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VP News

Update on Vigyan Rail

The work on Vigyan Rail exhibition is on in full swing. Nearly half the exhibition work has been completed. The fixing of the exhibits will begin very soon. Vigyan Rail – Science Exhibition on Wheels train should be ready by November 25, 2003. There has been an effort to make every coach different with interesting backdrops, panels and models/ exhibits. The nodal officers of the participating Departments/ Ministries met at the Vigyan Rail exhibition site for the second time to review progress and provide further inputs on November 12, 2003. The date for flag off could be in the first week of December, 2003.

Nodal officers of different Ministries/Departments, officials of Ministry of Railways, Vigyan Prasar and members of the Monitoring Committee inspecting the progress of fabrication/design of Vigyan Rail.

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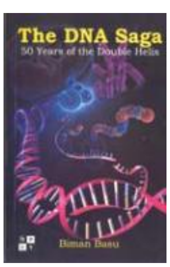
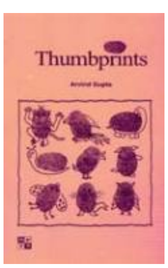
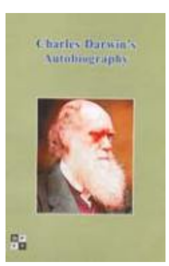
Our New Publications



The DNA Saga
Biman Basu
ISBN: 81-7480-099-9
pp.132 Rs.75



Thumbprints
Arvind Gupta
ISBN: 81-7480-100-6
pp.48 Rs.45



Charles Darwin's Autobiography
ISBN: 81-7480-103-0
pp.60 Rs.25

Ms Sunita Narain, Director, Centre for Science and Environment (CSE), New Delhi, delivering a lecture under the auspices of Vigyan Prasar Popular Science Lecture Series at Technology Bhawan, Department of Science and Technology, on 12 November 2003. The topic of the lecture was "Role of Science in Environmental Governance".

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

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Editor : Dr. V.B. Kamble

Venus Transit – A Rare Celestial Spectacle

On October 24, 1995 and June 11, 1999, we had a rare opportunity of witnessing a Total Solar Eclipse from India, when millions observed and enjoyed one of the most spectacular phenomena of nature. When Moon comes in between the Earth and the Sun, it is the solar eclipse. However, when either Mercury or Venus – either of the interior planets - comes in between the Sun and the Earth, it is called a transit. In a few months from now, we shall have the good fortune of watching Venus move across the disc of the Sun

The discs of the planets Mercury or Venus, as seen from Earth, are much smaller than that of the Moon. Therefore they make no more than a small black dot when they move in front of the face of the Sun. With every transit, depending on the geometry involved, this dot may traverse a different path across the face of the Sun. The transits do not take place frequently because the orbits of both Mercury and Venus are tilted at small angles to the ecliptic (the average plane of Earth's orbit around the Sun – the planets are always seen close to it), and hence they will usually be either above (north) or below (south) the ecliptic. This also the reason why we do not have solar eclipse on every new Moon day, or lunar eclipse on every full Moon day – the Moon ay be somewhat above or below the ecliptic. A transit will occur if the inferior conjunction occurs within a day or two (that is, the Sun, planet and the Earth coming on the same line with the planet in between) of the date at which the planet crosses the ecliptic.

The transits of Mercury can be seen 13 to 14 times in a century (incidentally, the first transit of Mercury in the twenty first century took place on May 07, 2003 which was visible in the entire country). However, transits of Venus across the disk of the Sun are among the rarest of planetary alignments. Indeed, only six such events have occurred since the invention of the telescope (1631, 1639, 1761, 1769, 1874 and 1882). It is interesting to note that there is no person living today who has witnessed a Venus transit before, the last transit having taken place 121 years ago, 06 December, 1882 to be precise. Venus transits show clear pattern of recurrence at intervals of 8, 121.5, 8 and 105.5 years. **The next two transits of Venus will occur on June 08, 2004 and June 06, 2012.** The entire transit of June 08, 2004 will be visible from Europe, Africa (except western parts), Middle East, and most of Asia (except eastern parts). India is ideally suited to observe the entire sequence of transit. We are very fortunate indeed.

What is the significance of transits? Edmund Halley realized that transits could be used to measure distance of the Sun from the Earth, also called Astronomical Unit. Kepler's laws gave relative distances between all the planets and the Sun, but, the absolute distances were not known. Halley did not live to see Venus transits in his lifetime, but, his efforts gave rise to many expeditions in 1761 and 1769 to observe the transits of Venus which gave astronomers their first good value for the Sun's distance from Earth. By timing the events from various places on the Earth and using elementary geometry, the distance to the Sun can be determined. More accurate methods are available now, but careful measurements in the 18th and 19th centuries gave distances to within 1% of that currently accepted.

The stories of expeditions all over the globe to observe the transits of Venus in the 17th and 18th centuries are as thrilling as they are inspiring. Captain Cook had observed a transit of Venus from Tahiti in June of 1769 and one of Mercury from Mercury Bay in New Zealand in November of the same year. In India too, there had been some observations of transits but no rigorous measurements could be taken to have been of much scientific value. Observations were planned from Pondicherry, for the Venus transit of 1761 by Le Gentil of France. He set out on a long sea voyage to India, in order to be in time for this transit. Unfortunately, Britain and France were at war during this period and when he was about to land in Pondicherry it had been taken over by British forces! He stayed on for observing the next transit in 1769, but the weather did not permit him! William Crawford observed the 1874 transit from Mauritius. Ernst Emil Becker of the Berlin Observatory made observations of the 1874 transit from an expedition to Isaphan. The first scientific observations made in 1882 by the Yale Heliometer, then largest in the world, were of the 1882 Venus transit.

While a transit of Mercury or Venus offers a great opportunity to the scientists to measure the planetary distances from the Sun, it provides a great occasion to science communicators to utilise the spectacular event to communicate the basic scientific aspects related to several astronomical phenomena in particular, and Science & Technology (S&T) in general to the members of the community. To capitalise on the tremendous possibilities offered for Science and Technology popularisation, Vigyan Prasar and National Council for Science and technology Communication have drawn up plans that include a variety of programmes for students, teachers and the general public. The main objective of the proposed programme is to utilise the event of Venus Transit for triggering an interest in Science and technology. A spate of activities would involve students, teachers and the general public. But remember! Do not try to observe the transit without taking proper precautions, or else your eyes could be permanently damaged.

June 08, 2004 is our date for rendezvous with Venus, a rare phenomenon which would take place after a gap of 121 years. As during the Total Solar Eclipses of 1995 and 1999, this would be an event in which students, teachers, general public, and Government / non-Government organisations, would be involved. We do hope you would be a part of this nation-wide S&T popularisation programme. Please do write to us about your ideas and suggestions.

❐ **V. B. Kamble**

Editor : **V.B. Kamble**

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Antoine Laurent Lavoisier

Founder of Modern Chemistry

❑ Subodh Mahanti

"Chemistry, like all other sciences, had arisen from the reflections of ingenious men on general facts, which occur in the practice of the various arts of common life."

Joseph Black

"As dangerous as is the desire to systematize in the physical sciences, it is, nevertheless, to be feared that in storing without order a great multiplicity of experiments we observe the science rather than clarify it, render it difficult of access to those desirous of entering upon it, and finally, obtain at the price of long and tiresome work only disorder and confusion. Facts, observations, experiments—these are the materials of a great edifice, but in essembling them we must combine them into clusters, distinguish which belongs to which order and which part of the whole each pertains."

Lavoisier in his Memoir on Combustion in General (1777)

Known as founder of modern chemistry, Lavoisier instilled in his colleagues a new aspect for quantitative techniques, the foundation of all progress in the field. While Black and Cavendish both instituted the use of careful quantitative analysis, Lavoisier succeeded in convincing other chemists of their importance. He did for chemistry what Galileo for physics: introduced sound methodology, empiricism and a quantitative approach.

Ray Spangenburgh and Diane K. Moser in History of Science In the Eighteenth Century, Universities Press (India) Limited, 1999.

Antoine Laurent Lavoisier, a 'many-sided genius', is regarded as founder of modern chemistry. He is one of those scientists, whose work actually led to the establishment of the foundations upon which modern science rests. When Lavoisier started working in chemistry it could hardly be called a distinct scientific discipline. While there was a large mass of empirical information but there was very little theoretical basis and it had no formal language of its own. The characteristics of metals, salts, acids and alkalis were well-known but gases were hardly known to exist. Modern chemistry was born when Lavoisier, with the help other chemists, derived his theory of combustion. While demonstrating the central role of oxygen in combustion, Lavoisier disproved the phlogiston theory. Lavoisier's theory of combustion revolutionized the field of chemistry as a whole. He clearly demonstrated the role of oxygen in respiration of both animals and plants. He showed quantitatively the similarity between respiration and combustion. He appreciated the importance of measurements in chemistry. For making careful measurements, he got balances constructed, which were of very high precision. Lavoisier's most sensitive Fortin balance was accurate to 1 part in 40,000. Lavoisier's use of measurements in experiments changed chemistry from a science of observation to science of measurement. He established the composition of water and many organic compounds. He clarified the distinction between compounds and elements and provided a logical system of chemical nomenclature. He made precise measurements of the mass changes in chemical reactions. And in doing so he formulated the law of conservation of mass, that matter is neither created nor destroyed in chemical changes. Lavoisier laid the framework for understanding chemical reactions as combination of different substances. He also produced pioneering work on anatomy and physiology.

Antoine Laurent Lavoisier

Lavoisier's monumental achievements in chemistry constituted only one of his many activities. It is interesting to note that his public duties were so numerous that he could spare only one day in a week for scientific investigations. He performed many important administrative functions in the Royal Academy of Sciences. He made significant improvements in the manufacture of gunpowder. He wrote important papers on economics. As a member of the Temporary Commission on Weights and Measurements (1791-93), he played an important role in planning for the metric system. Lavoisier made contributions to agriculture and demonstrated the advantages of scientific farming at a model farm near Blois. In 1785 Lavoisier was appointed as secretary to the Government's committee on agriculture. He drew up reports and instructions on the cultivation of crops. He also promulgated various agricultural schemes. He was a member of a committee concerned with social conditions of France and he developed schemes for improving public education, equitable taxation, savings banks, old age insurance and other welfare schemes.

