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A giant interplanetary leap to Mars

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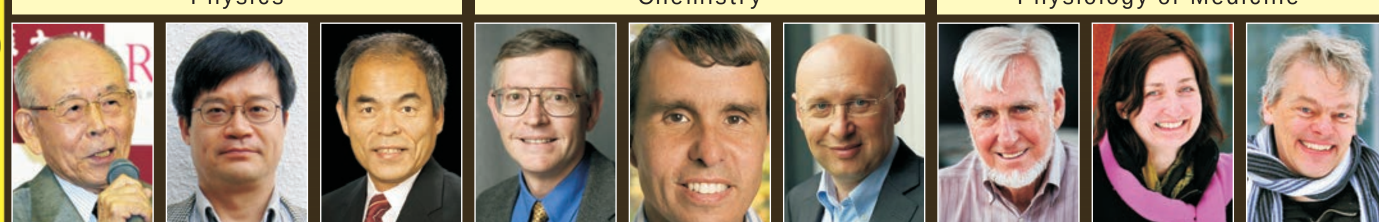

Isamu Akasaki, Hiroshi Amano, Shuji Nakamura, William E. Moerner, Eric Betzig, Stefan W. Hell, John O'Keefe, May-Britt Moser, Edvard I Moser

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

Swachchta shapath and classic convergence

Dr. R. Gopichandran

The call to clean up our environs through the Swachh Bharat Mission is unique, scheduled to gain collective momentum from the 2nd of October 2014. We go beyond the one-day opportunity by taking the oath to not litter our places in the future too. The convergence is in collective action and importantly so by taking note of the consequences of inaction on all of us.

Remarkably, the initiative is set to up-scale on Gandhi Jayanti. This is because of the spirit of self motivation he stood for and his conviction that a person's true character is seen in the manner she/he behaves when alone. This is a profound insight and is probably the quintessence of scientific temper. Even as we recognise/perceive rights/wrongs/rationality, it often calls for extra zeal to engage in action that is for common good. This zeal gains greater significance when we act in a righteous manner even when we are not watched – by anyone in our vicinity or the long arm of law.

We need to also ask if we always need a watchdog to keep tabs on us. Is it not essential to spontaneously adhere to norms of behaviour that do not disrupt systems/quality of life? One of the easiest and simplest manifestations of such good behaviour is cleanliness. The oath to "not un-clean" should only inspire us to stay on course.

Can we use this coming together as a window of opportunity for collective action through science clubs to start with? Motivated children who volunteer to communicate and with citizens while on roads and other public places and check them from littering can be rewarded with vouchers/certificates. Contributions by colonies and households to energy conversions from bio-degradable wastes can also be highlighted through appropriate forums. Initiatives of this nature can be supported through the Corporate Social Responsibility programmes of industry. The large number of initiatives by civil society organisations, already in progress can be up-scaled and could mutually reinforce this collective government-led action. Municipal authorities can also play useful roles in this context.

We have to however also be awake to some grotesque and almost insolent behaviour/misdemeanour we allow of some of our fellow citizens. Some of us do not care about spitting at traffic junctions or on roads, by lowering our car shields. This behaviour stems from typical indifference and loathsome attitude. We also care a damn while answering calls of nature, in full sight of public. Can this be tolerated in any measure and in all circumstances? Can we reprimand such disruptive behaviour through punitive measures on a priority basis? It will be useful to therefore adopt a twin approach of reprimands and inspiration to sustain the collective momentum we wish to initiate.

We as citizens of our land rejoice at the technological excellence we witnessed in the shape of the Mars Orbiter Mission. Scientists and technologists would have hypothesised, validated assumptions, calibrated, observed and interpreted with exemplar precision and speed. Learnings from this exploration can reinforce the values of the methods of science and one's preparedness to recognise the unknown as they dawn on us.

A low hanging fruit from a citizen's perspective to engage in astronomy is the citizen science approach (www.zooinverse.org). Science clubs and other institutions active in this area may like to draw useful insights on this area from Marshall *et al.* 2014 (Philip J. Marshall, Chris J. Lintott & Leigh N. Fletcher 2014 'Ideas for Citizen Science in Astronomy', http://arxiv.org/pdf/1409.4291.pdf). A detailed analysis of various approaches for on-line engagement is presented by Tinati *et al.* 2014 in this context (Ramine Tinati, Elena Simperl, Markus Luczak-Roesch, Max Van Kleek, Nigel Shadbolt 2014 'Collective Intelligence in Citizen Science – A Study of Performers and Talkers', http://humancomputation.com/ci2014/papers/Active%20Papers%5CPaper%2028.pdf). Facets of astronomy and astrophysics are indeed equally robust windows of opportunity to expand our vision, steeped in scientific temper. Tenacity of purpose to achieve the best establishes the convergence between space missions and the drive to clean up places/spaces we live in.

All references cited in this editorial were accessed on 1 October 2014.

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A giant interplanetary leap to Mars

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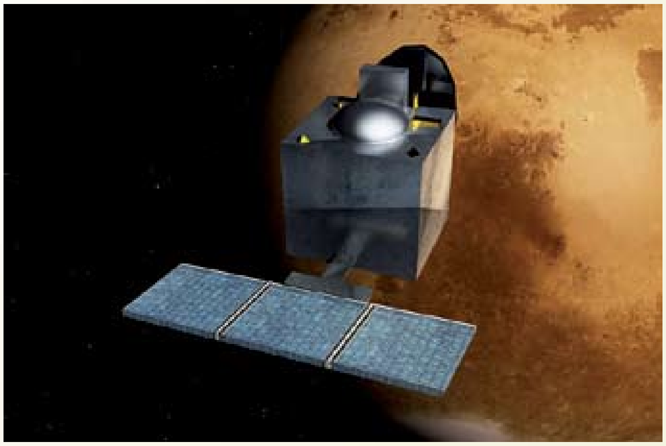
India created history on its maiden attempt in an interplanetary mission. On 24 September 2014, Indian Space Research Organisation (ISRO) successfully placed the Mars Orbiter Mission (MOM) spacecraft, also known as *Mangalyaan*, in the orbit of Mars. The MOM spacecraft is designed to orbit Mars in an elliptical orbit. For the next six to ten months, it will remain a satellite of Mars, click pictures and sniff out details on the atmosphere and morphology of the red planet.



