in the country's 39 reserves in 17 states, but the survey found that more than a quarter of them live outside the reserves. The survey was the first to include the Sundarbans, the region of mangrove forests on the border of India and Bangladesh, where 70 tigers were counted.

In India, tiger census has been traditionally done by 'Pugmark tracking', which involved collection of pugmark tracings and plaster casts from the field and analysis of these separately for individual male, female, and cub of tiger and leopard. In order to obtain good pug impressions, PIPs (Pug Impression Pads) were laid along various roads, animal tracks and footpaths in the forest area.

Unlike earlier tiger estimates, when only pugmarks of individual tigers were counted, for the latest census conservationists used hidden cameras and DNA tests to count the animals in the wild. According to Rajesh Gopal, Director, National Tiger Conservation Authority, the count is more scientific this time and therefore more accurate.

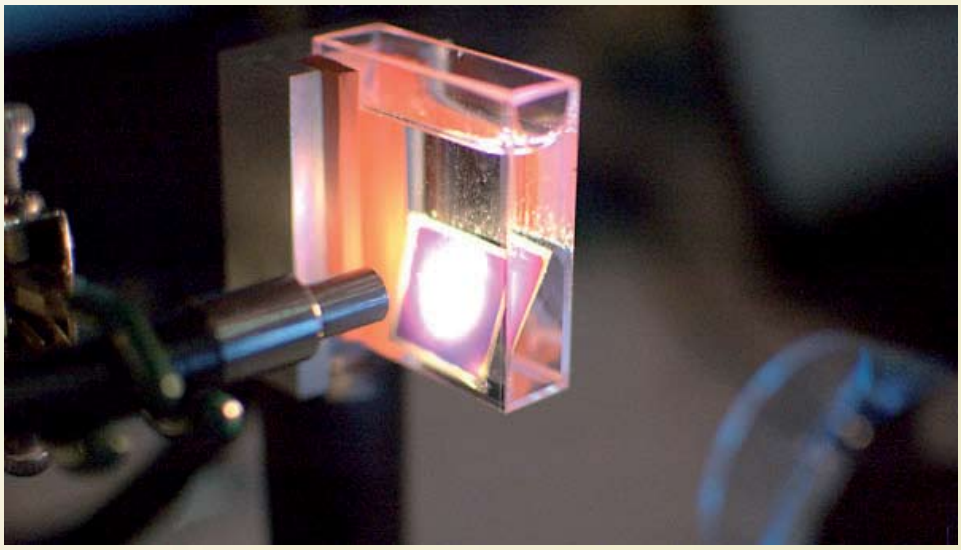
Chip splits water in sunlight to generate hydrogen

A team of scientists at the Massachusetts Institute of Technology in USA has developed what could be called the first practical artificial leaf, which can split water into its two components, hydrogen and oxygen using sunlight, which can then be stored and used later in a fuel cell to generate electricity. In nature green plants use the green pigment chlorophyll as catalyst to split water into oxygen and hydrogen. Of course, in plants the hydrogen is used up to make food while the oxygen is released into the atmosphere. The new device can be used to generate hydrogen.

The new chip, made from silicon, electronics and catalysts, is the same size and shape as a playing card, but thinner. To make the artificial leaf, the MIT team spread its catalysts on opposite sides of a silicon wafer. The silicon absorbs sunlight and passes energetic, negatively charged electrons and positively charged electron vacancies (holes) to the catalysts on opposite sides that use them to make H_2 and O_2. When the device is placed in a clear jar and exposed to sunlight, the setup converts 5.5% of the energy in sunlight into hydrogen fuel, which can be stored and used in a fuel cell to generate electricity. The new artificial leaf uses nickel and cobalt as catalysts, which are relatively cheap, and has so far operated continuously for at least 45 hours. The research was reported by Daniel Nocera, a chemistry professor at MIT, who did the work, at the biannual meeting of the American Chemical Society, at Anaheim, California, USA on 28 March 2011.

