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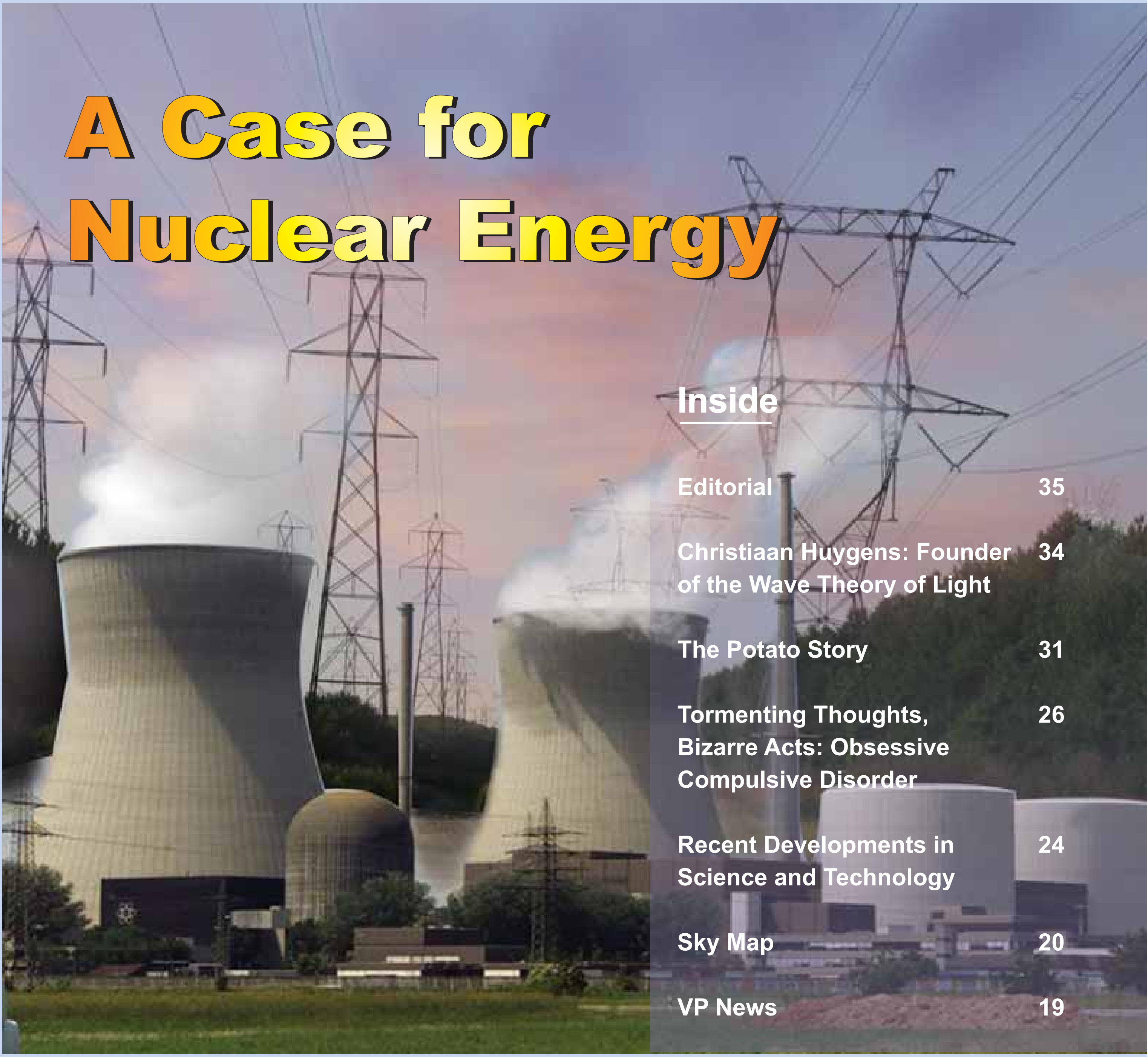

A Case for Nuclear Energy

Inside

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

A Case for Nuclear Energy

India occupies 2 per cent of the world's land mass and currently generates about 2 per cent of the global electricity; and yet has a share of 16 per cent of the world's population. Our annual per capita consumption of electrical energy is only about 480 kWh. For China it is 1,800 kWh, while for USA it is 13,680 kWh! Incidentally, 1 kilowatt hour (kWh) is also called 1 'unit' of electrical energy on which are based our monthly electricity consumption bills. India's total installed capacity as of today is 145,000 megawatts of electricity. However, to achieve even a modestly high level of economic growth, the domestic generation capacity will need to be increased at least *tenfold* in coming few decades, say, by 2051.

At present, thermal sources (coal, gas and oil) provide nearly 65 per cent of electricity, while hydroelectric sources provide 25 per cent of our energy requirements. About 7 per cent of our electrical energy comes from renewable energy sources, while nuclear sources provide for only about 3 per cent of our requirements. Although, the contribution of nuclear energy to power sector today is quite modest, it is destined to play a crucial role in meeting India's energy requirement in coming decades.

Increased availability of electricity is necessary for the progress of any developing country like India. However, mere availability alone is not a sufficient criterion. It also must provide for a long-term energy security, should be sustainable and based on diverse fuel sources and technologies. We must, therefore, examine all fuel resources in the country and tap them keeping short, medium and long term scenarios in perspective. Surely, hydro and renewable sources and technologies must be exploited to the maximum. These, together with coal would meet our short and medium-term requirements.

But, even with full utilization of all existing commercially exploitable domestic hydrocarbon, hydroelectric and non-conventional resources, an increased level of generation capacity cannot be sustained for more than a few decades. How do we meet our long-term energy requirements, then? It is the nuclear resources we shall need to tap. True, our uranium resources are modest, but thorium resources are vast. This is a situation unique to India. Hence, our energy programme has to be on different lines as compared to other countries, where uranium resources are relatively large or readily accessible from different parts of the world. For sure, India's three-stage nuclear power programme takes cognizance of the nuclear resource profile of our country.

Nuclear energy is released when nuclei of heavy atoms like uranium absorb a neutron and break up into smaller fragments. This process is known as fission. During the process, some mass disappears and turns into energy given by Einstein's famous formula $E= mc^2$, where E is the energy produced, m is the mass that is converted into energy and c is the velocity of light. If all atoms of 1 kg of uranium undergo fission, they would produce energy equivalent to that produced by burning 3,000 tonnes of coal! When one uranium nucleus is split, two or three neutrons are liberated, which in turn split more uranium nuclei and liberate more neutrons, and so on. This is what is called a "chain reaction". In nuclear bombs like the ones that destroyed Hiroshima and Nagasaki, this chain reaction goes uncontrolled, resulting in a huge explosion. In a nuclear reactor used for power generation the chain reaction is controlled by absorbing most of the released neutrons, and allowing only some neutrons to cause fission. The energy generated in a fission reaction in the form of heat can be used to raise steam and run turbine to generate electricity.

But, here lies the catch! Not all atoms of uranium can be split by neutrons! In nature, we find uranium atoms of two types - lighter uranium "isotope" with 92 protons and 143 neutrons (denoted by symbol U^{235}) and heavier uranium isotope with 92 protons and 146 neutrons (denoted by symbol U^{238}). Only the U^{235}, present to the extent of about 0.7 per cent by weight in ordinary uranium, is fissile (that is, it can undergo fission), and hence, for use in a nuclear reactor, uranium needs to be "enriched" so that it contains a higher percentage of U^{235} isotope to sustain chain reaction. Enrichment, however, is a complex and an expensive process. In such reactors, however, we need to use boiling water or graphite as "moderators" to slow down the speeds of the neutrons so that they can hit the U^{235} isotopes and split them. When "ordinary" water (H_2O) is used as moderator, the reactor is called Light Water Reactor (LWR).

To get around the complex and expensive process of uranium enrichment, Canada developed CANDU reactors that

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Christiaan Huygens

Founder of the Wave Theory of Light

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Christiaan Huygens

> "Less famous than Galileo, Descartes, Isaac Newton, or Leibniz, Huygens nevertheless belongs among them for his exceptional mathematical and experimental skills, more importantly, his deep intuitions about motion and light. He developed the best ideas of Cartesian mechanism with the help of Galilean principles and classical geometry."
>
> *The Oxford Companion to the Modern History of Science*

Christiaan Huygens was one of those who laid the foundations of modern science. Historians of science usually associate Huygens with the scientific revolution, the period of advances in science that was at its height in the 17th century and produced widespread change in traditional beliefs held since the Middle Ages. Huygens is regarded after Newton, as the most influential physical scientist of the late 17th century. As one of his biographers A. E. Bell wrote: "Huygens had not the religious feeling of a Spinoza or the sensitivity of a Pascal, nor was he a philosopher of the rank of Leibniz. In an age when human mind was making great marches into the territory of natural philosophy, Huygens's energies were thrown into the study of applied mathematics, into optical researches or astronomy and he managed somehow to pursue the most strikingly original researches in several subjects quite simultaneously. In that interesting period in Europe, between the death of Galileo in 1642 and the rise to fame of Newton, Huygens, in fact, stood unchallenged as the greatest man of science of that age."

Huygens' reputation as a modern physicist rests on his wave theory of light. He discovered the phenomenon of polarization. He made original contributions to the science of dynamics; that is, the study of the action of forces on bodies. He discovered the laws of collision of elastic bodies at the same time as John Wallis and Christopher Wren.