Artist's rendering of the Mangalyaan orbiting Mars (Source: Wikipedia)

India is the first country to reach Mars's orbit on it maiden attempt and the first Asian country to launch a successful Mars mission, all with much less expenditure than any other Mars mission before it.

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MOM is India's first interplanetary mission and ISRO has become the fourth space agency in the world to reach Mars, after the Russian Federal Space Agency (ROSCOSMOS), US space agency NASA, and the European Space Agency (ESA). Before ISRO, only the European Space Agency could place its orbiter right in the first attempt ('*Mars Express*' in 2003). However, India can claim to be the first country to achieve the distinction, as the European Space Agency is a conglomeration of several countries. Japan and China are the other Asian countries that had attempted Mars missions, but failed.

Accomplished at a cost of around Rs 450 crore, which in itself is an achievement as the most economical interplanetary space mission till date, the Mars Orbiter Mission is an ambitious leap forward for India's space programme.

After its launch on 5 November 2013, *the* MOM spacecraft had travelled over 670 million kilometres (radio distance is 210 million kilometres) between Earth and the red planet during its 300 days' journey. A number of manoeuvring was done by ISRO scientists to ensure successful insertion of the orbiter into Mars orbit.

As it goes around Mars in a highly elliptical orbit, with the closest point of around 420 km and the farthest of around 80,000 km, the *Mars Orbiter* will employ five instruments to do scientific studies like exploration of surface features, morphology, and mineralogy and study of Martian atmosphere.

Interestingly, only three days before ISRO's *Mars Orbiter* arrived at Mars, on 21 September, NASA's *MAVEN* (Mars Atmosphere and Volatile Evolution) spacecraft successfully entered Mars's orbit. Both *Mars Orbiter* and *MAVEN* will supplement each other in solving the mystery of Mars' missing water.

While on the ground, *Curiosity* – NASA's robotic rover – continues to search for local evidence of past and present water, *MAVEN*'s investigation, along with those of India's *Mars Orbiter*, will provide necessary data to scientists for better understanding of the planet. Together, these missions could reveal the entire planet's geological history.

Mission objectives

Mars Orbiter Mission is India's first interplanetary mission to planet Mars with an orbiter craft designed to orbit Mars. The mission is designed to demonstrate India's capability to perform deep space communication, navigation, mission planning, and management; and incorporate autonomous features to categorise and

Mars Orbiter is being maneuvered from ISRO's Mars mission control complex in Bangalore handle contingency situations. Although the mission is primarily a technological mission, it has a number of scientific objectives like exploration of Mars' surface features, morphology, mineralogy and its atmosphere.

The *Mars Orbiter* carries five scientific payloads to observe Martian surface, atmosphere and exosphere extending up to 80,000 km for a detailed understanding of the evolution of the planet, especially the related geologic and the possible biogenic processes. The payloads consist of a camera (Mars Colour Camera), two spectrometers, a radiometer, and a photometer. Together, they have a weight of about 15 kg.

Considering the critical mission operations and stringent requirements for spacecraft navigation to put the orbiter in gravitational sphere of influence of Mars, ISRO has already achieved the technological objective.

While writing this article, four out of five instruments have already been activated. Mars Colour Camera (MCC) has captured and sent back breathtaking views of Mars. The images returned from the Mars Orbiter are truly captivating.

Journey to Mars

It was in 2008 when ISRO launched its first Moon mission *Chandrayaan*-1. The Mars mission was conceptualised during this time. A feasibility study was conducted in 2010 and subsequently the project was approved by Government of India.

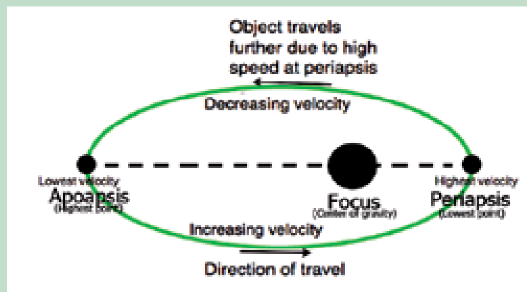
Scientists from ISRO, Physical Research Laboratory (PRL), and Hindustan Aeronautics Limited (HAL) took about 15 months for the design and construction of the spacecraft and preparation of the launch vehicle, aiming for a target launch date of 28 October 2013. The launch date was calculated to meet the trans-Mars injection requirements needed to place the *Mars Orbiter* into the correct heliocentric Mars transfer orbit. Scientists of ISRO calculated the manoeuvring sequence and procedure of the orbiter based on the location of the launch, the orbital insertion parameters at Mars, resource availability in the spacecraft, the orbital positions of Earth and Mars at the time of the *Mars Orbiter*'s arrival at the gravitational sphere of influence of Mars and many other factors.

Construction on the *Mars Orbiter* was successfully completed on schedule on 2 October 2013, and the spacecraft was shipped to its launch site in Sriharikota. The orbiter was integrated on top of its PSLV-XL (Polar Satellite Launch Vehicle) rocket – which had been under assembly since August 2013.