Three years ago, an MIT team led by Nocera devised a special cobalt and phosphorus-based catalyst that breaks water molecules apart and knits pairs of oxygen atoms into O2 molecules (Science, 1 August 2008). Researchers had previously made H_2-forming catalysts. But these were expensive. This time, the device uses cheaper catalysts to generate H_2. The process was based on the researchers' creation of a new catalyst consisting of cobalt, phosphates and an electrode.

When placed in water and electricity from any source is run through the electrode, the catalyst produces oxygen. It is combined with another catalyst such as platinum that can produce hydrogen gas from water, to duplicate photosynthesis. According to Nocera, the artificial leaf shows particular promise as an inexpensive source of electricity for homes of the poor in developing countries. He said, placing the artificial leaf it in a single gallon (3.78 litres) of water in bright sunlight could produce enough electricity to supply a house in developing countries with its daily electricity requirement.



Artificial leaf. When light is shone on the silicon chip coated with catalysts and immersed in water hydrogen is produced.

The conversion of solar energy into hydrogen under ambient conditions is considered to be one of the greatest challenges scientists face in this 21st century. Scientists believe this process could help create cheap electricity, reduce our dependence on fossil fuels, and thus help mitigate global warming.

Your opinion

Dream 2047 has been inviting your opinion on a specific topic every month. The reader sending the best comments will receive a popular science book published by VP. Selected comments received will also be published in *Dream 2047*. The comments should be limited to 400 words.

This month's topic:

"Is the extensive use of technology in making umpire's decisions killing the sporting spirit in the game of cricket?"

Response should contain full name; postal address with pincode and email ID, if any; and should be accompanied by a recent passport size photograph. Response may be sent by email (opinion@vigyanprasar.gov.in) or by post to the address given below. If sent by post, "Response: *Dream 2047* May3 2011" should be clearly written on the envelope.

Vigyan Prasar
A-50, Institutional Area, Sector-62, Noida 201 307 (U.P.)
Phone: 91-120-240 4430/35 Fax: 91-120-240 4437
Email: info@vigyanprasar.gov.in Website: www.vigyanprasar.gov.in

Winners of "Your Opinion" contest for February 2011

Topic: "Has the teaching of science in schools helped in removing the scourge of superstitions and irrational beliefs existing in our society in any significant manner?"

1. M.J. Lilly, PGT
NLC GHSS, Block-II,
Neyveli – 3, Tamil Nadu

In our country science text book at school level are updated and designed to include new information from time to time. While in teaching science students should be made to understand the concepts rather than memorising them, application of principles and concepts in real life situation is very important. But, rote learning just to score marks has become the order of the day. Only when the concepts sharpen the reasoning ability of the students can they remove the superstitions and irrational beliefs existing in the society in a significant manner. Instead, teaching and learning has become examination oriented and the students are shaped into mark scoring machines. The joy of learning, understanding and appreciating the various concepts of science is missing, as teachers are in a hurry to complete the syllabus and prepare the students for the examinations. As marks are the deciding factors at various levels, application of scientific skills finds no place in our society. Let us hope that the future generation rectifies the existing scenario for the betterment of humanity by wiping out the superstitions and irrational beliefs from our society.

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Puneeta Malhotra, Science Coordinator
K. R Mangalam World School
G.K. II, Delhi
puneeta_krm@yahoo.co.in

Science is taught as a compulsory subject up to class X, but most of educated people are unable to apply the science they learn to real life situations. The teaching of science lacks practical aspect thus observing, finding patterns, linking observation to theory and predicting – the method of science is not inculcated in the students. Experiments if conducted are more of verification experiments like finding the value of "g" using simple pendulum, and if a student does not get the value as 9.8m/s2, the teacher marks that as incorrect. So the students often manipulate to get the "correct" answer. A hidden message that goes across is there is only one correct answer, not that there can be other factors that affect the value of "g" so that the student gives his answer and tries to find the reason for variation. I am trying to put across the fact that we as teachers do not develop critical thinking in our students and therefore we are still tied by the ropes of irrational beliefs and superstitions. Teaching science does create disequilibrium in our mind, and we start questioning the beliefs but to sustain this inquiry and to develop a habit of rational thinking, more stress needs to be laid on hands-on experience and activities which provide scope for exploration. More emphasis on the method of science will help in removing the scourge of superstitions and irrational belief.