Huygens' contributions as an astronomer were quite significant. He designed improved telescopes and discovered Titan, the largest moon of Saturn. Huygens was the first to describe correctly the nature and true shape of Saturn's ring system in 1656. He found that Saturn's rings consisted of rocks and could explain the phases and changes in the shape of the ring. His findings on the nature of Saturn's rings were based on prolonged observations with a home-made telescope. Some scientists attacked not only Huygens's ring theory but also his observations. However, eventually they had to agree with his observations because improved telescopes proved Huygens to be right. A division near the outer edge of Saturn's B ring, discovered in 1981, was named after Huygens. In 1656, Huygens observed the Orion Nebula and he also prepared the first known drawing of this nebula. The brighter interior of the Orion Nebula is named Huygens Region in Huygens' honour. Huygens also discovered several interstellar nebulae and some double stars.

Huygens was born on 14 April 1629 at The Hague, The Netherlands. His father Constantin Huygens (1596-1687) was an important Dutch diplomat. It is through his father's influential connections that Huygens could establish contacts with a number of important scientists in Europe. Huygens himself wrote his name as "Hugens". It is also sometimes written as "Huyghens".

Huygens was taught at home by private tutors until he was 16 years old. He was greatly influenced by René Descartes, who was a friend of his father and used to be a frequent guest at their home. Descartes took keen interest in the mathematical progress of his friend's young son. In 1645, Huygens attended the University of Leiden and stayed there until 1647. At Leiden he studied law and mathematics. In 1647, he shifted to the College of Orange at Breda. Here also he continued to study law and mathematics.

Huygens started his research in science in 1651. In that year he showed the fallacy in a system of quadratures proposed by Gregoire de Saint-Vincent and it was followed by his work on the quadrature of the conics. Thereafter, Huygens engaged his attention to the improvement of the telescope. Assisted by his brother, he developed a new and better method of grinding and polishing lenses. In 1657 he wrote a book on probability theory – the first book on the subject – after being encouraged by the French mathematician, physicist and philosopher Blaise Pascal (1623-62).

Huygens' first major achievement was the invention of the pendulum

Thomas Young

clock. Though in 1581, Galileo had observed that a pendulum would keep the same time whatever its amplitude, but it was Huygens who could use this insight successfully to construct a more reliable clock. Huygens demonstrated that when a pendulum moves in an arc of a circle it does not move with an equal swing. He further demonstrated that a pendulum would produce an equal-timed or isochronous swing if it moves in a curve called cycloid – a curve traced by a point on the circumference of a circle rolls along a straight line. He also demonstrated how the pendulum could be made to move in a cycloidal path to run the escapement. The first clock based on Huygens' design was built by a local clock maker named Salomon Coster in 1657. It was patented in 1658. The clock is kept at Museum Boerthaave in Leiden. This clock is described in Huygens' book *Horologium* (The Clock) published in 1658. The importance of Huygens' invention of the pendulum clock lies in the fact that it raised the measurement of time both in science and daily life to a new level which in those days nobody imagined to be possible.

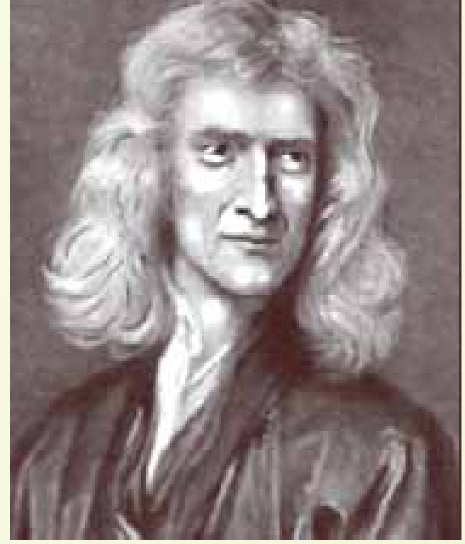
In 1656, Huygens discovered the law of conservation of momentum and also proved that the quantity $\frac{1}{2}mv^2$ is conserved in a collision. He studied the centrifugal force, and in 1659 he brought out the similarity between the centrifugal force and gravitational force. During his visit to England in 1663, the Royal Society of London elected him a Fellow.

In his best-known work *Horologium oscillatorim* (The Clock Pendulum), published in 1673, Huygens presented a brilliant mathematical analysis of dynamics, including discussions of the relationship between the length of a pendulum and its period of oscillation, and the laws of centrifugal force.

Huygens described his wave theory of light in his second most important book *Traite de la lumiere* (Treatise on Light) published in 1690. This work established him as a great modern physicist. He was the first to describe the propagation of light as a wave of motion. Huygens assumed that

John Wallis

the whole space is pervaded by extremely rare medium called aether and light is produced by a series of waves or vibrations in this medium. These vibrations or waves, which spread outwards from the source, are set in motion by the pulsations of the luminous body. So, according to him, light moves in aether in the same way as sound moves in air. According to Huygens, an expanding sphere of light behaves as if each point on the wave front were a new source of radiation of the same frequency and phase. This is known as "Huygens' principle". He worked on his wave theory of light almost at the same time Isaac Newton (1642-1727) was developing his



Isaac Newton

emission or corpuscular theory of light. Because of the Newton's tremendous influence in the scientific world, Huygens' theory was not given due importance. English physicist Thomas Young (1773-1829) gave experimental support to the wave theory of light. Today we know that both concepts are appropriate depending on the experimental situation.

Gottfried Wilhelm von Leibniz (1646-1716), one of the greatest mathematicians of all time, was taught by Huygens. E. T. Bell wrote: "Up till 1672 Leibniz knew but little of what in his time was modern mathematics. He was then twenty-six when his real mathematical education began at the hands of Huygens, whom he met in Paris in the intervals between one diplomatic plot and another. Christiaan Huygens (1629-1695), while primarily a physicist, some of whose best work went into horology and the undulatory theory of light, was an accomplished mathematician. Huygens presented Leibniz with a copy of his mathematical work on the pendulum. Fascinated by the power of the mathematical method in competent hands, Leibniz begged Huygens to give him lessons, which Huygens, seeing that Leibniz had a first-class mind, gladly did...Under Huygens' expert guidance Leibniz quickly found himself. He was a born mathematician."

Huygens invented numerous devices and patented a pocket watch (1675). He carried out experiments with internal combustion and designed

René Descartes

a basic form of internal combustion engine, fuelled by gunpowder. However, he never built a successful combustion engine.

It is interesting to note that Huygens believed that planets were populated. In his book, *Celestial Worlds Discover'd: or, Conjectures Concerning the Inhabitants, Plants and Productions of the Worlds in the Planets*, he speculated that the universe was brimming with life. In fact he wrote in detail about shipbuilding and other engineering on Jupiter and Saturn. Giordano Bruno also believed in many inhabited worlds but he was burnt at the stake for harbouring such liberal views including the Copernican theory. But in Huygens' Netherlands there was a liberal climate which encouraged such speculations.

Huygens was a loner. He worked alone; he did not gather disciples around him. After the death of his father he almost became a recluse and lived in his country home.

He died on 8 July 1695 at The Hague, Netherlands.

A mountain on Moon is named after Huygens. It is called Mons Huygens. Among other things named after Huygens include: The Huygens probe, which landed on Saturn's moon, Titan; Asteroid 2801 Huygens; a crater on Mars; Huygens eyepiece – an achromatic two-element processing eyepiece; Huygens wavelet – a secondary wave as used in Huygens' principle; and Huygens Software – a microscopic image package.

The important works on life and work of Christiaan Huygens include the following: *Huygens and Barrow and Newton and Hook: Pioneers in mathematical analysis and catastrophe theory from evolvents to quasicrystals* by V. I. Arnol'd (Basel, 1990); *Christiaan Huygens and the Development of Science in the Seventeenth Century* by A. E. Bell (London, 1947); *Christiaan Huygens* by E. J. Dijksterhuis (Haarlem, 1951); *The Land of Stevin and Huygens* by D. J. Struik (Dordrecht-Boston, Massachusetts, 1981) and *Unrolling Time: Christiaan Huygens and Mathematisation of Nature* by J. G. Yoder (Cambridge, 1988).

Sir Christopher Wren

Gottfried Wilhelm von Leibniz

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

The Potato Story

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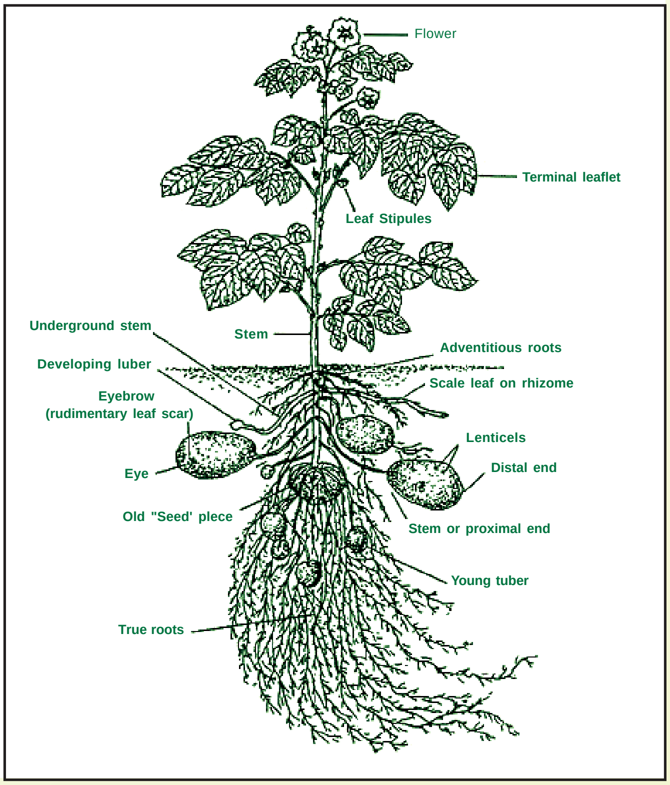
Don't feel tickled and giggle. This is serious. The year 2008 has been designated as International Year of the Potato. Potato is considered very valuable food stuff, capable mitigating massive poverty raging in very many parts of the world. In fact UN's Food and Agriculture Organisation (FAO) argues that potato has the key to solve hunger and starvation world over and hopes to inspire farmers to take to cultivation of potato, especially in poor nations ravaged by poverty and food shortage.