The use of the PSLV-XL rocket was a change from the original mission proposal that recommended the use of the more-powerful Geosynchronous Satellite Launch Vehicle (GSLV). However, the GSLV had failed twice in 2010 and to find the cause of failure

The ISRO's *Mars Orbiter* captured this global view of Mars with its Mars Colour Camera on 28 September 2014, from a distance of 74,500 kilometres [Source: ISRO]

The *Mars Orbiter* will be able to capture full-globe views when it is near the apoapsis of its orbit (farthest from the surface). The spacecraft will spend most of its time near apoapsis. As a result, the *Mars Orbiter* will be able to capture a series of global views of Mars at different phases and of different parts of the planet over time.



When the spacecraft is closer to Mars, it will be able to capture detailed view of a part of the planet's surface.

Mars's limb from Mars Orbiter spacecraft

ISRO's *Mars Orbiter* took this photo of the hazy limb of Mars on 24 September 2014, just two hours after entering orbit, from an altitude of about 8,449 kilometres. [Source: ISRO]

Mangalyaan in the making

Launch of Mangalyaan

took time. ISRO did not want to take a chance and decided to use the tried and tested polar satellite launch vehicle (PSLV). Time of launch was crucial. If it could be done sometime in November 2013, less energy would be required to insert the orbiter in the gravitational field of influence of Mars. If launch is delayed, ISRO would have to wait till 2016 when the next Mars launch window would open. Therefore ISRO decided to launch the mission with a PSLV-XL rocket that carried six stretched solid rocket motors using 12 tons of solid propellant instead of the 9 tons used in the standard PSLV variant.

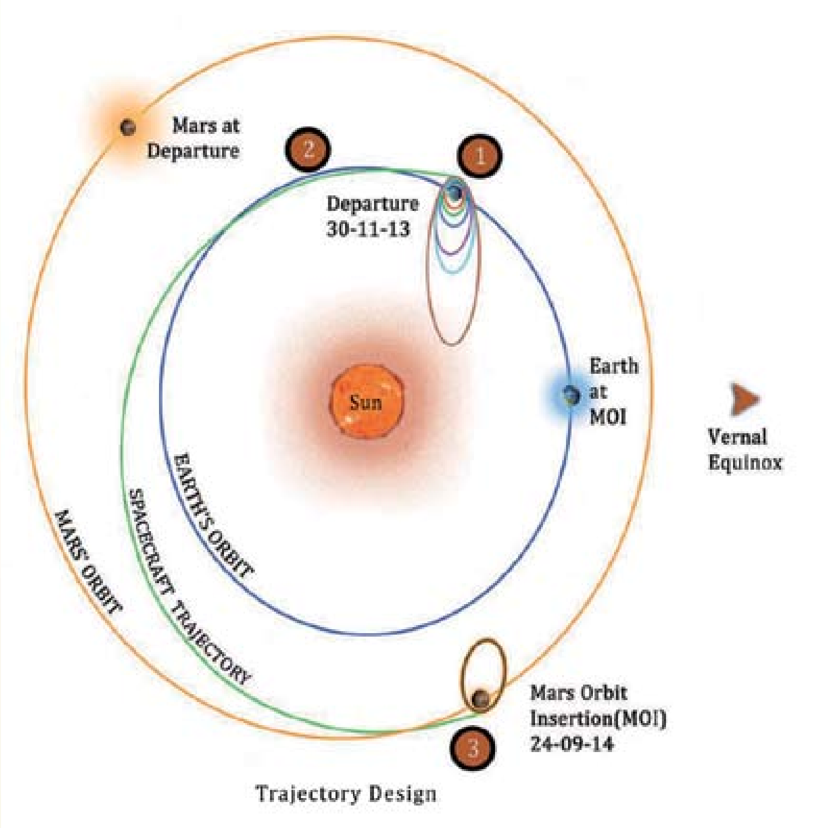


Image shows trajectory correction manoeuvres undertaken by ISRO throughout the journey of Mars Orbiter Mission (image courtesy ISRO)

The switch in launch vehicle, however, meant that MOM could no longer be launched directly into a Mars transfer orbit. Rather, the craft would have to be launched into an elongated Earth orbit, and then perform a series of orbit-raising manoeuvres to raise its apogee while using Earth's gravity to sling-shot it into the correct Mars transfer orbit.

As launch preparations continued, MOM's launch date was rescheduled from 28 October to 5 November 2013 because of the delayed arrival of a necessary telemetry ship at the Fiji Islands in the Pacific, which would track the satellite after launch. On 5 November 2013, the orbiter was launched on time at 14:38 hrs IST from the First Launch Pad at the Satish Dhawan Space Centre. Over the next 42 minutes, the PSLV-XL inserted the orbiter into Earth orbit, a process completed at 15:20 hrs IST. The successful launch of the Mars Orbiter Mission marked India's entry into interplanetary space.

A series of five planned orbit raising manoeuvres were done, controlled by engineers at the Spacecraft Control Centre at ISRO's telemetry, tracking and command network in Peenya, Bangalore. Of the five planned manoeuvres, the first was a 416-second firing of the spacecraft's liquid engine (LAM), the second a 570.6-second burn, and the third a 707-second burn. At this point, the Mars Orbiter's apogee was 71,636 km.

> Through spearheading cutting edge technology demonstration like MOM, ISRO has once again proved the science and technology capability of India.

During the fourth burn, an under-burn prevented the spacecraft's apogee from reaching the planned 1,00,000 km. Instead, the orbiter was in a 78,276-km apogee orbit. The resulting under-burn mandated the addition of a supplementary orbit-raising manoeuvre of the orbiter. After this supplementary orbit raising manoeuvre (starting at 05:03 hrs IST on 12 November 2013, with a burn time of 303.8 seconds) height of the apogee was increased from 78,276 km to 1,18,642 km.

The fifth orbit raising manoeuvre of the orbiter took place on 16 November 2013, with a burn time of 243.5 seconds. Height of the apogee now increased from 1,18,642 km to 1,92,874km.