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Dr. G.R. Prakash, Associate Professor
Regional Institute of Education (NCERT)
Mysore 570 006

Teaching of science in most schools is in no way different from rest of the subjects. India being a land of innumerable religions and cultures, there are lots of beliefs and superstitions which cannot be even listed out completely. Moreover, in India religion and science have a happy blend. Religious beliefs, superstitions have no place in science. However, our constitution ensures right to religion to our citizens. Many beliefs and superstitions have been forgotten. This may be the combined influence of education, media and modern civilisation. However, it may take another century to get rid of all vices. As a workable solution for the present all such beliefs and superstitions which do not harm/insult others' feelings may be allowed to exist. Apart from overcoming blind beliefs, science should help one to develop rational thinking in one's daily life.

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National conference on "Conservation of Biodiversity"

Dr. Parul R. Sheth

The National conference on "Conservation of Biodiversity was organised jointly by Vigyan Prasar (VP) and National Centre for Science Communicators (NCSC), Mumbai on 20 and 21 November, 2010 at Indian Institute of Science, Bangalore. The conference was attended by science communicators, scientists and student community.

Prof P. Balaram, Director, Indian Institute of Science, Bangalore inaugurated the conference. Keynote address was delivered by Prof. Madhav Gadgil, eminent ecologist from Pune. Er Anuj Sinha, Director Vigyan Prasar briefed about the varied activities of VP in creating awareness about biodiversity. Mr. A.P. Deshpande, Chairman,NCSC and Mr. Suhas Naik-Satam, Secretary, NCSC, Nehru Centre, Mumbai were present on the occasion.

In his keynote address Prof Gadgil spoke about the importance of conservation of biodiversity including assessment of impacts of any human interventions on environment. He stressed the importance of Environmental Impact Assessment (EIA) by saying that EIAs should be treated as serious scientific exercises, which must be firmly anchored on to the bedrock of facts, and like all science be open to public scrutiny.

Prominent experts have presented papers on biodiversity conservation in four technical sessions: (i) Biodiversity in Agriculture; (ii) Presentation of projects by students; (iii) Conservation Strategy; and (iv) Role of Science Communicators. Vigyan Prasar organised a poster exhibition on biodiversity during the conference.

Session on Biodiversity in Agriculture

The session on Biodiversity in Agriculture was chaired by Prof Madhav Gadgil. Dr Anil P. Joshi pioneer of Himalayan Environmental Studies & Conservation Organisation (HESCO), Dehradun, who is involved with consistent development of rural villages, said that loss of biodiversity is a major challenge for human race today and the culprits are human choice and greed, development factors, changing environment, etc. Rural India, which covers 90 per cent of bioresources of the country, is the hub of bioresources. Today, commercialisation has set in in agriculture, horticulture and other related fields and this has become the main reason for depletion in diversity.

Speakers of technical session - Biodiversity in Agriculture

The importance of linkages between the chemical ecological profiles of bioresources and the physical niches they occupied was elaborated by Dr R. Gopichandran, Principal Research Scientist, Environment & Climate Change Wing, Gujarat Energy Research & Management Institute; Research, Innovation & Incubation Centre (GRIIC), Gandhinagar.

Dr R. N. Ray from NCSCT network, Bhubaneshwar said that the involvement of students in biodiversity conservation would help mobilise a large force in the processes. Giving examples of National Children's Science Congress of NCSTC, DST and National Green Corps programme of Department of Environment and Forest through eco-clubs, Dr. Ray stressed the need of involving students to spread the green movement in the country.