Potato spreads world over

Any Indian cuisine is unthinkable without *aloo*, the much loved potato. Be it *aloo mutter*, *aloo fry* or any form it takes, *aloo* is indispensable part of the feast. But *aloo* was quite unknown 500 years ago in India. Historians state that it was during the reign of Emperor Jahangir that Indian taste buds were introduced to potato by the European traders. In fact, it was the European traders who took this crop to various parts of the world and made it truly a global food.

Nevertheless, neither Europe nor India is the birth place of potato. Home town of potato is tucked way in Lake Titicaca, which sits at 3,800 m above sea level in the Andes mountain range of South America, on the border between Bolivia and Peru. Fossilized remains of possibly cultivated tubers found on a cave floor in Chilca Canyon in this region, suggest that the potato was cultivated here as far back as 7,000 years ago.

The potato's journey around the world began about 8,000 years ago when communities of hunters and gatherers began domesticating wild potato plants that grew around the lake in abundance. Even to this date about 200 species of wild potatoes are found in the Americas. Painstakingly, by trial and error, the early farmers selected a suitable crop for cultivation. Once domesticated as cultivated crop, communities living near the lake had sufficient food stock in the form of potatoes. Potato was well suited to the local climatic condition of Andes valley and the indigenous people of that region ravished on potatoes.



Potato plant

Since then potatoes have been central to civilisations in this region. The food security provided by maize and potato, further benefited by the development of irrigation and terracing, allowed the emergence of the Huari civilisation around 500 CE in Mesoamerica. Around the same time, the city state of Tiahuanacu rose near Lake Titicaca, thanks largely to its sophisticated "raised field" technology – elevated soil beds lined with water canals – which produced potato yields estimated at 10 tonnes per hectare. At its height, around 800 CE, Tiahuanacu and neighbouring valleys are believed to have sustained a population of 5,00,000 or more, all due to the bounty that potato was as a food crop.

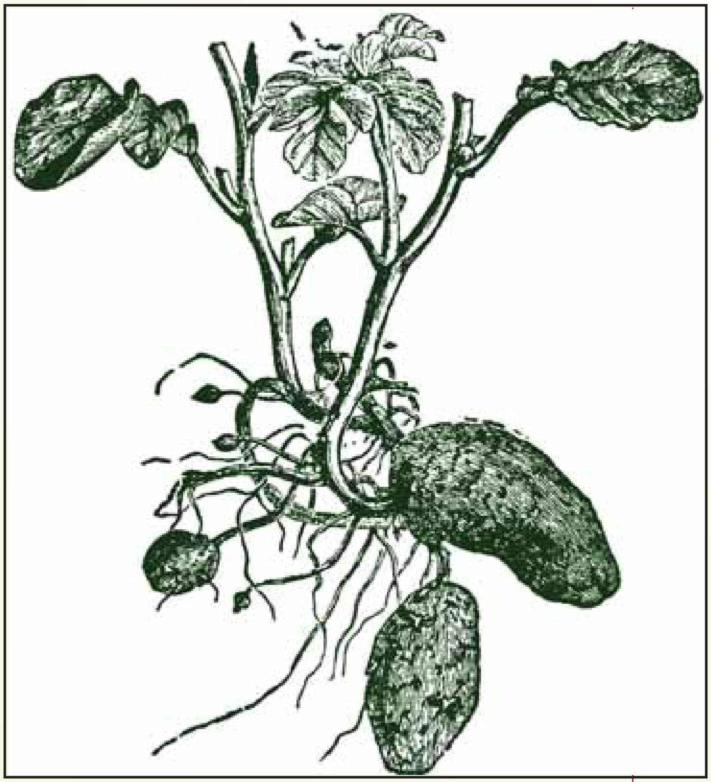
Subsequently the Inca civilisation emerged around 1200 CE. In less than 100 years, Incas created the largest state in pre-Columbus America, extending from present-day Argentina to Colombia. The Incas adopted and improved the agricultural advances of previous highland cultures, and gave special importance to maize production. Even while maize was the staple food, potato was fundamental to their empire's food security. In the Incas' vast network of state storehouses, potato – especially a freeze-dried potato product called chuño – was the main food item stored. It was not unusual to store three to seven years of requirement in the storeroom. The freeze-dried potatoes were used to feed officials, soldiers and labourers and as an emergency stock after crop failures. Potatoes were so important and central to the culture of that time that unit of time in these parts was the measure of how long it took to cook a pot of potatoes!

The Spanish invasion in 1532, spelt the end of the Incas – but not of the potato. The Spanish conquest of Peru between 1532 and 1572 destroyed the Inca civilisation and caused the deaths and devastations – from war, disease and despair – of at least half the population. The European colonisers came in search of gold, but the real treasure they took back to Europe was potato.

The diffusion of the potato from the Andes to the rest of the globe brought tragedy and misery to the Incas but was bliss to the world at large. When Columbus set foot in the New World, Europeans had no inkling of the existence of the potato. They lived on cabbage soup and mushes and gruels made of wheat, rye, barley, or dried peas. And, despite recurrent crop failures and repetitive famines, they seemed satisfied. It was only in 1535, near Lake Titicaca in southern Peru, that Europeans, the Spanish conquistadores, first reported seeing this tuber that had been domesticated by Andean Indians thousands of years before. In his *Chronicle of Peru*, Pedro de Cieza de León wrote perhaps the first description of potato from a European point of view. "…[T]he roots…are the size of an egg, more or less, some round some elongated; they are white and purple and yellow, floury roots of good flavour, a delicacy to the Indians and a dainty dish even for the Spaniards." Native potatoes came in a variety of colours; white, off-white, purple, crimson, and yellow.

Initially potatoes were not welcomed in Europe; it was received initially with apathy and then with hostility before it was embraced all over Europe. The first evidence of potato cultivation in Europe dates from 1565, on Spain's Canary Islands. By 1573, potato was cultivated on the Spanish mainland. Soon, tubers were being sent around Europe. As potato was cultivated in gardens around Europe, there were many who argued that potatoes were not fit for human consumption at all. In the 17th century, Scottish clergymen banned their flocks from planting potatoes, saying that the tubers are not to be consumed as food as it is not mentioned in the Bible. Physicians all over Europe reported that potato caused leprosy, syphilis, and scrofula. Botanists – even the great Linnaeus – cast suspicion on it because it is related to "devil's herb," the deadly nightshade. Nevertheless, Europe ultimately emerged as the heartiest eaters of potato and also introduced it world over.

The widespread adoption of the potato as a food crop in Europe was delayed not only by entrenched eating habits and hostile cultural views, but also by the challenge of adapting the plant to Europe's temperate climate. In Europe the summer days are longer than the nights and in winter the reverse, whereas in Andes, there is no appreciable difference between day and night lengths throughout the year. The day length plays a significant role in leaf formation, flowering and many other biological activities of plants. Therefore it was not just a matter of transporting a seedling to Europe. It took almost 150 years before varieties suited to long summer days began to appear and European farmers could cultivate potato on a large scale.



Potatoes grow at the roots

Potato was not a year-round crop and it tended to get spoiled when stored. Therefore one needed to harvest and preserve it for future use. In case of grains it was not that difficult. To meet the challenge the indigenous Andean farmers developed a freeze-dried preparation called *chuno*, which is still in use today. The potatoes were spread on the ground and left there at night to freeze. The following day the tubers were treaded with bare feet to squeeze out the water. This procedure was repeated over four or five consecutive days and at the end of the period the *chuno* was dried off and stored. When required, the *chuno* softened rapidly in boiling water and was quickly ready to eat and could be used in stews, etc. Throughout the ages *chuno* was as important in the Andean region as *roti* and rice was elsewhere.

When the new varieties suited to European conditions arrived, it was indeed opportune. In the 1770s, much of continental Europe was devastated by famines due to crop failure and hunger. Starvations and food shortage was all around. It was in this testing time that Prussia's Frederick the Great ordered his subjects to grow potatoes as insurance against cereal crop failure. The US President Thomas Jefferson served French fries to White House guests to popularise potato. It was not until the late 1700s that Europeans finally took up the potato with a gusto. Thereafter, it revolutionised their eating habits. It came to feed millions to the exclusion of most other vegetables.

If *chuno* was relished in Andes, new ways of cooking potatoes emerged in Europe. Peasant people during 1750s in Europe roasted potatoes in the embers and ate them with salt – precursor to today's delicacy, baked potatoes. The nobility of Europe on the other hand ate them sliced thinly, powdered with flour and fired in butter and oil – forerunner to today's chips.

Potatoes come in various colour and textures

By 1815 potato become a staple crop across northern Europe and America. The Industrial Revolution was transforming the agrarian society and in the new urban environment, potato became the first modern "convenience food" – energy-rich, nutritious, easy to grow on small plots, cheap to purchase, and ready to cook without expensive processing. The part played by potatoes in emergence of the Industrial Revolution is well recorded.