Lavoisier served on a committee that explored hospitals and prisons of Paris and then recommended remedies for their horrible state. Lavoisier worked on a scheme for improving the water supply to Paris and on a method for purifying water. During the Revolution he published a report on the state of France's finances. He had given money without interest to the towns of Blois and Romorantin for the purchase of barley during the famine of 1788. Politically Lavoisier was a liberal. He saw the great necessity for reform in France and he worked for it but he opposed revolutionary methods.

Lavoisier and his wife

Lavoisier was born in Paris on August 26, 1743. His father Jean-Antoine Lavoisier was a Parliamentary counsel (*avocat au parlement*). His mother Emilie Punctis was the daughter of a wealthy attorney. After the early death of his mother, Lavoisier was brought up by a maiden aunt. He had a happy childhood. He studied at the College Mazarin, in which he enrolled in 1754. At the College Mazarin he studied mathematics and astronomy with Nicolas de Lacaille (1713-62), chemistry with Guillaume-Francois Rouelle (1703-70) and botany with Bernard de Jussieu (1699-1786). He received an outstanding education in language, literature, science and mathematics. Following his family tradition, he pursued the study of law and he finished his education in the Faculty of Law in 1763. He obtained his license to practice law in 1764. But his inquiring mind took him to the world of science. First he studied geology (1763-67) under Jean Etienne Guettard (1715-86), who was the first to prepare a geological map of France. Lavoisier accompanied Guettard on several extensive geological trips through various regions of France. Lavoisier assisted Guettard in preparing *Mineralogical Atlas and Description of France*. While going through these geological trips, Lavoisier realized the close relationship between field mineralogy and the chemical analysis of minerals. He set up a laboratory in his own home. In 1765 Lavoisier published a paper on how to improve the street lighting of a large city like Paris. For this paper he received a Gold Medal from the Royal Academy of Sciences in 1766. In 1768 Lavoisier presented a paper on the analysis of water samples. Following this he was admitted to the Royal Academy of Science as adjoint-chimiste (associate chemist). In his early days Lavoisier published research papers on the Aurora Borealis, on thunder and on the composition of gypsum.

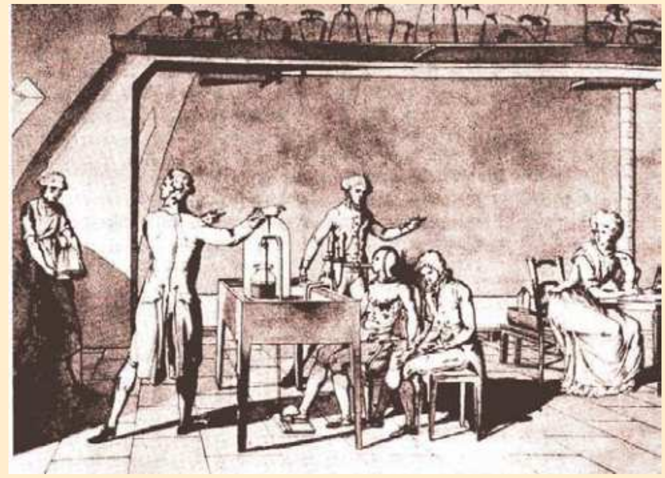
Antoine Lavoisier and his wife, Marie-Anne, presiding at the death of phlogiston (courtesy, Park Davis, Division of Warner-Lambert Company)

In 1768 Lavoisier became a member of a private consortium called the *Fermiers Generaux* (Farmers General), which had leased from the Government the right to collect some indirect taxes for six years. This was to ensure a steady income for financing his scientific investigations. Lavoisier had the wealth to invest as through his family he had became independently wealthy as early as in his early 20s. Lavoisier took his duties as tax collector very seriously and spent much time away from Paris on inspection duty. Lavoisier's father bought him a title of nobility in 1772. In 1777 Lavoisier had purchased the country estate of Frechines near Blois.

In 1771, Lavoisier married Marie-Anne-Pierette Paulze (1758-1836). She was 14 at the time of her marriage with Lavoisier. Her father was a colleague of Lavoisier in the Farmers General. Marie Paulze's mother was a niece of Abbe Terray, France's Controller General of Finances and one of the most influential men of the French kingdom. Lavoisier's marriage with Marie Paulze proved to be very successful. She was a skilled artist, engraver and painter. She studied under Louis David (1746-1825), who painted the only known portrait of Lavoisier from life. She kept laboratory records and made sketches of her husband's experiments. She learnt English and Latin. She translated the new chemical treatises from England, which included the works of Priestley and Cavendish. Ray Spangenburg and Diane K. Moser wrote: "Lavoisier was a mover in the scientific world; although his money came to be sure, from the *Fermiers Generaux*, he spent it lavishly in the interest of science, and his private laboratory was a meeting place for all the major scientific figures of Europe. Thomas Jefferson and Benjamin Franklin both were warmly welcomed there. Lavoisier's wife, Marie-Anne, who married him when she was 14, attended these meetings, illustrated them for Lavoisier's books and was always deeply involved in his work. She translated works from English for him, took notes and participated actively."

Lavoisier, after being appointed to the National Gunpowder Commission in 1775, shifted his residence to the Royal Arsenal of Paris. At the Arsenal, Lavoisier was in effective charge of gunpowder production and research. He was appointed as a director of the gunpowder administration (*regisseur des poudres*). Before Lavoisier took charge of the gunpowder administration in France, it was in a very chaotic

Lavoisier demonstrating the composition of air
(Figure: Vies des savants, 1870)



An experiment in Lavoisier's laboratory
drawn by his wife

state. He greatly improved the gunpowder, its supply and manufacture. Lavoisier abolished the vexatious search for saltpetre in the cellars of private house. He also built an excellent laboratory of his own in his home. His new home became a gathering place for scientists and freethinkers. After dinners, which used to be presided over by his wife, the guests often used to be escorted to the laboratory to witness demonstration of new experiments. One of Lavoisier's co-workers at the Arsenal was Pierre Simon Laplace (1749-1827). Lavoisier, with the help of Laplace, extended Joseph Black's early work on calorimetry. They developed an ingenious ice calorimeter and with this they measured heats of combustion and respiration. It was a modified version of Black's calorimeter. This was the beginning of thermochemistry. They also derived an apparatus for measuring linear and cubical expansions. It may be noted here that Eleuthere Irenee du Pont (1771-1834) was an assistant to Lavoisier at the Arsenal. Du Pont later migrated to the USA (1800) and in 1802 he established a factory on the banks of the Brandywine River in Delware for making gunpowder. This venture of du Pont later developed into one of the world's largest chemical concerns.

Lavoisier is best known not for his major experiments or discoveries but for his synthesis of the existing chemical knowledge. Much of Lavoisier's work was the result of extending and coordinating the research of others. He interpreted and organized the experimental results of others and whenever necessary substantiated by his own experiments. Justus von Liebig (1803-73), the great German chemist, said that Lavoisier "discovered no new body, no new property, no natural phenomenon previously unknown. His immortal glory consists in this—he infused into the body of science a new spirit." Lavoisier could achieve all this because he was not working as an isolated scientist. He was the focus of a school of collaboration. He was an important member of France's Royal Academy of Sciences—the world's most impressive assemblage of scientists. He was also an important public figure—he was at the centre of efforts to reform the French political economy.

In 1777 Lavoisier published a paper on respiration. The title of the paper was "Experiments on the respiration of animals and on the changes, which the Air undergoes in passing through the lungs." Lavoisier demonstrated that respiration was a slow combustion or oxidation. The process of respiration used oxygen and released carbon dioxide. In his *Memoir of Heat*, Lavoisier wrote: "the heat released in the conversion of pure air by respiration is the principal cause of the maintenance of animal heat."

In 1783, Lavoisier, jointly with Claude Berthollet, Antoine Francois de Fourcroy and L. B. Guyton de Morveau, published *Methode de nomenclature* (*System of Chemical Nomenclature*). It proposed new names for elements. The need for an international nomenclature consistently reflecting the composition of substances became evident to Lavoisier when he was asked to write an article on history of chemistry for an encyclopedia. Before Lavoisier, the language used in chemical texts was full of inconsistencies, imprecision and double meanings. The terms used in old alchemical and chemical texts were drawn from many languages – Greek, Hebrew, Arabic and Latin. The names of chemical substances were based on a variety of analogies and impressions. A few examples of the terms used in early chemical and alchemical texts are indicated below:

Flowers of Zinc	Zinc Oxide
Oil of Vitriol	Sulphuric acid
Spanish Green	Copper acetate
"Father"	Sulphur
"Mother"	Mercury

Lavoisier suggested that the elements in a compound should be reflected in its name. Based on this suggestion 'Flowers of zinc' became zinc oxide (a compound of zinc and oxygen) and 'oil of vitriol' became sulphuric acid), a compound of sulphur, oxygen and hydrogen). The new system of nomenclature proposed by Lavoisier had a provision for indicating relative proportions of the elements in a compound, for example sulphurous acid contains less oxygen than sulphuric acid.

In 1789 Lavoisier published *Traite elementair de chimie* (*Elementary Treatise on Chemistry*). Many consider it as the


Pierre Simon Laplace

first textbook on modern chemistry. While Lavoisier not only designed this book for beginning students but in it he also used his own experiments and discoveries to redefine the content and practice of chemistry. It beautifully summarized Lavoisier's main experiments and theories on which he based his movement to revolutionise chemistry. It incorporated the earlier knowledge of chemistry of salts into the new framework. In this book Lavoisier described in detail the experimental basis for his rejection of phlogiston theory in favour of his own theory of oxygen. In this book Lavoisier presented his definition of an element, as 'the last point which analysis can reach.' Lavoisier conclusively rejected the four-element theory, an idea that dated back to Empedocles and Aristotle. According to this theory everything was believed to be composed of earth, air, fire and water combined in different proportions. Each of these supposedly element represented different pairs of essential qualities—earth the cold and dry; water, cold and weight; fire, hot and dry; and air, hot and weight. It used to be believed that an important consequence of four-element theory was that water could be converted into earth. Lavoisier refuted this claim without any scope of doubt. The book contained a list of 33 elements known at that time. The list included metallic and nonmetallic solids, earthy substances; the gases oxygen, nitrogen (then called azote), and hydrogen; and light and heat (caloric). Lavoisier's list of elements provided the basis from which modern Periodic Table of elements has grown. The book had such an enormous influence on chemistry that it is compared with Newton's *Prinicipia* in physics.