Talking about EIA and Environment Management Plan (EMP) preparation and implementation, Dr. Shalini Sharma, Chair Professor, Institute of Engineers, Hyderabad, said that EIA Notification 2006 provide the guidelines for obtaining the Environmental Clearance (EC) for any project. She stressed upon the need for assessing the positive and negative aspects of any new upcoming project. The validation report should be prepared by the project validator (PV), who should have no involvement with the project implementer or state/central environmental clearance committee member.

Loss of biodiversity can trigger large unpredictable changes in an ecosystem and some of these may adversely impact agriculture and human health. The prime objective of India's nuclear energy programme is the development and use of nuclear energy for peaceful purposes such as power generation, applications of nuclear science, medicine, industry, research and other areas. This was the subject of Mr. Rupesh Gaikwad of the Institute of Chemical Technology, Mumbai who presented various applications of nuclear science in the field of agriculture using radioisotopes and radiation technique.

Prof Madhav Gadgil interacting with participants of the conference

The session was conducted by Ms.

Kinkini Dasgupta Misra ,Scientist and Nimish Kapoor, Scientist of VP.

At the end of the session a set of recommendations were prepared which was discussed in the interactive session with the experts and the participants.

Participants at the Conference

Session on presentation of projects by students

Dr.Robert Singh, Associate Professor, Department of Biotechnology, Mizoram University, Aizwal, chaired the session. The first presenter was Ms. Rita Zomuanpuii from Aizwal, Mizoram who spoke about the distribution pattern, larval habitats and per cent incidence of various Anopheles mosquito species from varied geographical locations. Her results enlightened the role of vector transmission ability, insecticide susceptibility and genome status of the Anopheles mosquito in Mizoram.

Mr. Rajdeo Singh from St. Xavier's College, Mumbai, gave an account of medicinal plants; the Global Positioning System (GPS) co-ordinates of about 250 species. The study according to Mr. Singh would be crucial for conservation measures of important medicinal plant species and GPS will prove to be an efficient tool for in-situ conservation of important plant species.

Banana is the fourth most important food after rice, wheat and maize in Mizoram. Ms Hrashel Lalremsiami from Mizoram University presented her work on application of tissue culture techniques for sustainable utilisation of banana in Mizoram.

The presentation by Mr. Arijit Chatterjee from Kolkata, West Bengal included case studies done in West Bengal on conservation of monitor lizards and herons by villagers. Despite common allegations on local people being ignorant and destructive to wildlife, it was the villagers who actively participated in conservation strategies of wildlife.

Mr. P. C. Lalrinfela, from the Department of Biotechnology, Mizoram University presented his paper on the genetic diversity of banana. Because of the serious threats for the loss of crop, conservation and sustainable utilisation of banana genetic resources needs to be taken up as a priority through intervention of biotechnological approaches.

The impact of synthetic chemical use on biodiversity of crop fields was presented by Mr. Soumya Sarkar from West Bengal State University. Preliminary data analyses suggested significant erosion and alteration of the wide diversity of crop field due to extensive use of pesticides and herbicides.

A paper on 'Medicinal plants of sub-tropical mountain forests in the eastern part of Mizoram' was presented by Mr. R. Lalrinkima from the Dept of Forestry, Mizoram University. In order to preserve indigenous traditional knowledge of medicinal plants, field work was done in different villages.

Following the student presentations, Prof. C.D. Patil, former Secretary of Karnataka Rajya Vigyan Parishad (KRVP) briefed on the working of KRVP, an organisation working in the field of science popularisation and environmental awareness.

Session on Conservation Strategy

Dr. A.P. Jayaraman, Vice Chairman, NCSC, Mumbai, chaired the session on Conservation Strategy. Dr. T.N.C. Vidya from Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore spoke about elephant migration.

Studies from Arunachal Pradesh on motivations for hunting, off-take rates, awareness of wildlife laws among tribal communities, potential impacts of hunting and the consequences for wildlife populations were discussed by Dr. Aparajita Datta from Nature Conservation Foundation., Mysore.