In India, British colonial governor Warren Hastings is credited with promoting potato cultivation during his tenure, from 1772 to 1785. By the late 18th to early 19th century, potatoes were sufficiently established in the hills and plains of India to have varieties with local names, such as: *Phulwa* (flowering in the plains), *Gola* (round potatoes), and *Satha* (maturing in sixty days). Today potato is so well entrenched in the cuisine of India that most of us would be surprised to know that potato is not indigenous to India!

Production and consumption

In the last 500 years potato has taken over the world by storm. Today, potatoes are cultivated not only throughout the Americas, but also in China's freezing uplands, in India's hot and humid subtropical lowlands, and even on Ukraine's arid steppes. Today farmers worldwide harvest more than 300 million tonnes of potatoes. That makes it the fourth biggest food crop, trailing only behind corn, wheat, and rice. In Russia potato was called the "devil's apple", yet the famine and hunger of 18th century, forced them to adapt to potato and today Russia is the second largest producer of potato. China is the leading producer followed by the Russia and India. India and China today account for a third of the global production of potatoes.

Uses of potato

We all look at potatoes as a *sabji*, or vegetable. However, once harvested, potatoes are used for a variety of purposes, and not only as a vegetable for cooking at home. In fact, it is likely that less than 50 percent of potatoes grown worldwide are consumed fresh. The rest are processed into potato food products and food ingredients, fed to cattle, pigs and chickens, processed into starch for industry, and re-used as seed tubers for growing the next season's potato crop. According to an FAO estimate, just over two-thirds of the 320 million tonnes of potatoes produced in 2005 were consumed by people fresh; baked, boiled or fried and used in a staggering range of recipes: mashed potatoes, potato pancakes and so on.

But global consumption of potato as food is shifting from fresh potatoes to value-added, processed food products. One of the main items in that category is the yummy French fries. Another processed product is the mouth-watering potato chips – made from thin slices of deep-fried or baked potato. The chips themselves are undergoing vast changes in the past decade. From simple salt or chilli flavour, chips now come in variety of flavours – cheese and cream, tomato tango to name a few. Dehydrated potato flakes and granules or potato flour is often used by the processed food industry. Gluten-free and rich in starch, potato flour is used by the food industry to bind meat mixtures and thicken gravies and soups. Industry also uses modern starch processing to retrieve as much as 96 per cent of the starch found in raw potatoes. In Eastern Europe and Scandinavia, crushed potatoes are heated to convert their starch to fermentable sugars that are used in the distillation of alcoholic beverages such as vodka.

Potatoes are also used to produce glue, animal feed and fuel-grade

Like the tuber, potato is known by various names around the world. The Incas called it *papa*, so do most modern-day Latin Americans. Spaniards who came to conquer the land got it confused with another tuber of the Latin America, sweet potato, which was known as *batata*. Thus in Spanish it acquired the name *patata*. The English word potato comes from Spanish *patata*. In Hindi, the potato is called *aloo*, but in Gujarati, the potato is called *bataka* or *batata*. In French it is called 'ground apple', and in Finnish it is *peruna*, which means "earth pear."

ethanol. One of the first widespread uses of the potato in Europe was as farm animal feed. Potato starch is also widely used by the pharmaceutical, textile, wood and paper industries as an adhesive, binder, texture agent and filler, and by oil drilling firms to wash boreholes. Potato starch is a 100% biodegradable substitute for polystyrene and other plastics and used, for example, in disposable plates, dishes and knives. Potato peel and other "zero value" wastes from potato processing are rich in starch that can be liquefied and fermented to produce fuel-grade ethanol.

Unlike other major field crops, potatoes are reproduced vegetatively, from other potatoes. Therefore, a part of each year's crop – ranging from 5 to 15 percent, depending on the quality of the harvested tubers – is set aside for re-use in the next planting season. There is lot more to potatoes than being just a *sabji*.

Potato is a versatile, carbohydrate-rich food. Freshly harvested, it contains about 80 percent water and 20 percent dry matter. About 60 to 80 percent of the dry matter is starch. On a dry weight basis, the protein content of potato is similar to that of cereals and is much higher in comparison with other roots and tubers. Hence potato has replaced cereals in many developed countries. Potatoes are rich in several micronutrients, especially vitamin C; eaten with its skin, a single medium-sized potato of 150 g provides nearly half the daily adult requirement (100 mg). The potato is a moderate source of iron, and its high vitamin C content promotes iron absorption. It is a good source of vitamins B1, B3 and B6, and minerals such as potassium, phosphorus and magnesium, and contains folate, pantothenic acid and riboflavin. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing, and dietary fibre, which benefits health.

In addition, the potato is low in fat. However, preparing and serving potatoes with high-fat ingredients raises the caloric value of the dish. As part of the trend toward greater consumption of "convenience foods", demand for fried potatoes is increasing. Over-consumption of these high-energy products, along with reduced physical activity, can lead to overweight – obesity. Potatoes in the form of fast food is said to increase the risk of overweight heart disease and Type-2 diabetes.

Potato's fame captured by famous artists - Vincent Von Gogh

Bavarian war in 19th century was termed as a 'Potato War', because it continued till the potato stock got exhausted.

The plant

The botanical name of potato is *Solanum tuberosum*. It is a herbaceous annual, belonging to the "nightshade" family of flowering plants that grows up to 100-cm tall and produces a tuber, which is potato. The potato shares the genus Solanum with at least 1,000 other species, including tomato and eggplant.

As the potato plant grows, its compound leaves manufacture starch that is transferred to the ends of its underground stems. The stems thicken to form a few or as many as 20 tubers close to the soil surface. Therefore, potato tubers are modified stems in a strict botanical sense. The number of tubers that actually reach maturity depends on available moisture and soil nutrients. Tubers may vary in shape and size, and normally weigh up to 300 g each.

At the end of the growing season, the plant's leaves and stems die down to the soil level. The tubers then serve as a nutrient store that allows the plant to survive the cold and later regrow and reproduce. Each tuber has from two to as many as 10 buds (or "eyes"), arranged in a spiral pattern around its surface. The buds generate shoots that grow into new plants when conditions are again favourable. In India the potato is often grown as a winter crop. The initiation and development of potato in the plant occurs only when two specific environmental conditions are met. Short-day photoperiod (daylight) and cool night temperature are required for the proper growth. These conditions are available only during winter in sub-tropical Indo-

Gangetic plains, and hence potatoes are grown in this season. However, in the hills the conditions are available almost throughout the year and hence are grown in summer also.

Potato and world hunger

Why is it that UN and its Food and Agricultural Organisation are promoting potato cultivation all over the world? FAO argues that potato has potential to feed the poor and that this potential of potato is yet to be fully tapped. The poor and undernourished nations consume significantly less potato compared to developed nations. According to FAO, potatoes could be additional food supplement in case for hunger and food shortage. Nevertheless there are hurdles in promoting the cultivation and consumption of potatoes in new areas. The tubers are vulnerable to a host of diseases. Some varieties of potato are especially resistant to particular diseases, but may not grow well in new regions of the world or taste that yummy.

During the approximately 8,000 years that potatoes have been cultivated in the Andes, farmers through the ages have selected types to meet their particular local needs and preferences. This vast and age-old selection process has resulted in thousands of distinct types, and Andean Indians sometimes grow up to 200 different kinds of potatoes in a single field. Most of these Andean potatoes are quite unlike what people elsewhere take to be "normal" for a potato. They can have skin and flesh that is often with brilliant colours, sometimes bright yellow or deep purple. Some have eye-catching shapes, often long, thin, and wrinkled. And most have a rich potato flavour and a high nutritional quality. These little-known potatoes are adapted to marginal growing environments and possess considerable resistance to various troublesome diseases, insects, and nematodes, as well as frost. The choice of variety is of major importance in potato growing as it affects the yield, quality, storability and ultimate use of the produce.

Following this tradition, the International Potato Centre (CIP) in Lima, Peru hopes to develop potatoes suited to various local conditions. Climate, soil types, day length, and native diseases are identified in each local region and appropriate new potato crop is developed by crossing the lines of wild or cultivated potato. Such localisation of potato crop to given climatic and eco region is potentially feasible, because the potato has the richest genetic diversity of any cultivated plant. So there is plenty of potential to tailor a new cultivar to meet the needs of farmers in most places on the globe. In India, Central Potato Research Institute in Shimla and its seven regional centres undertake research and development work for new varieties, seed production, disease prevention and mitigation, and certification.

But the potato's biggest advantage, according to the International Potato Centre, is that it yields more food, faster, on less land, and in harsher climates than any other major food crop. Up to 85 percent of the potato plant is edible, compared to only about 50 percent for cereal grains. Agriculturally, no other crop grown in developing countries has more production potential. While major cereals are fast approaching the limits of their production potential, the yield potential of the potato is still largely underexploited even in some industrialised countries. Furthermore, in developing countries, the potato is seen as a logical candidate to solve food problems. In terms of nutrition, as little as 100 gm supplies about 10% of the recommended daily allowance of protein for children. One hundred grams of potato also supplies the equivalent of 10% of an adult's need for thiamine, niacin, vitamin B6 and folic acid, and 50% of their vitamin C requirement. Moreover, the Centre notes, potatoes "are ideally suited to places where land is limited and labour is abundant – conditions found in much of the developing world." Thus potato could give food and work together!