Lavoisier, based on his own experiments and by interpreting the experimental results obtained by others, worked out a theory of combustion. Before Lavoisier it was phlogiston theory, which explained combustion. Lavoisier also went on to show that air is a mixture of two gases—oxygen and nitrogen (he called it azote). Of course, now we know that air contains other gases also. But before Lavoisier air was considered a single substance and not a mixture. Lavoisier showed that it was oxygen which supported combustion. The phlogiston theory was the first comprehensive theory of chemistry. Its chief proponent was Georg Ernst Stahl. The term "phlogiston" was coined by Stahl from the Greek word for "inflammable." Stahl used this term for the first time in his treatise (1697), in which he sought to distinguish combustion from fermentation. In the seventeenth century, chemists generally believed that some combustible substances contain an "inflammable principle." And when such substances burn this so called inflammable principle is released. Stahl sharpened this concept. He equated the inflammable principle or phlogiston with elementary principle, as fire was thought in those days. Phlogiston could not be obtained in isolation. Stahl reasoned that sulphur was composed of vitriolic acid and phlogiston because it could be produced by treating vitriolic acid with charcoal, a phlogiston-rich substance. Similarly metals are made of their oxides (calxes) and phlogiston as oxides could be converted back into metals by heating with charcoal. Stahl's ideas about phlogiston came to be known as phlogiston theory. This theory stated that combustion was a loss of substance called phlogiston. And so the residue or ash was composed of the original material deprived of its phlogiston.


Claude Berthollet

Phlogiston was regarded a weightless or nearly weightless substance. Though the phlogiston theory was derived from an erroneous concept it helped to explain innumerable puzzling chemical phenomena. For chemists of those days the phlogiston theory became an important means of organizing otherwise disconnected observations into a coherent body of knowledge. It stimulated all kinds of experiments on combustion, on oxidation, on respiration and on photosynthesis. While carrying out these experiments chemists came across many phenomena, which could not be explained by resorting to the phlogiston theory. It was found that when some metals were calcined, the resulting calx was heavier than the initial metal. Supporters of phlogiston theory tried to explain this phenomenon by proposing that in some metals, phlogiston had negative weight. It was found that the red precipitate of mercury (mercury oxide) could be turned back into a metal simply by heating. This implied that no phlogiston-rich source such as charcoal was neededto convert an oxide (calx) back in to a metal. In spite of these problems most chemists of eighteenth century did not discard the phlogiston theory and while subscribing to this erroneous theory they made pioneering contributions particularly to the study of gases.

In a series of experiments carried out during 1772-74, Lavoisier burned phosphorus, lead, sulphur, and other elements in closed containers. While carrying out these experiments Lavoisier found that while the weight of the solid increased but the weight of the container and its contents remained same. The immediate consequence of this observation was that some part of the whole system must have lost weight. The most probable candidate for this was the air present in the vessel. Now if air lost something, a partial vacuum would exist in the closed vessel. This is because the experiment was carried out in a closed vessel. This was exactly what was found by Lavoisier. When he opened the vessel, the air rushed in to fill up the vacuum. And after this when Lavoisier weighed the container and its contents he found that the weight increased than the original. It clearly demonstrated that the formation of the oxide (or calx) was the result of the combination of air and the metal. The weight increased because of the gain of air and not due to loss of phlogiston. Lavoisier also discovered that the gas generated by heating an oxide (calx) with charcoal was nothing but fixed air earlier discovered by Joseph Black.

It was from Joseph Priestley's experiments that Lavoisier got the idea that oxygen supported combustion. Priestley had


Antoine Francois de Fourcroy

discovered oxygen. However, he could not realize the full significance of his discovery. Lavoisier correctly interpreted the discovery made by Joseph Priestley.Even before Priestley, Pierre Bayen, an apothecary in the French army, isolated oxygen. In 1774 Bayen observed that red precipitate of mercury (mercuric oxide or HgO) produced a gas when it was heated. Bayen identified it 'fixed air' (CO_2) earlier produced by Joseph Black. Soon after Bayen's demonstration Priestley repeated Bayen's experiment, probably independently. Priestley's experiments identified the chemical nature of the gas. Priestley observed that the gas, produced by the red precipitate of mercury, supported combustion better than the normal air. As Priestley believed in phlogiston theory, he called this new air phlosisticated air. The properties of Priestley's new air seemed to be exactly the reverse of Black's dephlogisticated air. He also found that breathing it "peculiarly light and easy." It may also be noted that Carl Wilhelm Scheele (1742-86), a Swedish chemist, also discovered the same gas. He called it 'fire air' and he postulated that fire air was part of atmospheric air. However, Scheele's discovery was published later. Lavoisier was quick to see the significance of new findings. After knowing Priestley's experiment, Lavoisier immediately recognized its true significance. He realized that Priestley had isolated one part of the air that supports combustion and respiration and other part of the air does not. In 1779 Lavoisier finally announced that the air is composed of two gases—one that supports combustion and the other gas does not support combustion. The part that supported combustion, Lavoisier named oxygen, a name derived from Greek roots meaning "to give rise to acids." He thought all acids contain oxygen. Here Lavoisier was proved to be wrong later. It was one of those rare occasions when Lavoisier was wrong. Though Lavoisier proved wrong the name "oxygen" has been retained. The other gas he named "azote" again from Greek root meaning "no life". Unlike oxygen, azote was renamed nitrogen in 1790.


Henry Cavendish

Even at the risk of little diversion it is work while to briefly describe Joseph Priestley's life. Priestley lived in Leeds, a city in north England. He was a Unitarian minister. A Unitarian is a person who denies the doctrine of Trinity—the union of three divine persons Father, Son, and Holy spirit) in one Godhead and believes that God exists in one person or being. A Unitarian accepts the moral teachings, but rejects the divinity of Jesus. In his political belief Priestley was a radicalist. He supported the American colonists when in 1776 they revolted against George III (1760-1820), King of Great Britain and Ireland (1760-1820). He was against slave trade and religious bigotry. Priestley sympathised with the French Revolution. He began his scientific experiments in a local brewery of the city of Leeds. In 1780, Priestley moved to Birmingham, where he became a member of the Lunar Society. Other member of this society included Erasmus Darwin (1731-1802), James Watt and Matthew Boulton. In Birmingham, Priestley built an elaborate laboratory, which was considered by many as one of the best laboratories of that time in Europe. It may be noted that on the day of Lavoisier's execution at the Guillotine, Priestly was forced to leave England for safety. For his support to revolutionaries in France, the rioting anti-revolutionaries burnt down his house. He spent his last ten years of his life in USA.

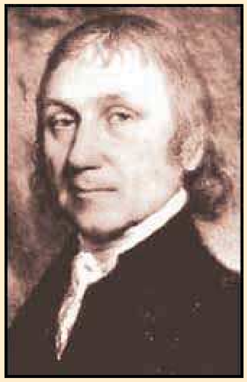

Georg Ernst Stahl

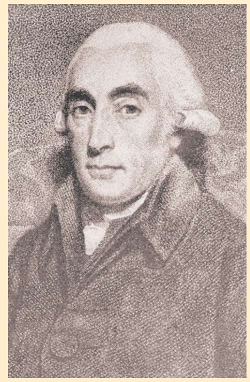
Thomas Kuhn in his much discussed book, *The Structure of Scientific Revolution*, cited Lavoisier's revolution in chemistry as a major example of scientific revolutions and paradigm shift. While many tend to agree with Kuhn but then there are some who fail to see how Lavoisier's chemistry provided an example to support Kuhn's theory. Because even after Lavoisier proposed his combustion theory, chemists took a long time to abandon the phlogiston theory in favour of Lavoisier's theory. It was certainly not a sudden change.

It was Lavoisier, who first showed that all substances can exist in the three stages of matter—solid, liquid and gas. He believed that those changes in state were the result of fire combining with matter. Lavoisier thought that the "matter of fire" or caloric, as he called it, was weightless and combined with solid to form liquid and combined with liquid to form gas. Lavoisier in his *Memoir on Combustion in General* published in 1777 wrote: "Undoubtedly it will not amiss to ask first what is meant by the matter of fire. I reply with Franklin, Boerhaave, and some of the philosophers of antiquity that the matter of fire or of light is a very subtle, very elastic fluid which surrounds all parts of the planet which we inhibit, which penetrates bodies composed of it with greater or less ease, and which tends when free to be in equilibrium in everything.

I will add, borrowing the language of chemistry, that this fluid is the dissolvent of a large number of bodies; that it combines with them in the same manner as water combines with salt and as acids combine with metals; and that the bodies thus combined and dissolved by the igneous fluid lose in part the properties which they had before the combination and acquire new ones which make them more like the matter of fire."

Reign of Terror in France did not spare Lavoisier, one of the greatest scientists of all times. As a tax collector of the Government that was deposed by the revolutionary forces, many considered Lavoisier as public enemy. After all, they argued, he was member of the agency, which collected taxes from poor and downtrodden populace for an unpopular king. Lavoisier's problem compounded when Jean-Paul Marat gained power in the revolutionary government and became a key force in the Reign of Terror that washed the streets of Paris in blood. Marat was a journalist who had early in his career pursued scientific ambition and he fancied himself a scientist. Lavoisier had condemned Marat's worthless pamphlet *Physical Researches on Fire* and he had also opposed the admission of Marat to the French Academy of Sciences. Marat had never forgotten this. Lavoisier had been arrested alongwith all members of the Farmers General were arrested and thrown into prison. Though the tax collecting farm was a natural target but its affairs were in good order and the charges against its members could be refuted. But Marat wanted to punish Lavoisier. A new charge of 'counter revolutionary activity' was contrived which ensured a guilty verdict. In 1787, at Lavoisier's suggestion a wall was erected to stop the influx of contraband. The extremist revolutionaries charged Lavoisier of imprisoning Paris and stopping the circulation of air. In 1791 the Farmers General was abolished and not long after Lavoisier was removed from his post in gunpowder administration and he was forced to leave the arsenal. Lavoisier was arrested in November 1793. On May 08, 1794 after a trial that lasted less than a day Lavoisier was guillotined. Along with him his father in law and other members of the Farmers General were also executed. Lavoisier's estate was confiscated, including his library and laboratory instruments. His wife Marie-Anne was also imprisoned but later released. She took refuge with a family servant. Marat who was instrumental in getting Lavoisier and other members of Farmers General convicted, himself was arrested and guillotined before Lavoisier. But that did not help Lavoisier. It has been reported that Lavoisier requested time to complete some scientific work. His request was refused and the presiding judge was said to have answered, "The Republic has no need of scientists." Joseph Louis Lagrange said: "It took but a moment to cut off that head: perhaps a hundred years will be required to produce another like it."