With the needed apogee achieved, spaceflight controllers initiated a 1328.89-second engine firing manoeuvre on 1 December 2013 to place the orbiter into a heliocentric transfer orbit towards the red planet. Trans-Mars Injection (TMI) operation was completed successfully at 00:30 hrs IST on 1 December 2013.

Cruise to Mars

After leaving Earth orbit, a total of three trajectory course manoeuvres were performed to ensure that the *Mars Orbiter* is aligned into the proper trajectory for arrival at Mars.

On 22 September 2014 at 14:30 hrs IST, spacecraft controllers successfully fired the 440N liquid apogee motor for 3.9 seconds. The test firing confirmed the engine's viability for planned orbital insertion operations 41 hours later.

Mars Orbital Insertion (MOI)

As the *Mars Orbiter* approached Mars for orbital insertion, the spacecraft reoriented itself to align its thrust with the craft's line of travel. Once in the proper orientation, the orbiter, already under the influence of Mars's gravity, passed into the shadow of Mars. This entry into the Martian shadow occurred five minutes before the start of the Mars Orbit Insertion (MOI) burn. As the MOI burn began, *Mars Orbiter*'s main liquid engine and eight smaller thrusters fired to begin reducing the vehicle's velocity to 1,098.7 metres per second.

As this burn began, the spacecraft moved behind Mars as viewed from the telemetry and tracking stations on Earth,

Continued on page 25

Crown jewel of ISRO – The LAM engine

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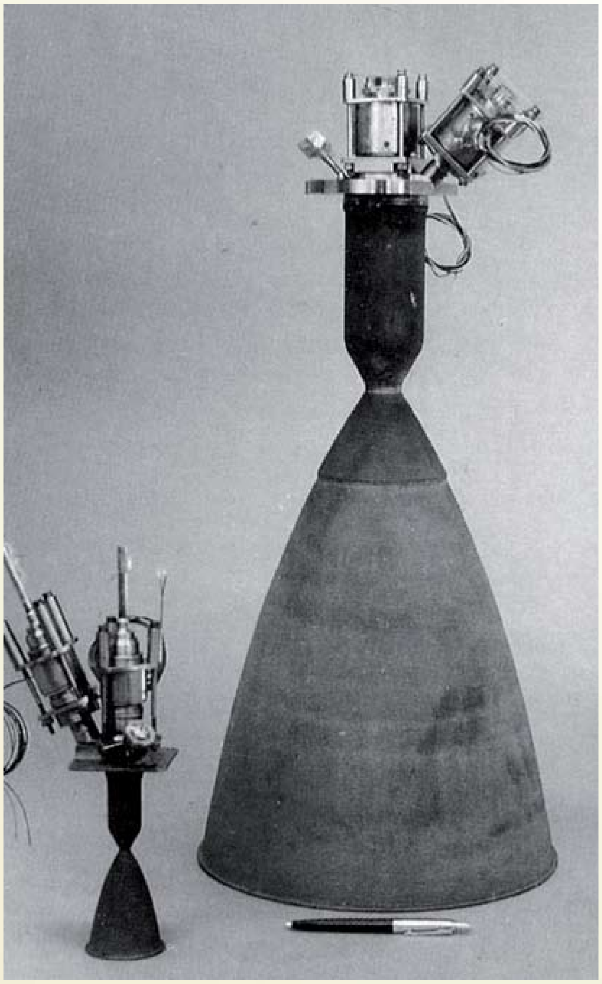
"Our navigators' calculations show that MOM has entered the gravitational sphere of influence (SOI) of Mars," ISRO announced in its social networking site, adding, the spacecraft was within 5.4 lakh km from Mars. India's maiden Mars mission entered into its crucial phase – make or break – at around 9:00 am IST on 22 September.

Having more than 99.9% of mass in the solar system, Sun is a dominating body in terms of gravity. Sun's gravitational sphere of influence is computed to extent about 2 light years. Therefore in the solar system, in general, it is the gravitational influence of Sun that predominates, except near the planets and other solar system objects. As the gravitational potential depends upon both mass and distance, objects near Earth, closer than 9 lakh km, will be under the gravitational influence of Earth rather than Sun.

Given that mass of Mars is smaller than Earth's, its gravitational sphere of influence extends only to 5.4 lakh km. As the Mars Orbiter Mission (MOM), in its historic rendezvous with the red planet entered into this SOI on 22 September around 9:00 am IST, it was falling from the sky, like an apple from the tree, towards Mars. But unlike an apple falling on the ground, MOM was not meant to crash, but go around Mars in a stable orbit.



LAM engine

By then MOM had travelled more than 680 million kilometres and had covered about 99% of the total distance. The spacecraft with 475 kg (dry mass) inclusive of a 15 kg payload was streaking through space at a breakneck speed of about 22.1 km /s in an orbit around the Sun that intersects the orbit of Mars. On 24 September at about 7:30 am IST both the MOM spacecraft and Mars arrived at this intersection. This was time when the thrusters on board the spacecraft were retro-fired, giving negative impulse for it to be inserted into Martian orbit.

> "Given that mass of Mars is smaller than Earth's, its gravitational sphere of influence extends only to 5.4 lakh km."

The spacecraft was equipped with a 440 N Liquid Apogee Motor (LAM) and eight numbers of 22 N smaller thrusters largely used for attitude control. These were the main engines that would provide the break necessary to get the MOM spacecraft gently into its orbit. (Here N is Newton, a unit of force equal to the force that imparts an acceleration of 1 m/sec/sec to a mass of 1 kilogram) However, had the negative thrust been more than required, then the resultant spacecraft velocity would have been less and the spacecraft would not have entered the projected orbit around Mars and the life of the spacecraft would have been substantially reduced. If the negative thrust was less, then the resultant velocity would have been more, making it impossible for the gravitational capture by Mars; the spacecraft would have just flown by and lost in space. Therefore it was crucial that the retro-firing of LAM on September 24 was immaculate.