The potato that reached Europe in the late 1500s was a variety called 'andigena'. But how it became the modern potato is a matter of debate. When grown in Europe today, andigena's stolons are very slow to swell to form tubers, and it produces little or no yield. Differences in day length between the short days of the central Andes and the long days of a northern European summer are the cause. It is probably accidental that the andigena was transformed into a useful crop for Europe. In the 1600s and 1700s, some people propagated potatoes by planting botanical seeds. This was different from the usual vegetative planting of potato from its 'eyes' – spores in the tuber. The resulting seedlings from the true seeds of potatoes were highly variable; virtually every plant differed from all the others. This allowed a vast number of genes to be combined and expressed, and among the types that arose were some that could form tubers during long days. This is the explanation believed by most potato geneticists. There is, however, a possible alternative: that an unrecorded ship introduced "long-day potatoes" from southern Chile. Chilean potatoes are almost certainly also derived from andigena, but for centuries they have been adapted to long-day production. Whichever method transformed andigena, it was one of the most valuable genetic developments of all time; it gave the world what is now its fourth largest food crop: the modern potato.

Tormenting Thoughts, Bizarre Acts

Obsessive Compulsive Disorder

Dr. Yatish Agarwal
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An illness found in up to three per cent of young people, obsessive-compulsive disorder does not divorce a person from reality. Yet, it fills the mind with senseless thoughts, impulses and images that haunt endlessly. These obsessions may drive a person into doing irrational acts or taking avoidant behaviour. This can cast a shadow on the person's individual, marital, social, and occupational life.

The facts of the mind, the games it can play, and the aces it has up its sleeve, can dwarf the most eerie pieces of fiction. When tormented by irrational ideas, we can be driven into doing the unthinkable. Ideas, impulses, and images of senseless and intrusive nature can possess us. Howsoever disturbing, unrealistic, or repugnant, it is sometimes impossible to escape them. Such repetitive, unwanted thoughts, called obsession, in conjunction with inappropriate or bizarre repetitive acts, termed compulsion, give birth to the obsessive-compulsive disorder.

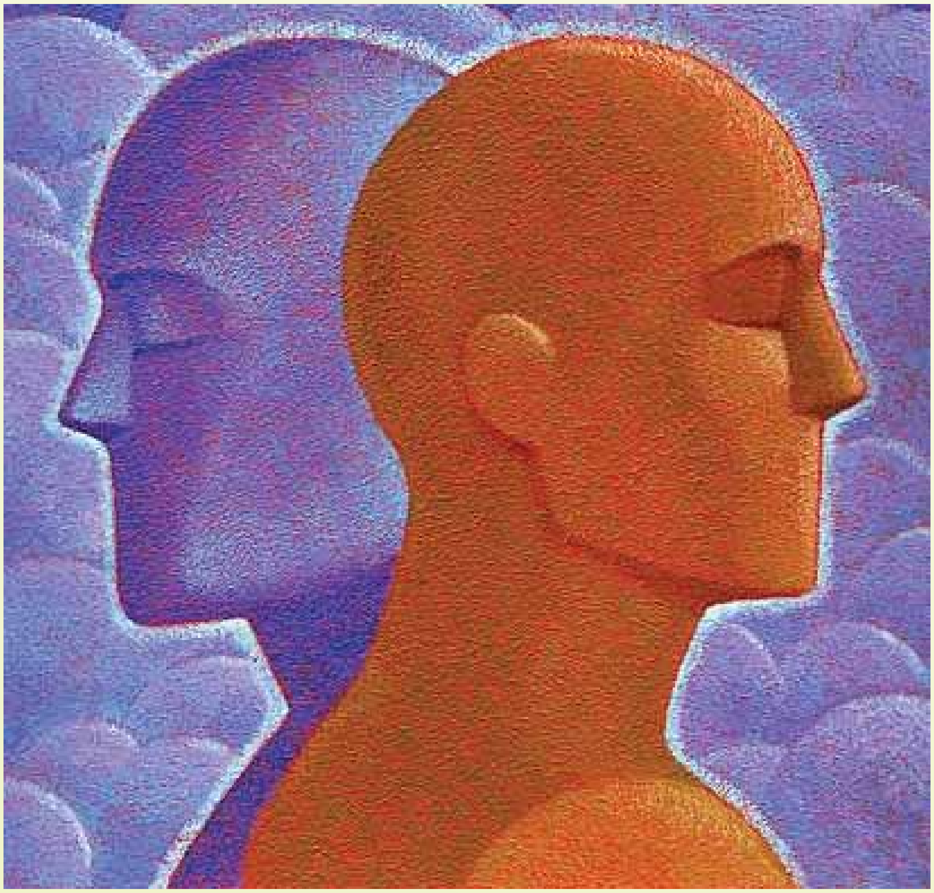
A common disorder, it can put you through hell and fire—guzzling a lot of time, causing much anxiety and distress, and interfering with your ability to function in various social settings. Preyed upon by this illness, you may well realise the irrationality of your thoughts and acts, and yet be unable to suppress them.

There are moments in our lives when many of us have bizarre, inappropriate thoughts and we may even engage in strange senseless actions. For example, about to leave for work you turn on the ignition of the car, and suddenly feel compelled to check if you had left the door open, stove burning, or the faucet flowing. Watching a game on the television you find that your team is doing well, and so you remain glued to your seat fearing that any movement on your part could undo your team! You are desperate to see a job through and decide that if you were to reach the spot in 'x' number of steps, you would accomplish it, and so you will yourself to take the 'x' steps! These are all examples of obsessive-compulsive behaviour, but they should not be regarded as a disorder unless they are persistent and repetitive and oppress life.

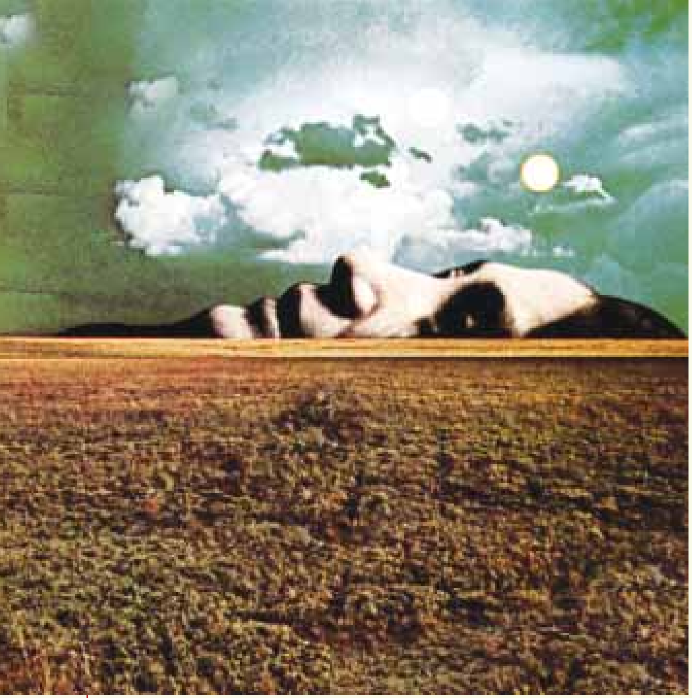
The following three case studies bring out this point rather well:

Raghav, 19, is a bright student. Both his parents are doctors and he has had the best of upbringing. Now for the last ten months or so, Raghav has been obsessed with the fear that if he were to see a street dog, he would catch the rabies. He has stopped going to college, does not drive, and is reluctant to step out of home. In his hurried turning away from a street dog, he fears, he might hurt the passers by. A well-informed boy, with access to the Internet, he has read all about rabies. He understands perfectly well that his fears are irrational, and his actions are bizarre, yet he is unable to rid of them.

Kiran is 23 years old. She is a much fussed-over daughter of an industrialist father. Kiran has dropped out of college because she fears that if she were to step out of the house, she would be swamped by germs. This fear is so dominant in her mind that even at home, she spends hours closeted in the bathroom. She washes herself repeatedly, washes her clothes, and spends hours scrubbing and cleaning the floor of the bathtub. The thought is so overpowering that she avoids meeting people, because she feels they could be carrying germs.



Mediscape



Her family is aghast at her preoccupation with this strange thought. They have also reprimanded her a number of times. Kiran understands that her ideas and actions are illogical but she has no control over them.

George is a 45-year-old engineer. He is regarded well by his office colleagues and friends. He is also a devout Christian. Yet, for the past many months, whenever he walks past the church, his mind fills with blasphemous thoughts. Perverse images flood his mind and he has no control over them. This was acutely distressing for him until he found a way out—he starts touching parts of his face in a stereotyped fashion to avoid the forbidden thoughts. He realises that his actions are senseless, but he is driven to perform them.

Who gets affected?

The disorder is much more common than was previously recognised. Few people affected with obsessive-compulsive disorder tend to share their bizarre thoughts and actions, and their tendency to keep it secret plays a major part in underestimating the numbers. Some recent community studies, however, made a specific enquiry into the presence of the symptoms and found that the disorder has a lifetime prevalence of 1.9 – 3.0 per cent in the general population.

The disorder begins most often in young people between the ages 18 and 24, but it may also affect children and older people. There is no gender bias and men and women are equally affected. The prevalence in first-degree biological relatives of individuals with obsessive-compulsive disorder is higher than in the general population, and, if one of the identical twins is affected, the other also runs a high risk of being affected, but this does not apply to non-identical twins.

Symptoms

The key points of obsessions and compulsions central to the disorder are: One, an idea, impulse or image intrudes itself insistently and persistently into the person's consciousness. Two, a feeling of anxiety and fear accompanies this central thought and frequently leads the person to take measures to counter it. Three, the obsession or compulsion is not native to the psychological being of the person. Four, the person recognises the thought or deed as absurd and irrational. Five, the person feels a strong desire to resist the obsessions and compulsions, yet is unable to do so.