Joesph Priestley


Joseph Black


Carl Wilhelm Scheele

After Lavoisier's execution, his wife petitioned for the return of his estate. And after obtaining Lavoisier's papers and books, she took up the task of publishing Lavoisier's unfinished memoirs. Thus Lavoisier's *Memoires de chimie* or *Memoirs of Chemistry* were published in two volumes in 1803. She presented copies to the important scientific societies and eminent scientists of Europe. As in the days when Lavoisier was alive, her home also became a meeting place to the leaders of science in France. Jean Baptiste Joseph Delambre (1749-1822), Baron Georges Lepold Chretien Frederic Dagobert Cuvier (1769-1832), Comte Joseph Louis Lagrange (1736-1813), Marquis Pierre Simon de Laplace (1749-1827), Pierre Eugene Marcellin Berthollet (1827-1907), Dominique Francois Jean Arago (1786-1853), Jean Baptiste Biot (1774-1862), Alexander von Humboldt (1769-1859) and others attended meetings at her home. She refused to attend those whom she thought did not use their political connections to save her husband. In 1804 Marie-Anne married Count Rumford. She kept Lavoisier's name after her marriage to Rumford. At the time of her marriage to Rumford, she was 47 and Rumford was 50. Her second marriage did not go well and it lasted for only four years.

Lavoisier's life ended at the whims of some lunatics but the great revolution in chemistry ushered in by him did not stop there. Thus Spangenburgh and Moser wrote: "With Lavoisier's death in 1794, his part in the great revolution came to a conclusion, but progress did not end there. From the foundations laid by Lavoisier, Black, Scheele, Priestley, Cavendish and, in a way, even Stahl, chemists in the 19th century were able to build an ever-more-accurate understanding of chemical elements, their nature, how they react with one another and what processes take place in those reactions."

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MRI Miracle

❑ Rintu Nath

Magnetic Resonance Imaging (MRI) improved the medical diagnosis and care significantly in recent time. MRI provides high quality three-dimensional images of human internal organs from any angle and direction, without surgical invasion, and in a relatively short period of time. It is a versatile, powerful and sensitive technique, and becoming a very important tool for medical diagnosis, treatment and follow-up.

Paul C. Lauterbur and Sir Peter Mansfield

The 2003 Nobel Prize in Physiology or Medicine has been jointly awarded to Paul C. Lauterbur of University of Illinois, Urbana (USA) and Sir Peter Mansfield of University of Nottingham (UK) for their discoveries in relation to Magnetic Resonance Imaging. Nobel committee recognizes these two scientists for their seminal discoveries concerning the use of magnetic resonance to visualize different structures. These discoveries have led to the development of modern MRI, which represents a breakthrough in medical diagnostics and research.

MRI is based on the principles of Nuclear Magnetic Resonance (NMR), a spectroscopic technique used by scientists to obtain microscopic chemical and physical information about molecules. According to its origin, the technique could be referred as *nuclear magnetic resonance imaging* (NMRI) instead of *magnetic resonance imaging* (MRI). However, it was thought that patients might incorrectly relate MRI with radioactivity or nuclear energy. It was christened in medicine world as 'MRI' to avoid the negative meaning associated with the word 'nuclear'.

To understand the mechanisms of MRI and the contribution of this year's Nobel laureates in that direction, one has to understand the basic principles of NMR technique on which MRI is based. The technique of NMR itself is quite a revolutionary one. Previously, in three occasions, Nobel prizes were awarded to scientists working in this field.

The birth of NMR

In Chemistry and Biological science, spectroscopy was used for various purposes to identify the chemical nature of the molecules in a matter. Each molecule has its own characteristics regarding how it reacts in the presence of light, x-ray etc. and those unique features are utilised in different spectroscopic techniques. NMR is a special branch of spectroscopy, exploiting the magnetic properties of atomic nuclei of the molecule.

NMR was discovered during 1945 in USA by Felix Bloch at Stanford University and Edward Mills Purcell at Harvard University. They were awarded Nobel Prize in Physics in 1952 for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith.

The basic physical structure of the atom is similar to our solar system. It has protons (positively charge) and neutrons (neutral charge) in its nucleus and electrons (negatively charged) are moving around the nucleus. Bloch and Purcell observed that when a substance is placed in a magnetic field, some atomic nuclei then behave like microscopic compass needles, which are called *nuclear spins*. These tiny compass needles or nuclear spins orient themselves with respect to the magnetic field in only few ways according to the laws of quantum mechanics. This orientation corresponds to different energy levels. The spins may jump between the levels when the sample is exposed to radio waves whose frequency exactly matches the energy spacing. This is called *resonance*. One way of measuring the energy level spacings is to change the irradiation frequency slowly. At resonance, the spins flip and an electric signal is induced in the detector. In other word, when the atomic nuclei return to their previous energy level, radio waves are emitted. The strength of the signal is plotted as a function of frequency in a diagram, which is called as the NMR spectrum. By interpreting the peaks in an NMR spectrum one can draw a three-dimensional picture of the molecule being studied.

It was discovered that the frequency for nuclear resonance depends not only on the strength of the magnetic field and the type of atom but also on the chemical environment of the atom. In addition, the nuclear spins of different nuclei could affect each other, generating fine structures, i.e. a further number of peaks in the NMR spectrum.

The advantages of using NMR in chemistry soon became obvious. The signals could be used to determine the number and type of chemical groups in a compound. In the period between 1950 and 1970, NMR was used for chemical and physical molecular analysis. However there were still some difficulties in using NMR method quite extensively due to its low sensitivity. Hence it was only possible to apply NMR method to study rather concentrated solutions of fairly small molecules.

The FT NMR

A major breakthrough occurred in 1966. Richard R. Ernst of Switzerland and Weston A. Anderson, USA, discovered that the sensitivity of NMR spectra could be increased dramatically if instead of slowly varying the frequency, the sample was exposed to short and intense radio frequency pulses. The pulses cause a signal to be emitted by the nuclei after few seconds. This signal is then measured as a function of time after the pulse. Records of the signals after each pulse are summed in a computer. Only problem is that the NMR signal measured as a function of time could not be interpreted simply.

Application of MRI technology

The impacts of MRI in medicine world are enormous. Surgical planning, real time cardiac imaging, musculo-skeletal characterization, and brain imaging are now routine by MRI applications. It is currently crossing over into the therapeutic side of medicine with the emergence of MRI-guided surgery. A brief description of applications of MRI in different areas of medicine is given below.

Brain and Spinal cord: MRI is an important diagnostic tool for diagnosing certain neurological diseases, such as multiple sclerosis, Alzheimer's disease, or stroke. It also helps in diagnosing tumours, infections and disorders in brain and spinal cord. With MRI, it is possible to see where in the nervous system the inflammation is localized, how intense it is, and also how it is influenced by treatment. Early diagnosis is key to effective treatment of these diseases. It also helps in differentiating the back pain caused by muscles and inflammation of spinal cord.

Breast: MRI is an important diagnostic tool in the treatment of breast cancer because of its superior ability to display contrast between soft tissues.

Chest and Abdomen: Organs of the chest and abdomen, including the liver, kidneys, and spleen, can also be examined in minute detail in MRI images. These enable the diagnosis and evaluation of tumours and functional disorders of these organs.

Heart: MRI is a useful non-invasive tool for diagnosing certain cardiovascular problems such as congenital heart disease (a heart defect present from birth), atherosclerosis (a condition characterized by hardening of the arteries) and other disorders in heart.

Blood Vessels: MRI is performed to evaluate aneurysms or to determine whether vessels in the brain, neck, legs or other areas have become narrowed due to hardening of the arteries.

Musculo-skeletal system: Because MRI can give clear pictures of soft-tissue structures near and around bones. It is often the best option for spine and joint problems like knee, shoulder, pelvis and hip, elbow, and wrist. The images allow physicians to see even the very small tears and injuries to ligaments and muscles.

Lungs: Recent technological advances have significantly improved MRI of lung by using certain rare gases, called noble gases (currently Helium and Xenon are used). This technology can enable physicians to detect pulmonary embolisms, blood clots in the lungs that must be treated before dislodging and subsequently and killing a patient.

Cancer patients: MRI examinations are very important in diagnosis, treatment and follow-up of cancer. The images can exactly reveal the limits of a tumour, which contributes to more precise surgery and radiation therapy.

Reduced sufferings of patients: MRI can replace previously used invasive examinations and thereby reduce the sufferings for many patients. Since no invasive instrument is needed in MRI, the risk of infection is also eliminated.

Guide to operation: New technological developments are now enabling more advanced support in the operating room with the emergence of MRI guided surgery. This advancement allows surgeons to see nearly real time video images of internal body tissue to guide them during surgical procedures.

Ernst discovered that when a mathematical operation called *Fourier transformation* is performed on these resonance frequencies, then it is possible to analyse the information in such a signal and to convert it to an NMR spectrum. This can be performed rapidly in a computer.

Ernst's discovery is the basis of modern NMR spectroscopy, called *Fourier Transform NMR* or *FT NMR*. This method helps in increasing the sensitivity by 10 to 100 times since the pulse response contains information on all resonance frequencies at the same time. FT NMR makes it possible to study small amounts of material as well as chemically interesting isotopes of low natural abundance or low concentration.

During the 1960s and the 1970s, improved super-conducting materials could produce new and better magnet designs. Higher and more stable magnetic fields lead to spectra with much better sensitivity and resolution. However, in order to move to very complicated molecules, the existing NMR technology was still not sufficient. It needed another breakthrough.

The 2D FT NMR

In 1975, Ernst and co-workers came with that breakthrough with their discovery of two-dimensional (2D) FT NMR. The transformation from 1D to 2D FT NMR was a revolutionary approach, which introduced many new possibilities in NMR technology.

In 1D NMR, the nuclear spins are exposed to a pulse. The signal is detected in the receiver after time 't', which is then plotted as a function of time 't' after the pulse. In 2D NMR, the nuclear spins are subjected to two (or more) pulses, with a time interval 't_1'. After the second pulse, the signal is acquired in the same way as in 1D NMR after time 't_2'. After this, one returns to the beginning of the experiment and repeats it with other values of t_1.