Flawless functioning of the LAM was pivotal to the mission. The LAM engine in the MOM spacecraft was indeed used seven times earlier in the mission. Once the PSLV placed the spacecraft in space on 5 November 2013, it was the LAM that was used to raise the orbit six times. On 1 December 2013 at 00:49 am (IST) LAM was fired for 1328.89 s, imparting an incremental velocity of 647.96 m/s, shoving the spacecraft into trans-Mars orbit. Since then the main LAM engine was hibernating.

If at the crucial moment on 24 September the activation of the engine had failed, the mission would have failed. The worry was not much about the eight thrusters, as they were used many times during the 300-day deep space journey and hence their health and performance was known. But in case of the LAM, prolonged deep space exposure could have resulted in corrosion, leak or bulging of the pipes, leading to impairment of the LAM, and hence it was primarily the health of LAM that the ISRO engineers were concerned about. Failure of the LAM at the crucial juncture would have deeply jeopardised the mission.

But LAM is not a dark animal as far

as ISRO is concerned. As ISRO's reliable launch vehicle the PSLV was only capable of placing the satellites in an elliptical Earth orbit, the LAM was developed to raise artificial satellites from this temporary orbit to geostationary or geosynchronous orbit locations. The *440 Newton* liquid apogee motor (LAM) engine had been the workhorse of ISRO for its space orbital programmes for past three decades.

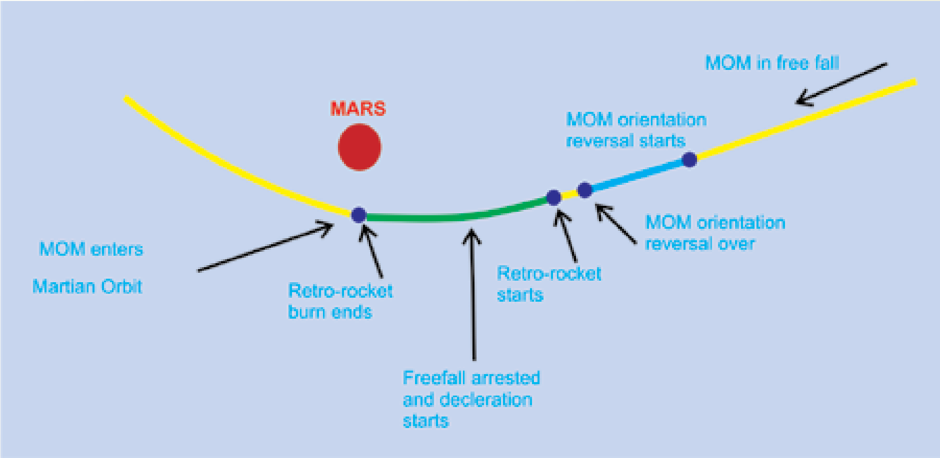
Way back in 1980s, ISRO realised it would need liquid propulsion rocket engines (LPREs) if it seriously intents to put significant payloads into low Earth orbits (LEO) and geostationary Earth orbits (GEO). In 1980s, ISRO obtained Soviet SA 2 anti-aircraft missile liquid propulsion rocket engines and began reverse engineering. ISRO's first liquid rocket motor had a thrust of 50 kg, powered by red fuming nitric acid (oxidiser) and hydrazine (fuel). Pressurised gas was used to push the propellants from their tanks into the combustion chamber.

Nonetheless, these small LPREs were inadequate for the goals ISRO had in mind of launching communication satellites to GEO. INSAT-2 series satellite programme demanded a more powerful liquid rocket motor. In fact ISRO had to face *Hobson's choice* when it had to first launch the experimental communication satellite, APPLE (Ariane Passenger Payload Experiment) in 1981. In absence of its own liquid engine, ISRO had to make do with a solid-propellant motor derived from the fourth stage of India's first launcher, the SLV-3.

> "If at the crucial moment on 24 September the activation of the LAM had floundered, the mission would have failed."

Solid fuel rockets are fine for the first stage, but in the last stage, one may like to shut off the rocket once the spacecraft achieves the desired velocity. One may like to activate it several times if required, to allow a change of orbit to be achieved with considerable precision. Unfortunately, once fired, a solid-propellant rocket would continue to operate until the propellants are used up, giving no or little scope for in-flight manoeuvring. Only a liquid motor has the flexibility to allow such control and ISRO embarked upon designing one earnestly.

Investing more than 8 years, establishing facilities to test the engine in airless conditions, ISRO came up with the design of the 440 N LAM, which generates a thrust of about 45 kg. Pressurised helium gas was used to push the propellants, monomethyl hydrazine and a nitrogen tetroxide mixture, from the tanks to the thrust chamber. Realising that the massive 440 N engine would be unwieldy to use for small corrections and attitude control of the spacecraft, ISRO also indigenously developed smaller liquid-propellant engine, known as 22 N thrusters. These thrusters can be fired in short bursts for attitude correction and station keeping, while the 440 N engine could be used to take the satellite from its temporary orbit to which PSLV takes it to its permanent LEO or GEO locations.



Mangalyaan Mars orbit insertion path

The indigenous LAM and the new thrusters were first tested on board *INSAT*-2A in July 1992. The spacecraft was fitted with sixteen 22 N thrusters and a 440 N LAM. In this maiden attempt the 440 N engine developed a snag. A valve meant to regulate the flow of helium gas into the propellant tanks malfunctioned. As a result, helium pressure in the tanks steadily increased raising concerns of a catastrophic explosion. ISRO engineers concluded that there was only one way to save the mission, to prolong the burn of the LAM than the planned duration. As additional fuel was gulped by the engine, the pressure build up eased; however the thrust chamber temperatures soared high. To the relief of ISRO, the thrust chamber withstood intense high pressure burn of the engine beyond the design capacity thus saving the mission.