Obsessions and compulsions can take many forms. The most common obsession is fear of contamination from germs, and this compels the person to carry intense cleaning rituals. People with this obsession may wash their hands dozens of times each day and this may cause their skin to become raw.

The second most common obsession is the doubt about whether doors are locked and appliances are turned off or not. This drives people to check things over and over again. For example, people with this condition may be compelled into making repeated checks whether they did lock the doors and windows, turned off the gas stove, and closed the water faucet or not. The compulsion is so overpowering that many times a person is compelled to take multiple trips back into the house from his workplace.

Other common obsessions include a fear that something terrible might happen—such as the death or illness of a loved one or self, or that a fire may break out. Some people may be obsessed about symmetry, order or exactness; forbidden or disturbing sexual thoughts, images, or pictures; nonsensical impulses such as shouting in public; and thoughts of accidentally and unknowingly harming someone. People may also avoid shaking hands with people because of the fear of contamination, or may stop taking the wheel because of the fear they will injure someone in a traffic accident.

Some 75 per cent people relieve the anxiety of their obsessions by performing equally irrational acts (compulsions). They are carried out to prevent or reduce anxiety, not to provide pleasure or gratification. The common compulsions—other than cleaning rituals and checking rituals that we just outlined—may include constantly rearranging or straightening objects, counting things, repeating words or prayers internally, and hoarding vast amounts of useless materials.

(Look for Causes, Complications, and Management of Obsessive-Compulsive Disorder in next month's *DREAM-2047*!)

Recent Developments in Science and Technology

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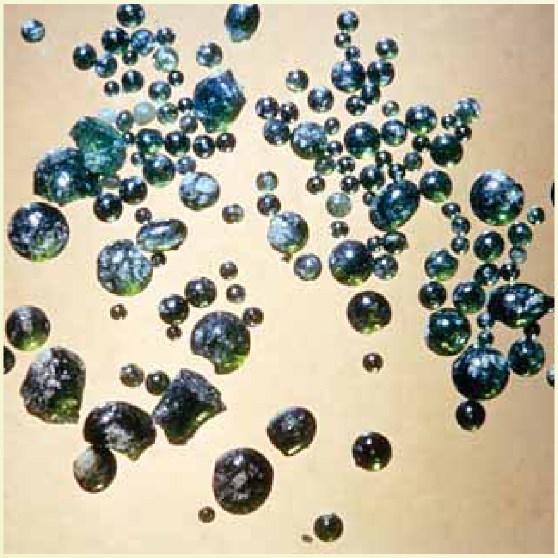
Water on Moon

After looking at the Moon through his telescope the Italian astronomer Galileo had named the dark, flat areas as 'maria', thinking them to be seas on the Moon. Of course, we know today that the Moon does not have seas. In fact, till recently there was little evidence of water on the Moon, although it was speculated that the area around Moon's south pole, called South Pole-Aitken may have some pockets of water ice. Now, researchers have found the first evidence of past water on the Moon, in the form of trace water molecules trapped in glassy, volcanic pebbles brought back to Earth by *Apollo* astronauts from the rim of the Shorty crater on the Moon. The tiny glass beads, 0.1-0.4 mm in diameter, are known as lunar volcanic glasses. These were formed more than three billion years ago when molten underground rock (magma) erupted from the lunar surface in fiery sprays and solidified. A team of researchers led by Alberto E. Saal of the Department of Geological Sciences, Brown University, Rhode Island, USA used the techniques of secondary ion mass spectrometry to analyse the volatile contents of the lunar volcanic glass beads. The analysis of these glass beads suggest that some parts of the lunar mantle may contain a few hundred or even a few thousand parts per million (ppm) of water (*Nature*, 10 July 2008). The water content of Earth's upper mantle is around 150 ppm. The high concentration of water found within the glasses suggests that the Moon may have had a wetter origin than previously thought.



Water has been detected in these glass beads which were collected in the early 1970s by Apollo astronauts. Since then scientists have been working hard to develop the technology necessary to fully examine them.

The new finding casts doubt over the currently accepted theory of Moon's origin according to which the Moon was formed out of debris thrown out when a Mars-size object collided with Earth and threw out molten material into space, where some of the fragments coalesced into the Moon. Scientists think that the high temperatures involved in this process would have vaporised all volatiles (lighter elements and molecules like water).

However, some planetary scientists believe that the findings do not throw out the collision model entirely. For example, if a part of the Moon had formed quickly after the impact — or (as simulations predict) from parts of the colliding body that did not hit Earth directly and therefore were not heated enough for the lighter elements to evaporate — it might have retained its water. The water could also have come from meteorites or asteroids that struck the Moon after its formation.

The final answer may be available only after NASA's *Lunar Crater Observation and Sensing Satellite* (*LCROSS*) crashes on the lunar south pole in 2009 and sends back data. If ice is found, it would be possible to check whether it represented the same ancient water in glasses, preserved in polar cold spots.

Why tree shrews never get drunk

Although humans enjoy drinking, the consequences of excessive alcohol consumption are often devastating. It is therefore natural to expect wild mammals also to behave in a similar manner after consuming alcohol. But it may not be so. A recent report in *Proceedings of the National Academy of Sciences* (29 July 2008), describes a tiny mammal – the pen-tailed tree shrew (*Ptilocercus lowii*) found in the jungles of Malaysia – that is also fond of drinking, but does not get drunk. According to Frank Wiens of the University of Bayreuth in Germany and his colleagues, who carried out the study, this is the first recorded case of chronic alcohol consumption – fermented nectar from flower buds of the bertam palm (*Eugeissona tristis*) in this case – by a wild mammal. The interesting thing is that even after consuming alcohol in doses from the inflorescences that would intoxicate humans, the pen-tailed tree shrews do not get tipsy; they do not wobble, lose their grip or show other obvious signs of inebriation. This, the researchers speculate, may be due a different alcohol metabolism in shrews compared to humans when it comes to detoxifying alcohol.

The study is the outcome of fieldwork started in 1996, which

The pen-tailed tree shrew of Malaysia spends several hours a night licking fermented nectar off the buds of a kind of palm.
Credit: A. Zitzmann

involved tracking the tree shrews in the dense growth of spiny palms. Wiens and his colleagues followed the tree shrews on their nightly palm crawls and tested hair samples for an alcohol metabolite (ethyl glucuronide), typical of chronic drinking. The researchers also measured palm fermentation and combined the results in a mathematical model to predict the shrews' probable alcohol intake.

The researchers conjecture that tree shrews cope with the risks of chronic high oral alcohol intake through an increase in effectiveness of the glucuronidation pathway of alcohol detoxification that keeps concentrations of alcohol in their blood and the brain low. Glucuronidation occurs mainly in the liver and the human body uses the pathway to make a large variety of substances more water-soluble, and, in this way, allow for their subsequent elimination from the body through urine. The results of the study may help in developing new strategies to help combat human pathologies related to alcohol abuse.

Trigger for northern lights revealed

Scientists have long known that the dancing curtains of colour, known as auroras or the northern and southern lights, seen during polar nights are generated by charged particles flying from the Sun and interacting with the Earth's magnetic field. The charged particles coming from the Sun, also known as 'solar wind', are strongest when the Sun is active and produce the brightest display of auroras. But even when the Sun is quiet, events known as substorms also produce auroras. But exactly what triggered the formation of the brilliant atmospheric displays had remained a mystery.

The Earth's magnetosphere is shaped like windsock, with the blunt end facing the Sun and the tapering tail end, called the magnetotail, pointing away from the Sun. In the magnetosphere, the geomagnetic field interacts with the solar magnetic field carried by the solar wind. When the two fields are aligned appropriately, the interplanetary magnetic field can deposit 10^{14} to 10^{15} Joules of energy into Earth's magnetosphere. At the subsequent onset of a geomagnetic substorm, this energy is explosively released. These substorms form when Earth's magnetic field lines collapse on each other. Each substorm generates a current of about one million to two million amperes over one to two hours and leads to the colourful auroral displays.

Scientists were aware of two events that occur in the tail of the magnetic field during substorms, but did not know which event acted as the trigger for the auroras. Over the past 30 years, there were conflicting views on whether local electrical disruptions in Earth's magnetic field — similar to the blowing of an electric fuse — or far-flung happenings in the magnetotail caused flare-ups of the substorms and their associated auroras.

To find out the truth, NASA launched five identical spacecraft, each about the size of a washing machine, in 2007 as part of the *THEMIS* (*T*ime, *H*istory of *E*vents and *M*acroscale *I*nteractions during *S*ubstorms) project. The mission was specially targeted to measure the electric and magnetic fields as well as the particles passing by at different locations around Earth. Coupled with ground observations, scientists were able to deduce the order of events in a substorm onset.

Colourful display of northern lights.

THEMIS data showed that the snapping of magnetic fields in the magnetotail occurred first, followed by a burst of auroras. The disruption in the charged particle current occurred only after the appearance of aurora. It was earlier believed that the snapping of the magnetic field caused the change in electric current and that, in turn, led to the auroras. According to the researchers, the new finding is a step in developing reliable forecasts of geomagnetic storms that can disrupt satellites in orbit and power grids on the ground.

Mars has water

It is now confirmed that Mars indeed has frozen water below its surface. NASA's Phoenix Mars Mission, which was launched a year ago to look for water and complex organic molecules that could be signs that life once existed on Mars, has sent back data after analysing Martian soil samples. Along with frozen water, the *Phoenix* lander also found the presence of sodium, potassium, magnesium, fluorides – nutrients that are important for life. However, it did not find any organic molecule in the Martial soil.