The change of 't_1' modifies the signal measured during 't_2'. This provides a two-dimensional table containing the signal intensity as a function of both 't_1' and 't_2'. After Fourier transformation with respect to both these time variables, one obtains a two-dimensional frequency spectrum. This helps in obtaining the two-dimensional structure of the molecule.

In 1991, Ernst was rewarded for his achievements in pulsed Fourier Transform NMR with the Nobel Prize in Chemistry. Ernst's contribution helped in determining what nuclei were adjacent to one another in a molecule, e.g. two atoms bound to each other. By interpreting the signals in an NMR spectrum it was thus possible to gain an idea of the appearance of the molecule, its structure.

The method was successful for relatively small molecules. But in case of larger molecules, it was still hard to differentiate between the resonances of the different atom nuclei. An NMR spectrum of this kind would give thousands of peaks where it was impossible to decide which peak belonged to which atom. The scientist who finally solved this problem was the Swiss chemist Kurt Wüthrich.

The Sequential Assignment

At the beginning of the 1980s, Kurt Wüthrich developed an idea about how NMR could be extended to cover biological molecules such as proteins. He invented a systematic method of pairing each NMR signal with the right hydrogen nucleus (*viz*. proton) in the macromolecule. The method is called *sequential assignment*, which is now the cornerstone of all NMR structural investigations. He showed how it was subsequently possible to determine pairwise distances between a large numbers of hydrogen nuclei. Then he used this information with a mathematical method based on distance-geometry to calculate a three-dimensional structure for the molecule. The technique can be simplified like this. If one knows all the measurements of a house, then one can draw a three-dimensional picture of the house. In the same way, by measuring a vast number of short distances in a protein it is possible to create a three-dimensional picture of its structure. Wüthrich was awarded Nobel Prize in Chemistry in 2002 for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution.

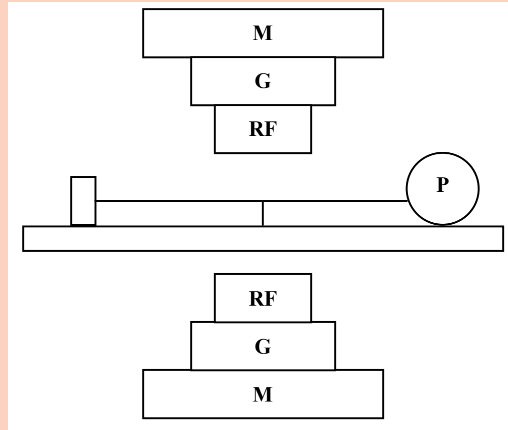
The idea of MRI

Though NMR technique in earlier years was used in determining the structure of chemical compounds, yet it took some time before this technique could also be used in the field of biology and medical science. However, scientists soon found the basic relationship between the chemical compounds in a solution and bio-molecules within human body.

Water constitutes about two thirds of the human body weight. The water is a molecule composed of hydrogen and oxygen atoms. Hence the nuclei of the hydrogen atoms are able to act as nuclear spins. As the body is exposed to a strong magnetic field, the nuclei of the hydrogen atoms are oriented into order. When pulses of radio waves are submitted, the energy content of the nuclei changes. After the pulse, a resonance wave is emitted when the nuclei return to their previous state as explained earlier.

The NMR technique during 70's could detect small differences in the oscillations of the nuclei. The high water content of the body actually helps in using NMR technique in the field of medicine. There are differences in water content among tissues and organs. Moreover, in many diseases, the pathological process results in changes of the water content of a particular tissue and organ. Therefore theoretically it is possible to obtain the detailed image of tissues and organs, including differences in the water content and movements of the water molecules in the investigated area of the body. Soon scientists came up with ideas that NMR technique could indeed be used in more diverse areas of medicine.

How MRI is done?



The conventional MRI unit is a cylindrical tube surrounded by a radio-frequency coil (RF), gradient coils (G), and a large circular magnet (M) as shown in diagrammatic sketch above. A wheeled bed is attached to the unit that slides into the cylinder. The MRI begins by slowly sliding the patient (P) through the long cylindrical magnet. The examination generally takes from fifteen minutes to an hour depending on examination, but can take much longer for a very detailed study. Now-a-days more patient-friendly newer MRI machines are emerging that take short time for examination and give more comfort to patients.

The development of MRI

The improved NMR technique of Ernst and his co-workers became the basis of MRI techniques in medicine. Raymond V. Damadian, a physician in New York, began in 1969 to think of a way to use magnetic resonance to probe the body for early cancer signs. In 1970, he surgically removed fast-growing tumours from lab rats and showed their NMR signals differed from those of normal tissue. In 1971, Damadian showed that the nuclear magnetic relaxation times of tissues and tumours differed. This encouraged scientists to consider magnetic resonance for the detection of disease. In 1977, Raymond Damadian first demonstrated the MRI of the whole body.

In the meantime, in 1972, Paul Lauterbur added the CAT scan idea to MRI and obtained the first magnetic resonance image or MRI. In 1973, Lauterbur discovered that introduction of gradients in the magnetic field made it possible to create

Current and Future MRI Techniques

MRI is still developing to accommodate many diverse applications. Some techniques that are being used today or may be used in future are mentioned here.

Functional MRI (fMRI): Functional magnetic resonance imaging (fMRI) utilizes echo-planar imaging and involves very rapid scans. The emergence of functional MRI (fMRI) opens up the possibility to provide insight into neurological and psychiatric disorders, such as schizophrenia, depression, dementia etc. The procedure has also been applied to children with developmental disorders, including autism, dyslexia, and other learning disabilities.

Interventional MRI (iMRI): Interventional MRI enables real-time scanning of the brain and spinal cord during surgery.

MR Angiography (MRA): MRA produces images of blood flow within the circulatory system.

MR Microscopy (MRM): Magnetic resonance microscopy is a form of high-resolution imaging. It works under the same principle as traditional MRI, only modified for smaller specimens.

MR Spectroscopy (MRS): Magnetic resonance spectroscopy can utilize any form of resonance imaging, such as the spin-echo technique.

Volume Imaging (3-D): Three-dimensional imaging uses the spin-echo technique to provide images of volumes (3-D image) instead of the conventional 2-D planar slice of organs or parts.

Kinetic MRI: It takes the image of an organ (e.g. joint) when the patient takes certain movement.

Functional Magnetic Resonance Imaging (fMRI): Functional MRI is often used beyond the scope of clinical applications to observe various workings of the brain, opening the doors to a new understanding of memory, language, and cognition.

two-dimensional images of structures that could not be visualized by other techniques. He described how addition of gradient magnets to the main magnet made it possible to visualize a cross section of tubes with ordinary water surrounded by heavy water. No other imaging method could differentiate between ordinary and heavy water before this technique was available.

Peter Mansfield utilized gradients in the magnetic field in order to more precisely show differences in the resonance. He developed a way to rapidly analyse the signals produced by Lauterbur's gradient method and converted them into an image. He showed how the detected signals rapidly and effectively could be analysed and transformed into an image. This was an essential step in order to obtain a practical method. He created the first fuzzy image in the mid-1970s. It was not clear enough for practical purpose and even Mansfield himself admits that he had not realised the technique's full potential at that time. He commented, 'I had people asking if it would work for the whole body, and saying that, if we managed it, the images would be clear enough for medical use. We just had to be persistent about it.'

He indeed worked persistently on it. He went on to make further improvements in the technique, including increasing its speed enormously so that changes in organs such as the brain could be followed in real time. In 1977, Mansfield developed the echo-planar imaging (EPI) technique. He showed how extremely rapid imaging could be achieved by very fast gradient variations. These findings provided the basis for the development of magnetic resonance into a useful imaging method in later years to produce images at video rates (30 millisecond per image).

MRI offers some major advantages over traditional diagnostic tools such as the X-ray (Wilhelm Conrad Röntgen of Germany received Nobel Prize in Physics in 1901) and Computed Assisted Tomography (CAT) scanning (Allan M. Cormack of USA and Godfrey N. Hounsfield of UK were awarded Nobel Prize in Physiology or Medicine in 1979). MRI is a unique imaging method because it uses radio-frequency waves and does not rely on ionizing radiation like X-rays or CAT. The MRI also shows exceptional contrast with soft tissue and no distortion. The images by MRI can be acquired in any direction and helps in highlighting different types of tissues. However, patients with magnetic metal in the body or a pacemaker cannot be examined with MRI due to the strong magnetic field.

The pioneering works of Lauterbur and Mansfield were responsible for making MRI a versatile, practical and widely used imaging technique. MRI is now a routine method within medical diagnostics. The first MRI equipments in health were available at the beginning of the 1980s. In 2002, approximately 22,000 MRI cameras were in use worldwide, and more than 60 million MRI examinations were performed. The superiority of MRI to other imaging techniques has significantly improved diagnostics in many diseases. MRI has replaced several invasive modes of examination and thereby reduced the risk and discomfort for many patients.

The MRI technology is still in rapid development. But the mankind will remember the revolutionary ideas provided by Lauterbur and Mansfield in realizing the MRI as we see it today. In its citation, the Nobel Assembly said that the development of MRI represented a breakthrough in medical diagnostics and research. Painless, harmless, and productive of the most brilliant images, it has enabled us to see our insides without danger or the need for surgery. The award of 2003 Nobel Prize in Physiology or Medicine to these two great scientists is the recognition of their services to mankind.

Source

Press releases from Nobel Foundation

A comprehensive account of MRI may be obtained from the following website:
http://www.bae.ncsu.edu/research/blanchard/www/465/textbook/otherprojects/2003/group3/index.html

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Corrigendum

"Noble Prize" in Page 25 of October 2003 issue of "Dream - 2047" should be read as "Nobel Prize". The mistake is regretted.