Dr. S. Shivaji from Centre for Cellular and Molecular Biology, Hyderabad stressed on the need for conservation of wild life. He briefed about the techniques of molecular biology such as microsatellite analysis, mitochondrial gene analysis, etc. He also reviewed the ongoing work at the Laboratory for the Conservation of Endangered Species (LaCONES).

Landscape level biodiversity mapping using remote sensing was presented by Dr. M.S.R. Murthy from the National Remote Sensing Centre, ISRO, Hyderabad. Dr. Murthy identified future challenges of Indian landscape level biodiversity studies and conservation.

Dr. Scot Wrighton who is involved with the Lavasa Project at Pune asserted that based on the experiences to date in Lavasa, new cities can be placed in undeveloped areas where they can be expected to grow and create viable urban alternatives to India's existing mega cities. To do this, extensive planning is required using the best possible environment-friendly urban development methods.

Session on the Role of Science Communicators

The session was chaired by Dr. D. Balasubramanian, Director, L.V.Prasad Eye Institute, Hyderabad. Dr. Bal Phondke, former Director, National Institute of Science Communication and Information Resources, New Delhi delivered a talk on role of media in conservation of biodiversity.

Talking about the role of science communicators in conservation of biodiversity, Ms Sumangala Mummigatti from All India Radio, Bangalore, said that community participation becomes an essential requirement for conservation of biodiversity.

Mr. Shekar Dattatri, a freelance film maker who makes films for the National Geographic and the Discovery Channels, averred about the impact of film media in communicating science and biodiversity. With the help of striking clipping from his films on biodiversity he proved his point.

Dr. S. Jeelani, curator, Science City, Kolkata presented the role of science museums to create mass awareness on Biodiversity.

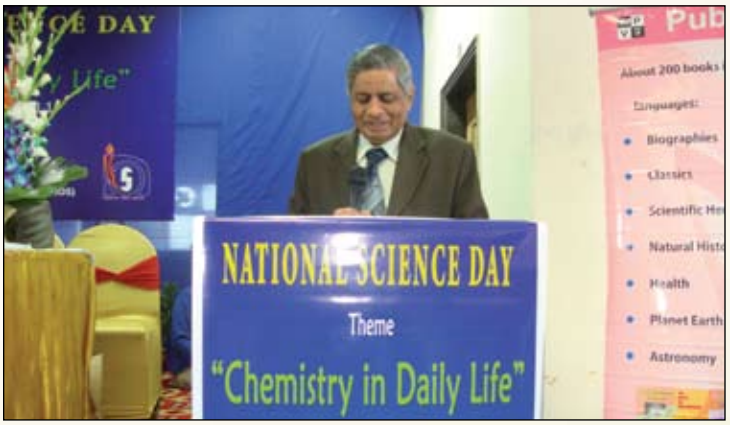
The conference ended on an inspirational note to preserve whatever biodiversity we have and make efforts to create awareness.

National Science Day 2011

National Science Day is celebrated in India on 28 February every year to mark the discovery of Raman Effect by Sir C.V. Raman. for which he was awarded the Nobel Prize in 1930. National Science Day 2011 was celebrated jointly by Vigyan Prasar (VP) and National Institute of Open Schooling (NIOS) on 28 February 2011 at NOIDA. Several competitions were organised throughout the day for college and school students and this drew a large number of participants.

Inaugurating the event Dr S S Jena, Chairman NIOS and Er Anuj Sinha, Director Vigyan Prasar expressed hopes for meaningful strategic partnerships in future. Dr Jena lauded the coming together of two prestigious organisations for the programme in their quest to provide quality education to all. Er Sinha said the event would build linkages with scientists, students and teachers of various institutions, schools and colleges. It will introduce the community to the facets of developments under the International Year of Chemistry 2011. Dr Kuldeep Agarwal, Director (Academic), NIOS and Dr S. K. Misra, Regional Director, NIOS were present at the inaugural session.