The *Phoenix* lander is equipped with a telescoping arm to enable it to scoop up soil samples so they can be analysed by the spacecraft's onboard instruments. The spacecraft landed on Mars on 26 May 2008 and has been apparently sitting on top of a layer of ice just a few centimetres below the surface, but the sticky quality of the wet Martian soil made it difficult to retrieve a sample. The tested soil sample was taken from a trench approximately 5-cm deep. When the robotic arm first reached that depth, it hit a hard layer of frozen soil. Two attempts to deliver samples of icy soil were foiled when the samples became stuck inside the scoop. The success came after the scooped soil had been exposed to the air for two days, letting some of the water in the sample vaporise away and making the soil easier to handle.

Water on Mars had already been identified from a distance, by the Mars-orbiting *Odyssey* spacecraft; the *Phoenix* data only confirms that observation. Besides, the *Phoenix* science team is trying to determine whether the water ice ever thaws enough to be available for biology and if carbon-containing chemicals and other raw materials for life are present. Meanwhile, NASA has extended the *Phoenix* mission for another month, up to the end of September 2008.

Titan's hydrocarbon lakes

After four years of observation by the orbiting *Cassini* spacecraft, it is now confirmed that Saturn's largest moon Titan indeed have liquid bodies, like lakes and seas, on its surface – the only place besides Earth to have such features (*Nature*, 31 July 2008). The foot-shaped lake is the first verified extraterrestrial body of liquid, and is likely filled with hydrocarbons like ethane or methane, simple compounds also common on Earth. The lake, about 20,000 km^2 in area, is in Titan's southern hemisphere. Similar-looking patches abound in the northern hemisphere, indicating that Titan's surface is likely dotted with such hydrocarbon seas.

NASA's Cassini *orbiter captured this view of Titan's Ontario Lacus from about 1,100 kilometres away in December 2007. A bright shoreline surrounds the hydrocarbon lake.*

Credit: NASA/JPL/University of Arizona

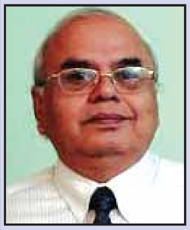
Titan's hydrocarbon lake has been named Ontario Lacus after the North American Great Lake of similar size. Since it absorbs nearly all light, it looks dark to the human eye, as it appears in the photo. *Cassini* data also reveal that the lake's surface is smooth, without any ripples or waves, which indicates absence of winds.

The researchers confirmed the presence of liquid ethane with *Cassini*'s Visible and Infrared Mapping Spectrometer, which picked up the hydrocarbon's tell-tale light spectrum signature. The ethane forms when sunlight breaks down methane in Titan's upper atmosphere. It is theorized that this ethane then forms clouds and rains onto the ground, cutting streams via erosion and pooling them into lakes.

This finding supports the idea that Titan has a "hydrological cycle" – forming clouds, raining out and evaporating into clouds again – as does Earth; but instead of water, two organic compounds – methane and ethane – constitute the cycle on Titan.

OBITUARI

Science Broadcaster B.M. Gupta passes away



B.M. Gupta

The well-known science writer and broadcaster, Brijmohan Gupta (b.May 04,1947), passed away on 9 August 2008. Shri Gupta had dedicated his life to science popularisation through electronic and print media. Recipient of many national awards, Shri Gupta has written more than 18 books on mass media, popular science, health and moral education. One of his books, *Swadheen Bharat main Manoranjan aur Kala*, had been awarded the 'Bhartendu Harishchandra Puraskar 2000' by the Ministry of Information & Broadcasting, Government of India.

A versatile radio producer, Shri Brijmohan Gupta had produced a large number of science radio serials. Some of the popular radio programmes he produced are: Radio DATE (Drug, Alcohol, Tobacco Education, with ICMR), Human Evolution (with NCSTC), *Chhoo - Mantar* (Explanations of so-called miracles, with Vigyan Prasar), *Dilli Apni Dilli* (Environment-based programme). Shri Gupta also conceived and organised a running commentary during the total solar eclipse of 24 October 1995, covering the entire path of totality in India.

As a science communicator, Shri Gupta was actively associated with the activities of Vigyan Prasar; Science Centre, Gwalior (MP); National Council of Science and Technology Communication (NCSTC); National Children's Science Congress; and Vigyan *Jatha*s. He was one of the team which conceived the idea of National Children's Science Congress, which is now a very popular platform for children. Vigyan Prasar had produced a radio serial "*Dharti Meri Dharti*" with All India Radio, New Delhi with his guidance and support.

Shri Gupta did his B.Sc. from Safia College, Bhopal and M.Sc. (Zoology) from from Motilal Nehru Vigyan Mahavidyalaya. He did his Diploma in Journalism from Jabalpur University. During his 37-year long career he was associated with several institutions. Among them are: Jawaharlal Nehru Agriculture University, Jabalpur; Safia College, Bhopal; *Yuva Sansar* weekly; the English daily *MP Chronicle*; AIR, Indore; AIR, Ambikapur; AIR, Gwalior; AIR, Shivpuri; AIR Delhi; Staff Training Institute (Programme), AIR, New Delhi; and Commercial Broadcasting Service (Vividh Bharti) AIR, New Delhi, from which post he retired last year.

The untimely death of Shri Brijmohan Gupta is a great loss of science communication activities in the country. Vigyan Prasar pays its tribute to him.

Editorial (Contd. from page 35)

use natural uranium (containing both U^{235} and U^{238} isotopes), but use pressurized "heavy water" as moderator. Incidentally 'heavy' water has hydrogen atom with one proton and one neutron in the nucleus of hydrogen atom (denoted by D_2O), while 'ordinary' water has hydrogen with only a proton as its nucleus (denoted by H_2O). There is one distinct advantage in using Pressurized Heavy Water Reactors (PHWRs). Energy is, of course, produced by the fission of U^{235} nuclei, but some of the U^{238} nuclei are converted to plutonium nuclei with 90 protons and 149 neutrons (denoted by Pu^{239}), *which is fissile*. Hence, the "spent" fuel from PHWR can be reprocessed and Pu^{239} separated which can be utilized as fuel in the second stage reactor. As of today, India has 17 nuclear reactors in operation producing 3,779 megawatts of electricity, two of which are LWR type using enriched uranium while the rest are PHWRs based on CANDU design using natural uranium as fuel. Surely, a few of U^{238} nuclei do get converted to Pu^{239} in LWRs as well that use enriched uranium as fuel.

India has only about 61,000 tonnes of uranium. But thorium (90 protons and 142 neutrons denoted by Th^{232}) resources are vast - some 2,25,000 tonnes. Although Th^{232} by itself is not fissile, it can be converted to a uranium isotope U^{233} by bombarding with neutrons in a nuclear reactor, Now, U^{233} is *fissile*, and can be used as fuel in another reactor that predominantly uses this isotope of uranium. Surely, the long-term goal of India's nuclear program is to develop an advanced heavy-water thorium cycle. India's 3-stage nuclear programme employs in its first stage the PHWRs fuelled by natural uranium, and light water reactors, to produce plutonium alongwith power. Stage 2 uses fast neutron reactors, also called Fast Breeder Reactors (FBRs), burning the plutonium to "breed" U^{233} from thorium. The blanket around the core will have uranium as well as thorium, so that further high-fissile plutonium is produced as well as the U^{233}. Then in stage 3, Advanced Heavy Water Reactors (AHWRs) would burn the U^{233}.

India's civil nuclear programme has progressed at a relatively slow pace as it is not a signatory to the Non-Proliferation Treaty (NPT). Incidentally, NPT is a treaty to limit spread of nuclear weapons. There are currently 189 countries party to the treaty, five of which have nuclear weapons. India did not sign the treaty as it considered it was biased towards the five nuclear weapon states (USA, UK, France, Russia, and China). As a result, India did not have access to nuclear resources or technology available elsewhere in the world. But, this has proved to be a blessing in disguise. Today, India is considered world leader as regards thorium technology which is still under development. The nuclear weapons capability of India has arisen independently of its civil nuclear fuel cycle and uses indigenous uranium. Because of its relative isolation in international trade and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium.

India's nuclear industry is largely without International Atomic Energy Agency (IAEA) safeguards, though four nuclear power plants are under facility-specific arrangements related to India's safeguards agreement with IAEA. The lack of full-scope IAEA safeguards has resulted in India being isolated from world trade by the Nuclear Suppliers' Group (NSG) comprising of 45 nuclear supplier States. It is worth mentioning that India has been scrupulous in ensuring that its weapons material and technology are guarded against commercial or illicit export to other countries.

But, things are looking up. As of now, International Atomic Energy Agency (IAEA) has already cleared the India-specific nuclear safeguards agreement. India will need to designate and put some of its nuclear power reactors under IAEA safeguards. Under the agreement, a total of 14 of India's 22 reactors are expected to come under the IAEA supervision by 2014 - the first ones as early as 2009. It would allow India to reprocess US-origin and other foreign-sourced nuclear fuel at a new national plant under IAEA safeguards. India will now proceed to NSG for a nod to allowing trade with a non-NPT country, followed by ratification from the US Congress, to finalize the agreement.

Today, India is largely excluded from trade in nuclear plant or materials, which has hampered its development of civil nuclear energy. India has a flourishing and largely indigenous nuclear power program and expects to have a nuclear capacity to produce 20,000 megawatts of electricity by 2020, subject to an opening of international trade. India is already in the process of constructing 6 power reactors, 4 of which are PHWRs and 2 pressurized water reactors through an agreement with Russia. Another 10 are planned and 9 proposed. According to a recent study by the Department of Atomic Energy, if we import nuclear reactors / fuel that would allow us to produce "additional" 20,000 megawatts of electricity by 2020 (that is, total 40,000 megawatts of electricity), the reprocessed plutonium to be used in FBRs would allow India to be self-sufficient in energy by 2050. Our 3-stage nuclear pogramme, however, would forge ahead unhindered.