Nobel Prize in Chemistry 2003

❑ Biman Basu
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Peter Agre and Roderick Mackinnon

The human body is a complex biochemical machine of which 70% is made up of salt water. A single human being has about one hundred thousand million cells. The various cells – e.g. muscle cells, kidney cells and nerve cells – act together in an intricate system in each one of us. Normal functioning of this complex system primarily involves transport of water and salts across the cells of the body. Although it was known for a long time that cell membranes selectively allow water molecules and some ions to pass through while restricting the passage of others, how exactly cell membranes did that was not clear. Now, thanks to the work of two Americans that have led to the clear identification of 'water channels' and 'ion channels', we know how cells are able to selectively allow passage of water and ions across cell membranes. The Nobel Prize in Chemistry for the year 2003 has been awarded jointly to the two scientists – 54-year-old Peter Agre of the Department of Biological Chemistry, Johns Hopkins University School of Medicine, Baltimore, Maryland, and 47-year-old Roderick MacKinnon of Howard Hughes Medical Institute Laboratory of Molecular Neurobiology and Biophysics, Rockefeller University, New York, "for discoveries concerning channels in cell membranes." Agre discovered and characterised the first water channel protein and MacKinnon has elucidated the structural and mechanistic basis for ion channel function. Agre and MacKinnon will share the prize money equally.

All living cells are enclosed by a lipid bilayer membrane that separates them from other cells and the extra-cellular medium. Cells also contain membrane-enclosed organelles such as the nucleus, mitochondria and chloroplasts. Lipid bilayer membranes are generally impermeable to water, ions, and other polar molecules; yet, in many instances, such entities need to be rapidly and selectively transported across a membrane, often in response to an extra- or intracellular signal. In osmosis, for example, small molecules such as water pass through a semi-permeable membrane that does not admit macromolecules or salts that are in higher concentrations on one side of the membrane. In some cases, while potassium ions (K^+) are allowed to pass, much smaller sodium ions (Na^+) are blocked. So the puzzle was: how could a fatty membrane allow water molecules to pass, or allow a larger ion to pass but stop a smaller ion?

Water channels

That there must be openings in the cell membrane to permit a flow of water and salts was postulated as early as the middle of the 19th century. In the late 1950s, it was found that water is rapidly transported through the red blood cell membrane via water-selective channels that exclude ions and other solutes. This unusual property of cells was studied in detail for the next 30 years and it was concluded that there must be some type of selective filter that prevents ions from passing through the cell membrane while water molecules, which are uncharged, flow freely. The appearance and function of the cell pores that allowed selective passage of water molecules remained for a long time as one of the classical unsolved problems of biochemistry. It was not until 1992 that anybody was able to identify what this molecular machinery really looked like; that is, to identify what protein or proteins formed the actual channel. The elusive water channels were finally discovered by Agre around 1990, and like so much else in the living cell, it was all about a protein.

In the mid 1980s, Agre was studying Rh blood group antigens from the red cell membrane. In 1988, he isolated a new membrane protein of unknown function from both red cells and renal tubules. After studying the peptide sequence and the corresponding DNA sequence of this protein, he realised that this must be the protein that so many had sought before him: the cellular water channel. Water channels allow the cell to regulate its volume and internal osmotic pressure, and are needed when water must be retrieved from a body fluid such as when urine is concentrated in the kidney. In plants, water channels are critical for water absorption in the root and for maintaining the water balance throughout the plant. Water channels are crucial for life and are found in all organisms, from bacteria to man.

The discovery of the new protein, now called aquaporin 1, was a decisive moment in the study of cell water channels. Aquaporin-like proteins have since been found throughout the living world; in humans alone, there are at least 11 different aquaporin-like proteins, many of which have been linked to various diseases. Plants have an even higher number of aquaporins. For human health, the physiological importance of the aquaporins is perhaps most conspicuous in the kidney, which processes 150-200 litres of urine to extract most of the water from urine and recycle it back into the body.

Ion channels

Water molecules are not the only entities that pass into and out of the cell. For thousands of millions of cells to be able to function as something other than one large lump, coordination is required, and that needs channel of communication between cells. The signals sent in and between cells consist of ions or small molecules. These start cascades of chemical reactions that cause our muscles to tense, our eyes to water, or mouths to salivate – indeed, that control all our bodily functions. Along a chain of nerve cells, through interaction between chemical signals and ion currents, information is conveyed from cell to cell like a baton in a relay race. The signals in our brains also involve exchange of ions between cells.

The idea of ion channels was postulated as early as 1890,

contd. on page...23

Recent Developments in Science and Technology

Sound-detecting hair cells grown in lab

US scientists have shown that the sound-detecting hair cells of the inner ear can be grown in the lab from embryonic stem cells. The work raises another possible alternative to cochlear implants for treating deafness.

Hair cells convert sound waves into electrical signals that go to the brain. In mammals including humans, these cells die off with age. The result is irreversible hearing loss.

Stefan Heller's team at the Massachusetts Eye and Ear Infirmary in Boston generated the hair cells by exposing mouse embryonic stem cells - which are capable of turning into any type of cell - to the chemical factors that a normal hair cell would encounter.

To see if these lab-grown cells would make themselves at home in a developing ear, Heller transplanted partially developed cells into chicken embryos. The cells continued to develop, behaving just like the hair cells the chicken already had.

Source : New Scientist, Oct 2003

PC in Pocket

A full-featured PC that is small enough to slip into a shirt pocket is being hailed by its makers as the world's first modular computer. The machine can perform as both a PC and a handheld computer.

The Modular Computing Core is developed by a Colorado-based company Antelope Technologies. The device is a single portable unit into which all the essential computing components are crammed. At 76 by 127 by 19 millimetres (5 x 3 x 3/4 inches), the MCC is not much bigger than a deck of cards.

This core unit can then either be slotted into a docking station to be used with a screen and keyboard as a desktop computer, or into small portable "shell" with a touch-sensitive screen, turning it into a handheld computer. "Modular computers will change the way people use their computer," claims Kenneth Geyer, president of Antelope Technologies.

Inside the MCC is a 1GHz microprocessor, 256 MB of RAM and a 10 or 15 GB hard drive. It will also run a full version of Microsoft's XP operating system, instead of the stripped-down operating systems used by handheld computers.

Source : Scientific American, Oct 2003

Gene linked to poorer memory

Researchers have discovered that one form of a common brain protein is responsible for poorer memory. It is a first step towards finding the genes for intelligence.

Human intelligence is partly inherited - studies of parents and children show that about half our cleverness, or lack of it, is down to genes rather than environment. Now Dominique de Quervain and colleagues at the University of Zurich in Switzerland have found one of those genes.

People who inherit the less common form of a serotonin receptor have worse short-term memory than people with the more common form. It is not - by itself - a gene for intelligence.

But scientists suspect that eventually, a set of such genes will be identified that together make the difference between a smart brain and a dull one. Intelligence is made up of many things including concentration and reasoning, but memory is certainly important.

Source : New Scientist. Oct 2003

Compiled by: Kapil Tripathi

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contd. from page...24

by the German chemist Wilhelm Ostwald (Nobel laureate in chemistry 1909). On the basis of experiments with artificially prepared colloidal membranes, he had suggested that electrical currents in living tissues might be caused by ions moving across cellular membranes. Subsequently, it was established by 1900 that membrane potentials are electrochemical in nature, and in 1925 the existence of narrow ion channels was proposed. During the 1970s, it was shown that the ion channels were able to admit only certain ions because they were equipped with some kind of "ion filter". Of particular interest was the finding of channels that admit potassium ions but not sodium ions – even though the sodium ion is smaller than the potassium ion. But no one knew how the ion channels really functioned.

The breakthrough came in 1998, when Roderick MacKinnon succeeded in determining the first high-resolution structure of an ion channel from the bacterium *Streptomyces lividans*. While at Harvard University, he found a short sequence of five amino acids in the potassium channel that acted as a filter against sodium ions and allowed potassium ions to pass through. The design of the selectivity filter was seen to be perfectly adapted to the job of desolvating potassium ions while keeping smaller sodium ions out.

Membrane channels are vital for the normal functioning of all living matter. For this reason, increased understanding of their function constitutes an important basis for understanding many disease states. Dehydration of various types, and sensitivity to heat, are connected with the efficacy of the aquaporins. Heatstroke deaths are known to be connected to problems in maintaining the body-fluid balance. In these processes the aquaporins are of crucial importance. Disturbances in ion channel function can lead to serious diseases of the nervous system as well as the muscles, e.g., the heart. This makes the ion channels important drug targets for the pharmaceutical industry.

The rapid progress in our understanding of membrane channel function over the past decade has been in large part due to fundamental discoveries concerning water and ion channels made by Peter Agre and Roderick MacKinnon. They have made it possible for us to understand these exquisitely designed molecular machines in action at the atomic level.

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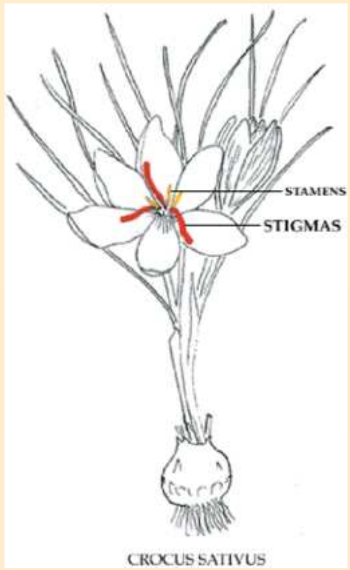
Saffron

The most precious and most expensive spice in the world

❑ T V Venkateswaran

"Spikenard and saffron; calamus and cinnamon, with all trees of frankincense, myrrh and aloe..." so Solomon wrote of the love of his life (Song of Solomon 4:14).

Saffron is the single rarest spice. The Saffron filaments, or threads, are actually the dried stigmas of the saffron flower, and these threads must be picked from each flower by hand, and more than 50,000 of these stigmas are needed to produce just 100g of red Saffron filaments, no wonder making it the world's most precious spice. Besides, Saffron's short blooming season -about three weeks in the fall - and its labour-intensive harvest make it the most expensive of the herbs and spices on the market. Saffron is very intensively fragrant (reminiscent to iodoform, but much more pleasant), slightly bitter in taste. By soaking saffron in warm water, one gets a bright yellow-orange solution, and from time immeorial, Saffron is often used, both for its bright orange-yellow colour and for its strong, intense flavour and aroma.



Saffron herb

Origin

The *saffron crocus* is a sterile triploid cultivated variety possibly developed from the wild *Crocus* of Greece. Its origins, like those of so many plants that have been in cultivation since antiquity, are lost to history. The genus Crocus has about 80 species that are native to regions from the Mediterranean to western China has been cultivated for its dye since ancient times. There is indication that this plant was grown in Palestine in the time of Solomon for saffron. It is hardly used now for textiles, but it still has considerable use in confectionery and other minor purposes.