With the introduction of the theme of National Science Day 2011 'Celebrating



Er Anuj Sinha , Director Vigyan Prasar delivering the National Science Day inaugural address

Er Anuj Sinha and Dr Kuldeep Agarwal, Director (Academic), NIOS presented awards to winners of science day


दैनिक जागरण
राष्ट्रीय विज्ञान दिवस पर छात्र बने वैज्ञानिक
कार्यक्रम
• विज्ञान दिवस पर बताए विज्ञान के चमत्कार
• कार्टून प्रतियोगिता में डीपी मॉडर्न स्कूल और जिन्सी ने मारी बाजी

हिन्दुस्तान
वैज्ञानिक बनने के लिए आगे आए छात्र

पंजाब केसरी
राष्ट्रीय विज्ञान दिवस महोत्सव मनाया

नईदुनिया
विज्ञान दिवस पर प्रतियोगिताएं संपन्न

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राष्ट्रीय मुक्त विद्यालय संस्थान में आयोजित हुई प्रदर्शनी
प्रदर्शनी के माध्यम से बताई नैनो टेक्नोलॉजी

नवभारत टाइम्स
NBT Noida
सेक्टर-62 में विज्ञान प्रदर्शनी

स्वाभिमान टाइम्स
विज्ञान महोत्सव का आयोजन

Participants of poster competition during National Science Day 2011

Chemistry: Our Life-Our Future' Dr Subodh Mahanti, Acaemic Head, Vigyan Prasar said that the year 2011 is declared as "International Year of Chemistry" by United Nations, which also coincide with the 100th anniversary of the Nobel Prize awarded to Madame Marie Curie — an opportunity to celebrate the contributions of women to science. Dr Mahanti briefed about the programmes and activities to be undertaken by Vigyan Prasar during the International Year of Chemistry 2011.

During the National Science Day event an exhibition on science and technology was organised to showcase technological developments in media, advancement in nano-technology, innovative experiments, popular science publications, colourful posters to save planet Earth. VP, NIOS, National Reseacrh Development Corporation, Jagran Institute of Mass Communication, Sadhna Academy of Media studies, Nano Science & Technology Consortium displayed their resource material and innovations in the exhibition.

Face-to-Face interactions with scientists were organised during the event. Delivering the National Science Day Oration under the theme "Outreach Learning Programmes - Beyond four Walls…", Shri SK Saraswat, CEO Thar Education Foundation, said, "The learning and teaching of chemistry in high school and college can be very interesting if the lecture method is supplemented with project based learning. These have to be open-ended with clear learning goals."

Prof RK Sharma of Chemistry Department, University of Delhi emphasised the application of principles of "Green chemistry" in performing interesting experiments in the college laboratories. Both the presentations were followed by intense discussion with the participants in the Face-to-Face Session.

During the event four competitions for students were organised including a debate on "Reduction of carbon footprint will bring about radical changes in our life style", Poster competition on "Climate Change" or "Many Moods of a Forest", Cartoon competition on "Nature cleanses, Man pollutes", and a Quiz on Chemistry.

Awards to the winners of debate, poster, cartoon, and quiz competitions were presented by Dr Kuldeep Agarwal, Director (Academic), NIOS and Er Anuj Sinha, Director, Vigyan Prasar.

Workshop on Innovative Experiments in Physics

Glimpses of the workshop

A one-day workshop was organised by Vigyan Prasar at Central Building Research Institute (CBRI), Roorkee on 28 March 2011. 50 students and 15 teachers from six schools and one college participated in the workshop. As a part of CSRI initiative, CBRI has adopted a number of schools and colleges for faculty training with the objective of promoting interest, excitement and excellence in science education.

Shri Rintu Nath and Shri Kapil Tripathi conducted the workshop. Thirty hands-on activities on innovative activities in physics were performed during the workshop. Participants took part in doing a number of activities themselves. A few experiments based on the PC interface developed by Vigyan Prasar were demonstrated and how new projects could be designed using the kit was explained. All the participants were given a CD "Innovative Activities in Physics" and a kit "Emergence of Modern Physics".

Vigyan Prasar has taken initiatives to collaborate with CSIR to conduct similar workshops for other laboratories.