> "Since 1992, IRSO's LAMs have flawlessly performed in more than 25 missions including *Chandrayaan-1*."

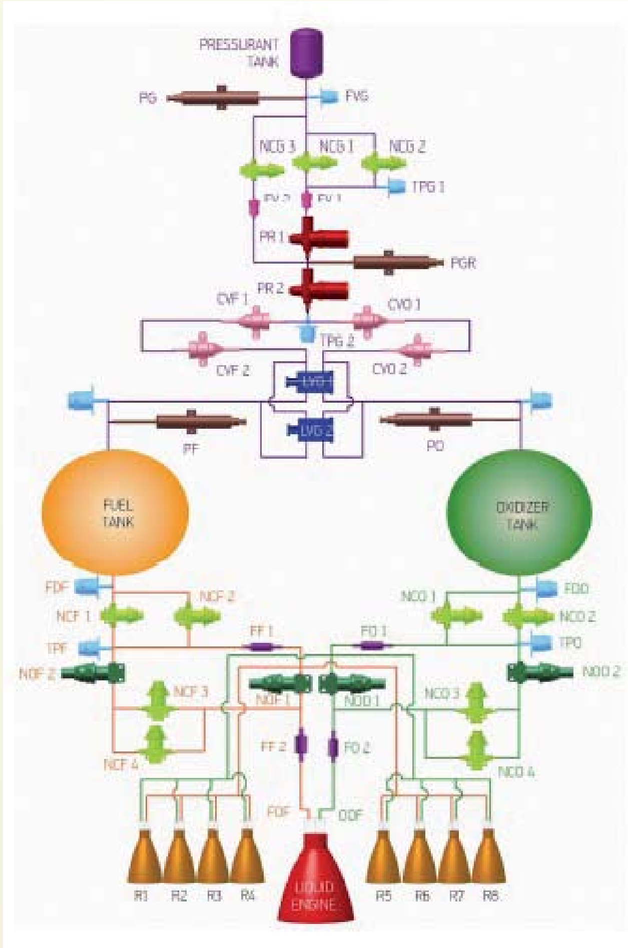
Since 1992, IRSO's LAMs have flawlessly performed in more than 25 missions including *Chandrayaan*-1. Most of the communication, weather and navigation satellites are placed in temporary transfer orbits after launch and the LAM is used to take them to their final orbit. In the *Chandrayaan*-1 mission the LAM was operated ten times, including once after a prolonged hibernation of two weeks.

Keeping the significance of awakening the LAM after 297 days of hibernation, ISRO had left nothing to chance. Anticipating contingencies, they had tweaked the LAM engine for the Mars mission. They added extra parallel fuel lines and a second set of valves. For ISRO such ingenious frugal engineering solutions are not uncommon. Way back in 1980s, when they had to transport the *Aryabhata* satellite in a non-metallic vehicle to test facility, they came up with the ingenious idea of using a bullock cart; thus the famous picture of satellite atop the bullock cart.

As their modified LAM in MOM had two sets of fuel lines and valves, ISRO used one set for all the Earth-bound orbit raising operations and trans-Mars injection, keeping the other set closed. The second set was reserved exclusively for operations near Mars. Further, both sets of propellant lines, and the engine were tested in test-bed before they were integrated into the MOM spacecraft. To be doubly sure, the engines were test fired on 22 September, 41 hrs before the crucial Mars Orbit Insertion (MOI).

ISRO indeed had a contingency plan if their effort to wake up the 440 N LAM engine on 22 September had failed. They had a plan B wherein it was proposed to fire the eight small 22 N thrusters for a longer duration, about 90 min, to get the necessary deceleration. However, if ISRO had to resort to plan B, then it would have had serious impact on the lifespan of the spacecraft and the orbit.

But luckily, the test-firing of the LAM along with the orbiter's trajectory correction manoeuvre (TCM) were completed flawlessly. For the test firing the parallel fuel lines and second set of valves of LAM were opened and the engine was tested. The very same test firing also provided some trajectory correction.



LAM schematic

On 24 September at 6:57am IST the MOM, being inside the SOI of Mars, was falling like a rock at a speed of 4 km/s. At 7:17 am, when the spacecraft was at an altitude of about 1,847 km from the surface of the Mars, the spacecraft was falling at a speed of 4.68 km/s. Then the LAM and eight thrusters were activated and negative impulse provided. Even as the thrusters started their breaking action, initially the falling speed continued to increase due to the gathered momentum and peaked to 5.89 km/s in the first few minutes, however, thereafter the breaking effect took dominance and the speed started falling and reached around 4.316 km/s with respect to Mars at the end of the MOI operation.

Mars Orbit Insertion burn had a planned change in velocity of 1,098.7 m/s with an anticipated burn time of 24 minutes and 14 seconds. However, at 7:46 am, after 1388.67 seconds, the engine shut down automatically as the accelerometers sensed that delta-v of 1,099 m/s had been achieved, dynamically adjusting for actual engine performance by shortening the burn slightly.

Incidentally, the point where speed reversal took place formed the lowest point reached near the surface by the MOM spacecraft prior to first perigee which occurred after the craft completed one revolution. If this point were closer than 200 km, probably the spacecraft would have spiralled and crashed onto the surface of Mars. If that point was more than 1,100 km, then the spacecraft would have escaped from the gravitational capture and lost into space. ISRO had expected that the point would be about 500 km after the course correction on 22 September and subsequent computation showed that actually the MOM spacecraft passed about 512 km above the Martian surface, giving this operation text-book perfection. Subsequently the spacecraft entered into an elliptical orbit around Mars on 24 September, making ISRO and the nation go dizzy.