History

Saffron was one of the most desired and expensive spices of ancient Greeks, Egyptians and Romans for its aroma, colour and supposed aphrodisiac properties. It was quite popular among the Phoenician traders, who carried it wherever they traveled. The ancient Assyrians used saffron for medical purposes. The excavations in Knossos, Crete, brought to light some frescoes where saffron is depicted. The most famous of these frescoes is the "saffron gatherer", where it was depicted that there was a monkey amongst the yellow saffron flowers. Hippocrates and other Greek doctors of his time like Dioskourides and Galinos mention crocus as a drug or a therapeutic herb. From the writings of Homer who calls dawn, "crocus veil", Aeschylus, Pindaros, and others, we know that the crocus was considered a rare pharmaceutical plant of ancient Greece with unique properties. It is referred throughout ancient history and in the course of many medical writings of the classical Greek and Roman times all the way to the Middle Ages.

In ancient times in and around Persia, saffron was used in the preparation of high quality paper, but more commonly it was used as ink, a practice that continued for centuries. Saffron ink of various shades of colour (from light yellow to blood red) was used for writing the address in the letters and edicts of kings and rulers, rubrics and headings in books and documents, and decoration and illustrations in texts. Saffron ink was also used for the writing of holy prayers and making charms, amulets and talismans, on paper, cloth and sometimes shrouds. In *Pahlavi* (language spoken in Iran) texts saffron is sometimes referred to as "*korkom*". In one translation of the Zoroastrian text "*Bandihesh*" saffron is described as an aromatic plant, while in another translation of the same text it is considered a colourant.

The ancient Hebrews called it, *Karkom*; the ancient Greeks, *Krokos*, but it is the Roman (Latin) that Linnaeus kept for the botanical name, *Crocus*. According to mythology Ovidius, the plant took its name from the youth Crocus, who after witnessing in despair the death of fair Smilax was transformed into this flower. Etymologically, the word crocus has its origin from the Greek word "*croci*" which means the weft, thread used for weaving on a loom. *Sativus* means cultivated, possibly a reference that it no longer grows wild. The Arabs called it, *Zahafaran* from which we derived the name saffron. In Sanskrit it is called as *Kumkuma* or *Kashmiirajan* and in Tamil *Kungumapu*.

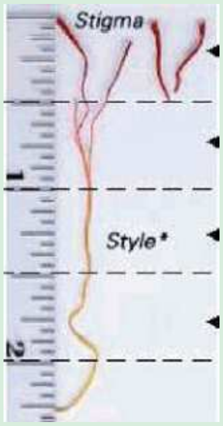
The plant

"*Crocus Sativus Linneaus*", as saffron is botanically classified, is in the Iris family. This group consists of about 80 species of hardy corms (as well as many forms or varieties), which bloom in fall, winter and early spring. They bloom so early in the spring they are often seen poking up through the snow. Crocuses grow wild in the Mediterranean region and continue into southwest Asia. One variety, C. sativus, is grown for its spice called Saffron, which is used to colour and flavour food (mainly rice dishes). Although the crocus is a triploid (three sets of chromosomes) and sterile, it produces fragrant lavender to purple-veined blooms. Each flower has three long red stigmata. The blood-red stigmata are called saffron threads (the spice).

Saffron is a stem-less perennial grass plant with a round sub-soil corm of 3-5cm diameter. Each corm produces 6 to 8 leaves similar to grass weeds. The short sprinkle roots grow at the base and circumference of the corm; the first part to appear in early autumn is the flower. However, in the first year after planting, because the corms are too weak and not properly established in the deep soil yet, the flower buds are not strong enough to develop and even the leaves come out later than usual. The flower consists of three sepals and three petals of the same lilac colour, which makes them hardly

How to chose good quality saffron?

There should be no other yellow or white plant parts (style) mixed in with the red threads (stigma), of the saffron crocus plant. This is the only part of the saffron crocus, which produces the saffron, the red stigmas. The way saffron-grading works is that the lower grades have more style left attached to the stigma. The stigmas are attached to a slender white style, which, when dried, turns pale yellow. The styles are typically as long as 1 ¾ inches and when dry, it curls and one can hardly see it. The Style of the saffron plant has no culinary value, which means no aroma, flavour or colour. If is left attached to the red stigmas, it adds 30% to 50% dead weight to the saffron, thereby increasing the weight but not contributing to aromatic or culinary value.



Style and stigma

Thus, the three criteria in mind every time one buys saffron are:

- Saffron threads (Stigmas) are all red (no other color).
- Saffron threads must be dry and brittle to the touch.
- Saffron aroma is strong and fresh, never musty.

distinguishable. There are three stamens with filaments twice as long as the anthers. Out of the single-ovule ovary in the center of the flower grows a long thin style of a light yellow colour, which ends in a triple stigma of 2-3 cm length, and bright orange red colour. It is the dried style and stigmas that constitute saffron the spice.

The stamen, the yellow pollen-producing organ, is not the source of Saffron, as it is often made out to be, but the long, crimson stigmas (female part of the flower) are the source of Saffron. While, it takes the dried stigmas of hundreds of flowers to make a gram of saffron, fortunately a little saffron goes a long way: about 1/2 teaspoon of powdered threads will flavour a cup (raw measure) of rice.

Because of being triploid, saffron is necessarily sterile, and its beautiful flowers cannot produce any seeds; propagation is possible only via corms. Distribution over larger distance requires human help, however, it is surprising that there is evidence that is was used by the Sumerians, more than 5000 years ago, indicating its hoary past.

Processing saffron

Moisture is one main adversary that shortens the shelf life and quality of the saffron, thus making drying the most important part of the saffron process. By cutting the stigmas apart prior to drying them, the "moisture" will evaporate out and no moisture remains inside the saffron stigma. On the other hand, if the stigmas attached to each other are left intact, moisture is trapped inside the stigma. Actually, it is the drying process that activates the chemical compounds, which release aroma, colour and flavour. You can tell high moisture content in saffron by the soft or spongy texture to the touch. Moist saffron will develop a musty smell instead of saffron's distinct clean aroma.

Chemical Composition

The stigmas of the saffron flower contain many chemical substances. There are carbohydrates, minerals, musilage, vitamins (especially riboflavin and thiamin) and pigments including crocin, anthocianin, carotene, lycopene and zigzantin. There is also an aromatic essence turpenic (safranal), and picrocrocin which gives saffron its distinctive flavour.

In the essential oil (max. 1%), several terpene aldehyds and ketones are found. The most abundant constituent is safranal, 2,6,6-trimethyl 1,3-cyclohexadiene-1-carboxaldehyd (50% and more); another olfactorically important compound is 2-hydroxy-4,4,6-trimethyl 2,5-cyclohexadien-1-one. Furthermore, terpene dervatives have been identified (pinene, cineol).

The bitter taste is attributed to picrocrocin, the glucosid of an alcohol structurally related to safranal (4-hydroxy-2,4,4-trimethyl 1-cyclohexene-1-carboxaldehyd). On de-glucosylation, picrocrocin yields safranal. Safranal and its relatives, most typically C_9 or C_{10} isoprenoids with a cyclohexane ring, are formed from carotenoid pigments as the result of enzymatic degradation

Chemistry of flavour, aroma and colour

There are three things that the chefs are looking for from saffron: aroma, flavour and colour are primarily due to the three chemicals, safranal, picrocrocin and crocin respectively.

Colour

The intensive colour of saffron is caused by carotenoids, especially crocetine esters (crocetine is a dicarboxylic acid with a carotenoid-like C18 backbone) with gentobiose. Saffron's colouring power is mainly produced by crocin ($C_{44}H_{64}O_{24}$), which is one of the few naturally occurring carotenoids easily soluble in water. This water solubility is one of the reasons for its widely preferred application as a colourant in food and medicine. In addition to crocin, saffron contains small amounts of the pigment anthocianin, oil soluble pigments including alphacarotene, betacarotene and zegxantin.

Flavour

The principal element giving saffron its special "bitter" flavour is the glycosid picrocrocin ($C_{16}H_{26}O_7$). This bitter tasting substance can be crystallized and produces glucose and the aldehyde safranal by hydrolysis that is when in contact with water. This is the reason saffron when steeped give more rich colour.

Aroma

Saffron has a strong aroma, which is produced by certain special volatile oils and essences. The main aroma factor in saffron is safranal, which comprises about 60% of the volatile

Stigmata of Saffron

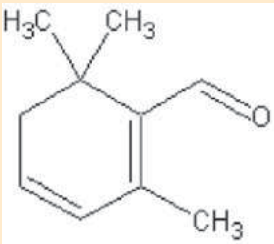
How the purity of saffron is measured?

One of the most important parameters in evaluating the quality of saffron is its colouring power, which is determined by measuring by spectrophotometry the amount of colouring factors present at 443 nanometers.

The general range of saffron colouring strength could be form 110-250+. Spice's aroma, flavour and natural dye depend largely upon its colouring power and it is the only measuring tool that assures one of consistent saffron quality. To get this number, saffron's principal chemical compound, crocin, is measured in a laboratory as per the testing standards prescribed by the International Organization for Standardization (ISO). Though crocin is only one among the compounds in saffron, it is the one that is measured because it is a precursor to the other compounds. Pure, all red saffron will measure higher on the colouring scale than saffron, which is usually mixed with other parts of the saffron plant to get differing grades of saffron.

components of saffron. In fresh saffron this substance exists as stable picrocrocin but as a result of heat and the passage of time it decomposes releasing the volatile aldehyde saffranal. Safranal is volatile liquid oil that produces a light yellow spot in water vapor and is readily soluble in ethanol, methanol and petroleum ether.

In order to extract the ethereal oils of saffron it is dissolved in pure water and distilled in a CO_2 current. The distillate is separated with ether, which is then removed by heat. The oil obtained is a yellow liquid with a strong aroma of saffron. This substance is a terpen, which is highly susceptible to oxidization and must be stored under special conditions.



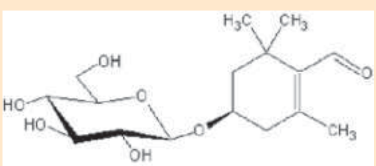
Safranal

Saffron uses

Because of its chemical composition saffron has unique qualities and properties. It is a rich source of the B group of vitamins, especially riboflavin. But more important perhaps are its properties of colour, aroma and taste. The colouring agent crocin is readily soluble in water and it is this water solubility that makes it preferred to other carotenoids as a colourant for food and medicine. In the food processing industry saffron is used as a colourant in sausages, margarine, butter, cheese and alcoholic and non-alcoholic beverages. It is also used for colouring and flavour in ice cream and sauces and dressings.