Nuclear energy does not imply nuclear reactors and nuclear weapons alone! It is safe, environmental-friendly, and has innumerable applications in fields as diverse as health and medicine, industry, hydrology, food preservation, and agriculture. We may note that in the field of nuclear agriculture, the mutant ground-nut seed developed at the Bhabha Atomic Research Centre (BARC), contribute to nearly 25 per cent of total ground-nut cultivation in the country. Similarly, the BARC developed mutant seeds of black gram (*urad*) contribute to 22 per cent of the national cultivation. In the state of Maharashtra, this percentage is as high as 95 per cent. In particular, so far as the future energy needs and economic development of our country are concerned, the agreement for nuclear energy would certainly prove to be extremely beneficial to our country in the decades to come.

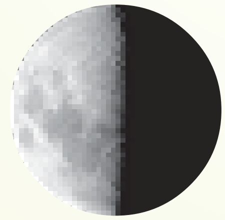
□ Vinay B. Kamble

Sky Map for September 2008

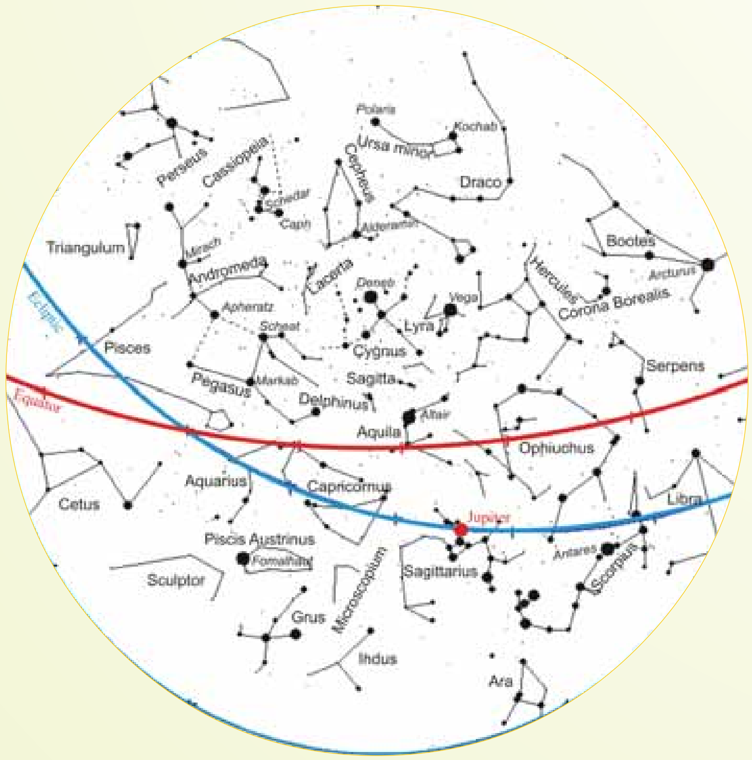
Full Moon

15 September

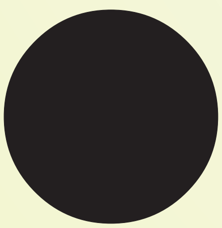
Moon - Last Quarter



22 September

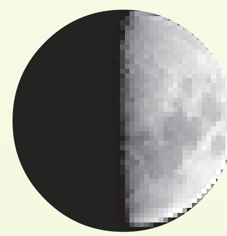


New Moon



29 September

Moon - First Quarter



7 September

The sky map is prepared for viewers in Nagpur (21.09° N, 79.09° E). It includes bright constellations and planets. For viewers south of Nagpur, constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Similarly, for viewers north of Nagpur, constellations of northern sky will appear higher up in the sky, and those of the southern sky will appear nearer the southern horizon. The map can be used at 10 PM on 01 September, at 9:00 PM on 15 September and at 8 PM on 30 September.

Tips for watching the night sky :

(1) Choose a place away from city lights/street lights (2) Hold the sky-map overhead with 'North' in the direction of Polaris (3) Use a pencil torch for reading the sky map (4) Try to identify constellations as shown in the map one by one.

Planet/Dwarf Planet Round Up:

Jupiter : In the constellation Sagittarius (*Dhanu Rashi*) up in the south-western sky.

Uranus : In the constellation Aquarius (*Kumbha Rashi*) up in the zenith sky.

Neptune : In the constellation Capricornus *(Makar Rashi)* up in the zenith sky.

Pluto : In the constellation Sagittarius (*Dhanu Rashi*) up in the south-western sky.

Prominent Constellations: Given below are prominent constellations with brightest star therein (in the parenthesis). Also given are their Indian names.

Eastern Sky : Cetus, Pisces / *Meen Rashi*, Sculptor, Triangulum.

Western Sky : Bootes (Arcturus) / *Bhutaap (Swati)*, Corona Borealis, Libra / *Tula Rashi*, Ophiuchus, Serpens,

Southern Sky : Ara, Aquarius, Capricornus / *Makar Rashi*, Grus, Indus, Microscopium, Piscis Austrinus, Sagittarius / *Dhanu Rashi*, Scorpius / *Vraschik Rashi*.

Northern Sky : Cassiopeia, Cepheus (Alderamin) / *Vrashaparva*, Draco, Perseus, Ursa Minor (Polaris) / *Dhruvamatsya (Drhuvataraka)*.

Zenith : Andromeda, Aquila (Altair), Cygnus (Deneb), Delphinus, Hercules, Lacerta, Lyra (Vega) / (*Abhijeet*), Pegasus, Sagitta.

□ Arvind C. Ranade
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Astronomy Workshop for VIPNET clubs of Punjab

Vigyan Prasar in collaboration with Punjab State Council for Science and Technology conducted a five-day astronomy workshop for the VIPNET clubs of Punjab from 29 July to 2 August 2008 at the Department of Physics, Punjab University, Chandigarh. Nearly 60 teachers from different districts of Punjab attended the workshop. The objective of workshop was to create awareness about astronomy in schools. Different school clubs were selected by the State Council through nominations. The workshop was inaugurated by Prof. M. M. Gupta, Chairperson of Department of Physics, Punjab University.


Arvind C. Ranade, Scientist, VP, delivering the lecture.

Resource material produced by VP, comprising the Astronomy Kit, Emergence of Modern Physics Kit, and book *Venus and its Transit* were given to each registered participant. During the workshop 60 simple 39-mm refractor telescopes were assembled by the participants, which were then gifted to them to start sky watching activities in their respective clubs on a regular basis. A logbook comprising 20 activities to be performed in a year was also given to each participant.

Lectures and demonstrations on different topics of astronomy like, 'Magnitude scale in astronomy', 'Origin of the Universe', 'Basics of the telescope', 'Sun and the Solar System', 'Origin of the Solar System', 'Types of eclipses', 'Astronomy in different wavelengths', 'Innovative physics', 'Constellations and Zodiac, 'Demonstration of astronomy kit', etc., were conducted. Arvind C. Ranade, Scientist (Vigyan Prasar), Dr. Sandeep Sahijpal and Dr. Vipin Bhatnagar of the Department of Physics, Punjab University and M. S. Marwah played the lead role in delivering the inputs. Sri R. K. Yadav from Vigyan Prasar helped the participants in assembling the 39-mm simple refractor telescopes.

A special event was organised on the occasion of the partial solar eclipse on 1 August within the campus of Punjab University. The participants enjoyed the event through telescope and also by viewing through solar filters. On the same night, viewing of planet Venus and Jupiter through the CPC 1100 GPS Celestron telescope of Department of Physics, Punjab University was conducted.


Participant testing their39mm simple refractor telescope

Sri Nimish Kapoor, Scientist (Vigyan Prasar) made a presentation on VIPNET activities and role of science clubs. Arvind C. Ranade from Vigyan Prasar, New Delhi and Dr. Neelam Gulati Sharma from the Punjab State Council for Science and Technology, Chandigarh coordinated the workshop.

Letters to the Editor

"Dream" of facts

I am a regular reader of your magazine although I am a teacher of literary dreams. All the articles are quite informative for both learners and teachers. The style of articles is quite lucid. The editorial of June 2008 on 'Climate Change and Health' is worth to be selected for a text book of English at college level. I congratulate you on your content and style.

D.M.Metri
metri_dmm@yahoo.com

I congratulate you on bringing out such a valuable magazine, which I receive every month. The article "The Grid Revolution" (July 2008), by Shri Rintu Nath, gave me a new insight into the rapid developments in the field of science and technology. It was highly informative.

Ananga Tripathy
P.O.: Kushang, Dist. Bloangir, Orissa 767065

I have been a regular reader of *DREAM 2047* since its inception. I appreciate the efforts being put in to bring out this magazine the articles in which can be understood by readers from all walks of life. The editorial on 'Chronic Lifestyles Chronic Diseases' in the July 2008 issue was self explanatory.

I have been working on soybean processing and utilisation since 1979 at Central institute of Agricultural Engineering (ICAR) and have developed a number of simple low-cost technologies for making different soy based foods, which are low-calorie diets and could be an effective means for fighting the chronic diseases and malnutrition that exist in this country.

Dr.A.P. Gandhi
Principal Scientist (Biochemistry)
Soybean processing and Utilisation Centre
Central Institute of Agricultural Engineering
Bhopal (MP)