The Mars orbiter spacecraft is now circling Mars in an orbit whose nearest point (periapsis) is at 421.7 km and farthest point (apoapsis) at 76,993.6 km. The inclination of orbit with respect to the equatorial plane of Mars is 150 degrees, as intended. In this orbit, the spacecraft takes 72 hours 51 minutes 51 seconds to go round the Mars once. After the retro-burn, which consumed about 50 kg of fuel, about 30 kg still remain permitting orbital maintenance and operation for at least 6 months.

If PSLV takes the credit for placing the MOM spacecraft in Earth orbit, it is the indigenously designed and built LAM, the crown jewel of ISRO, that deserve praise for taking the MOM towards Mars and gently placing it in Martian orbit. The real hero of 24 September is indeed the indigenously designed LAM.

The science objectives of Mars Orbiter Mission (*Mangalyaan*)

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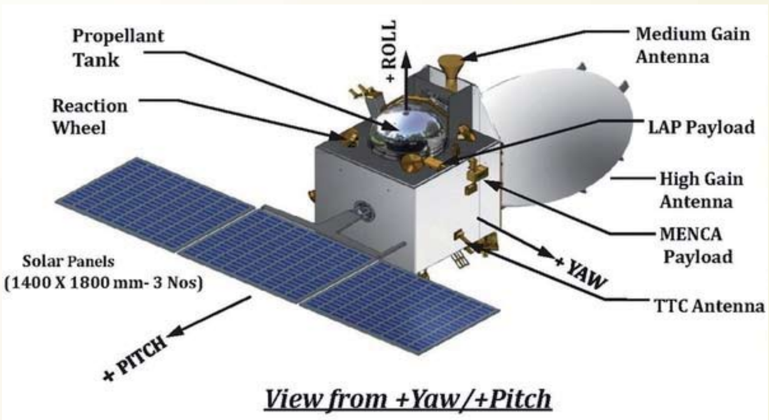
By mid-20th century, by and large it was known that among the eight planets of our Solar System only Mars has conditions other than Earth where there is possibility of any form of life, past or present. The other planets are either too hot or too cold. Moreover, Mars is the only planet where length of the day is comparable to that on Earth. Also, Mars has its axis of rotation inclined to the ecliptic (about 25°) which gives rise to the seasons on Mars. These are few which made Mars the hotspot for exploration of life and compelled humans to explore the red planet in search of another home for the every growing human population.



As far as the exploration of Mars is concerned, it has been going on since 1960, when the first attempt to send a spacecraft to the red planet was made. However, the first success came only in 1971 when the American spacecraft Mariner-9 was placed in orbit around the planet. In fact, out of 51 missions to Mars since 1960, only 22 have been successful, out of which three were flyby missions, four landers, four rovers and 11 orbiters. At present, there are five orbiters in operation including the latest Mars Orbiter Mission (MOM) of India and Mars Atmosphere and Volatile Mission (MAVEN) of the United States and two rovers named Opportunity (2003) and Curiosity (2011).

Telescopic studies and the last four-and-half decades' of space exploration have produced a wealth of data on the red planet. For example, we know that:

- Mars has approximately half the diameter of Earth
- It is less dense than Earth
- It has about 15% of Earth's volume and 11% of the mass
- Like Earth, Mars has undergone differentiation, it has a dense and metallic core with less dense overlaid region
- Mars consists of minerals like silicon, oxygen, metals, and other elements that typically make up of rocks.
- Mars has no evidence of global magnetic field. Observations showed that parts of the planet's crust have been magnetised, and that polarity reversals of its dipolar field have occurred in the past.
- Data from the *Phoenix* lander showed that the Martian soil is slightly alkaline and contains elements such as magnesium, sodium, potassium and chlorine.
- Liquid water cannot exist on the surface of Mars due to low atmospheric pressure.
- Martian atmosphere consists of largely carbon dioxide.
- Trace amounts of methane has been detected in the Martian atmosphere at about 10 parts per billion.

However, these figures do not confirm or support the possibility of life in any form and more data are needed to come to any definitive conclusion about the possibility of life on Mars.

It has been largely emphasised by the Indian Space Research Organisation (ISRO) that the Mars Orbiter Mission (MOM) is largely a technology demonstration mission. The prime objective of MOM is to showcase India's launch systems, spacecraft building and operation capabilities. However, within the permissible weight limit of payload of 15 kg by Polar Satellite Launch Vehicle, ISRO managed to send five different instruments on board.

Lyman Alpha Photometer (LAP)

The Lyman Alpha Photometer weights about 1.5 kg. It consists of an ultraviolet detector equipped with gas-filled molecular hydrogen and deuterium cells, with tungsten filaments located between an objective assembly and the UV detector. Its core objective is the precise measurement of the Deuterium-to-Hydrogen (D/H) ratio, which is an indicator of the atmospheric loss processes and the role of water in these processes. The variation in the D/H ratio is a strong evidence of the existence of water on the surface. The study of D/H ratio can lead to an understanding of evaporation processes in past.

Lyman Alpha Photometer

Martian Exospheric Neutral Composition Analyser (MENCA)

The MENCA is a quadrupole mass spectrometer and weighs about 4 kilograms. It consists of four parallel metal rods with opposing rods being connected electrically. A radio frequency voltage is applied between the two pairs of rods and a direct current voltage is then superimposed on the RF voltage. Ions entering the instrument travel down the quadrupole between the rods.

Martian Exospheric Neutral Composition Analyser

Exosphere is the uppermost layer of a planet's atmosphere. Most of the constituents of the exosphere are neutral atoms or ions. Most of the escape process occurs in the exosphere. MENCA will operate in the upper Martian atmosphere. Its core objective is to study the exospheric neutral density and composition at altitudes of about 372 kilometres above the Martian surface. MOM will have close encounters with the Martian moon Phobos, which would allow MENCA to estimate the upper limits of the neutral density distribution and composition around it. Studying the Martian exosphere will provide valuable data on the present conditions as well as atmospheric loss phenomena.