Medicinal Uses

Since ancient times saffron has been considered to have a number of therapeutic properties. It has been used as a sedative, a tonic, a stimulant of the stomach and an expectorant. It has also been used in the treatment of ailments such as dysentery, measles, enlargement of the liver and gallbladder and urological infections. The effects of the compounds in saffron on certain types of cancer are being studied.



Picrocrocin

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Letters to the Editor

I want to congratulate Vigyan Prasar for organizing a very timely and significant seminar on "Science Popularization through Indian Languages". It was really an enriching and thought provoking exercise on this emerging area of knowledge and expertise. An illustrated report on the seminar has also come out very nicely in *Dream 2047* (October 2003).

I just wanted to point out a small lapse from the reporting point of view. I have been quoted saying "*Digdarshan* as the first magazine on science". This has been reported wrongly. I had only said that *Digdarshan* was a general newspaper carrying some material on science and education. *Digdarshan* was not a full-fledged science magazine. Again it has been quoted "*Digdarshan* paved the path for subsequent printing of popular science books in Hindi and Indian language". This is again a distorted reporting. In fact, *Digdarshan* had nothing to do with paving the way to printing of popular science books in Hindi and other Indian languages. In my presentation, *Digdarshan* was mentioned only as to mark the first ever documented attempt of science writing/journalism in Indian languages. The first and second issues of *Digdarshan* carried a few reports/ articles on some scientific subjects.

Dr. Manoj Patairiya
Scientist "F", SCSTC, Dept. of S&T, New Delhi-110016

First of all, I would like to thank you for sending a copy of the monthly Newsletter of Vigyan Prasar, Dream-2047 of September, 2003.

I was really excited to see an article on a fascinating topic, "Bricks of the Universe (Quarks, Gluons and Leptons)" by Prof. U.C. Agarwala and Prof. H.L. Nigam. But I am highly disappointed to not that the said article contains dozens of serious mistakes enumerated below.

1. Eq. (3) appearing on page 33 is incorrect. Correct form is :
   $\propto^{-} \rightarrow e^{-} + \bar{\nu}_e + \bar{\nu}_{\propto}$
2. Similarly, correct form of Eq. (4) printed incorrectly as $n \rightarrow p + e^{-} + \nu_e$ is:
   $n \rightarrow p + e^{-} + \bar{\nu}_e$
3. The law of conservation of electric charge will not allow the reaction: $p + n \rightarrow p + p + \pi^{+}$ (third reaction of Eq. 5) to take place. However, the following reaction will occur:
   $p + n \rightarrow p + p + \pi^{-}$
4. In column 1 of Table 1 Neutriono, Taon Should be written as Neutrino and tauon. In column 3 rest masses of the particles should be in MeV/ c^2 or GeV/ c^2 unless one takes $\hbar = c = 1$. In column 10, some of the symbols representing antiparticles should be corrected.

Quark compositions of hadrons appearing in column 9 are not correctly written. Particle physicists, no longer write ∝ as ∝-meson. But it is referred to as muon because it is a fermion (having spin ½ ħ) and not a boson.

In Table 1, masses of electron-neutrino, muon-neutrino and tau-neutrino have been reported to be zero. However, I would like to stress that neutrino flavour oscillations require these neutrinos to have masses. The current values of the masses reported by October, 2002 issue of CERN Courier are as under.

Neutrino type	Masses
ν_e	< 2.2 e V/c^2
$\nu_{\propto}$	< 170 Ke V/c^2
ν_{τ}	<15.5 MeV/c^2

In Table III, which contains information about the various "properties" of quarks, terms like truth and beauty have been used. These terms were used about two decades back. Currently these quarks are referred to as bottom-and top-quarks. Additionally, masses of up-, down-and strange quarks should be taken as 330, 330 and 550 MeV/c^2 and not that which have been written.

In column 8 which gives the values of mean lives of particles, the mean lives for photon, graviton, electron and neutrino are written as constent (wrong spelling). Actually these particles don't decay. Hence, these particles should be referred as stable particles. In the last column giving the decay modes, $\nu_{\propto}$ has been shown to decay through $e^{-} + \nu_e + \nu_{\propto}$ but it should be written for the decay of muon. Infact, the decay of negative-muon should be written as:

$$\propto^{-} \rightarrow e^{-} + \bar{\nu}_e + \nu_{\propto}$$

and decay of π^{+} should be written as:

$$\pi^{+} \rightarrow \propto^{+} + \nu_{\propto}$$

On page 31 in the same table, columns 7 and 8 are mixed up. For some particles it contains information about mean lives and it also contains the values of strangeness quantum numbers of certain particles. Furthermore, I am not able to discern in what context in the text on page 31 half-life = 10^{-10} sec is used.

Prof. M. Irfan
High Energy Physics Lab, Physics Dept., Aligarh Musilim University, Aligarh - 202002

Many of the mistakes pointed out by Prof. Irfan are due to printing mistakes. We deeply regret these lapses. We shall print this article separately and the readers who are interested in having the corrected version of the article may write to us.

Editor

Vision Defects

Saying Bye-Bye to Spectacles Through Laser Eye Surgery

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

Nobody enjoys poor eyesight and cumbersome eyewear. That's why over the past couple of decades innovative eye surgeons have been trying different solutions to reshape the faulty eye's focussing apparatus.

They began with reshaping cornea through cartwheel surgery which came to be known as radial keratotomy. This soon gave way to laser. Laser has also evolved over years. The latest technique, LASIK, relies upon using the cutting edge of laser to alter cornea, the window of the eye, to bring images into sharp focus without any need for eye gear.

If you wish to someday shed your spectacles, read on for these tempting laser solutions. There are many ifs and buts, and you must understand them clearly before taking any decision.

How does laser eye surgery help correct the vision defect?

It changes the focusing ability of the eye. Based on years of diligent research, the eye surgeon calculates how he has to reshape the cornea so that it would start focussing the image in a clear, sharp fashion on the retina. He then uses the laser to reshape the curvature of cornea and this brings in the necessary vision correction. Once this happens, the need for eyeglasses or contact lenses is eliminated and you can happily say bye-bye to them.

Which all types of vision problems can be corrected by this laser eye surgery?

Once, laser eye surgery was used primarily to treat nearsightedness (myopia). That still constitutes the largest chunk of such surgeries. However, doctors now also use it to treat farsightedness (hypermetropia) and astigmatism.

What is the best age for this surgery?

Any time after 18 years if you are a young lady, and over 20 if you are a male. The preferable bit is to go for surgery in the early or mid-twenties. That's because the eye continues to grow till this age and its refractive power can change till then. If the surgery is done before the completion of development, the visual defect can resurface and all good results can come to naught.

Can every body go in for this surgery?

No. There are certain basic prerequisites:

● The candidate must be over 18 years of age. ● The vision error must be *stable* for at least two years. ● In myopia, the defect should be at least –1.5 dioptre. ● The cornea must not be affected by any disease and should be of uniform thickness. It should not be affected by keratoconus, a conical defect in the cornea that some people suffer from. ● The candidate for surgery should not have a dry eye or any infection in the eye. ● If you wear contact lenses, you need to stop using them for some time prior to LASIK so that your cornea can return to its natural shape. Thus, soft-lens wearers need to remove their contacts at least seven days before the procedure, and hard- or gas-permeable-lens wearers need to remove their contact lenses four weeks or longer before the procedure.

What does the doctor do during the procedure?

During LASIK, acronym for *laser in situ keratomileusis*, the most common type of laser eye surgery, a programmed mechanical device first slices a flap in your cornea that is thinner than a grape skin. The numbing eye drops prevent you from feeling any pain. The surgeon lifts and peels back the flap with a tiny instrument. Then you hear clicking noises as a laser precisely removes tiny amounts of your inner cornea.

Next, the doctor flips the flap back so it can naturally re-adhere to your eye. The doctor administers anaesthetic, anti-inflammatory, and antibiotic eye drops. Usually, both eyes are corrected during one visit. Once the procedure is complete, the doctor covers your eyes with transparent shields, and you are ready to go.

An older procedure, photo refractive keratectomy, more popularly known as PRK, involves completely removing the cornea's outer protective layer before the laser sculpting. The layer then has to grow back on its own within three to five days, sometimes a painful process.

How long does it take to do a LASIK?

It takes less than 10 minutes to correct each eye.

What happens during the recovery period?

During recovery, your eyes may feel gritty, irritated, or watery, and they may be more sensitive to light. These sensations typically last from a week to a month. Painkillers, rest, and cold compresses can decrease moderate discomfort. If you underwent LASIK, you may need to wear shields to protect your eyes during sleep for the first few nights following the procedure. You also need to use antibiotic and anti-inflammatory eye drops for about a week. If you had PRK, you wear a bandage and special contacts for about three days while your eyes heal. You may also need to continue to use eye drops for a few months.

Are any special precautions called for?

Yes, you must adhere to the guidelines of your doctor to ensure proper healing. Besides, take the following safety measures:

● Do not wear any make up for at least bout a week after surgery. ● Do not go swimming for the next two weeks. ● Do not rub your eyes for at least one month.

How soon is the benefit evident?

If all goes well, you should notice dramatic visual improvement within the first few days following the procedure. However, for the first two to three weeks your vision may fluctuate. On the downside, you also may see halos or starbursts around lights at night. Usually this goes away in three to four months.

What are the potential pitfalls and dangers of undertaking this surgery?

They range from very simple, transient difficulties to more serious ones. These include:

● The surgery may over correct or under correct your vision; you may need a second surgery to bring your eyesight closer to a perfect range. ● Alternatively, despite the improvement in your vision, you may still need contacts or glasses after the procedure for finding complete correction. ● Your vision may change over time, so you may need to have another surgery or use contacts or glasses. Contacts may become uncomfortable to wear after the procedure. ● You may see a glare around lights that impairs your vision at night. ● You may have temporary itchiness, irritation, watering, and sensitivity to light in your eyes. ● You may have increased dryness of the eyes. In most cases, this clears up in one to three months. But for some people it's a permanent side effect. ● There is risk of scars, injury, infection, and permanent sight impairment.

Are the benefits permanent?

Yes. Although the good effect lasts only till the vision remains stable. Once you go past age 40 or 45, you could need reading glasses to correct for the natural aging of the eye.

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