Mars Colour Camera (MCC)

Mars colour camera weights about 1.4 kg. It will capture colour images of the planet. The camera works in visible range of 400 to 700 nanometres and includes a multi-element lens assembly and a 2,000×2,000-pixel array detector with Red-Green-Blue (RGB) Bayer Filter.

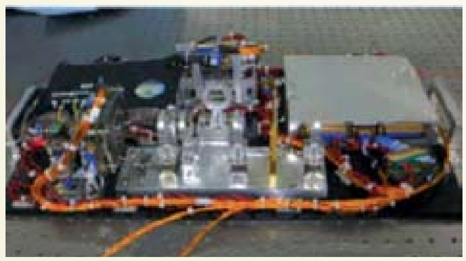
At periapsis (closest to the Martian surface), the camera is expected to provide images with a 50×50-kilometre frame size and a resolution of 25 metres per pixel. At apoapsis (farthest from the Martian surface), expected wide field of view is 8,000×8,000 kilometres. MCC imagery will help to study Martian surface topography.

Mars Colour Camera

Methane Sensor for Mars (MSM)

The MSM Payload weighs 3.6 kilograms and is designed to measure methane concentrations in the Martian atmosphere with parts-per-billion accuracy. The instrument features a Fabry-Perot Etalon sensor that uses multiple-beam interferometry at wavelengths of 1,642 to 1,658 nanometres to detect the signature of methane that has a characteristic overtone band at these wavelengths.

The source of methane on Mars has not been determined yet. The present understanding suggests that methane may come from volcanoes, fault lines or that it may be a by-product of electrical discharges from dust devils and dust storms. In January 2009, scientists claimed that they had discovered that the planet often vents methane into the atmosphere in specific areas, leading some to speculate that it may be a sign of biological activity going on below the surface. In this respect, finding the concentration and source of methane becomes very important.



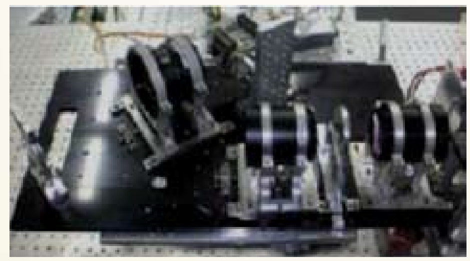
Methane Sensor for Mars

Thermal Infrared Imaging Spectrometer (TIS)

The TIS instrument weight 4 kilograms. It consists of a spectrometer that features an infrared diffraction grating that acts as dispersive element. The radiations reflected from the surface of the Mars will be gathered by mirror and the dispersed radiation will be refocused onto a detector. TIS uses a 120×160 element bolometer array detector. Bolometer receivers measure the energy of incoming photons. TIS is sensitive to infrared wavelength range of 7 to 14 microns. As IR radiation strikes the detector, the absorbing material is heated and changes its electrical resistance which can be measured via electrodes connected to each microbolometer and processed into an intensity read-out in order to create an IR spectrum. The TIS instrument measures thermal emissions from the Martian surface to deduce surface composition and mineralogy.

It is important to note that surface temperature of Mars gives rise to maximum radiations in infrared. Therefore, based on the mineral spread on the surface and composition, it is easy to demonstrate the surface maps of Martian mineralogy.

No doubt, a GSLV launch of MOM would have allowed bigger payloads and perhaps more sophisticated instruments to be taken to Mars. But, success in the maiden attempt, with minimum budget, has created extreme confidence in our space scientists who have put the country in the elite group of a handful of space faring nations that have succeeded in sending missions to Mars. ■



Thermal Infrared Imaging Spectrometer

Lymphatic Filariasis:
An infectious disorder of body deformities

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Lymphatic filariasis is a parasitic infectious disease caused by thread-like worms and is globally considered as a neglected tropical disease. Lymphatic filariasis is a serious health problem in tropical and sub-tropical regions of the world. More than 1.3 billion people all over world are at risk of infection and about 120 million are currently infected, with about 40 million disfigured and incapacitated by the disease. Lymphatic filariasis afflicts over 25 million men with genital disease and over 15 million with lymphedema or swelling. A condition known as elephantiasis - oedema with thickening of the skin and underlying tissues - is the most common symptom of lymphatic filariasis.

What are neglected tropical diseases?

Neglected tropical diseases are those diseases almost exclusively affect impoverished people living in rural areas or poor urban slums of low income countries. They are caused by parasitic worms, bacteria and protozoa. They can be fatal, but they primarily cause chronic lifelong disabilities leading to disfigurement, impaired child development, poor pregnancy outcomes, and impaired worker productivity.

Victims of neglected tropical diseases also encounter serious stigma in their communities, adding social consequences to their health problems. As a result, neglected tropical diseases affect the health of poor populations, and they mire infected individuals in poverty. On national and regional scales, their effects are so dire that these diseases are considered condition that promote and perpetuate poverty.

Causal organisms of lymphatic filariasis

Lymphatic filariasis is caused by infection with nematodes (roundworms) of family Filariodidea. There are three types of worms known to cause lymphatic filariasis. These are *Wuchereria bancrofti, Brugia malayi* and *Brugia timori*. *Wuchereria bancrofti* is the most common causal organism of lymphatic filariasis and occurs worldwide. *Brugia malayi* is found in South-West India, China, Indonesia, Malaysia, South Korean, Philippines and the Vietnam while *Brugia timori* is only confined to Indonesia. In *Wuchereria bancrofti* the male worm is 40 mm long while the female is about 50-100 mm long.

Lymphatic filariasis in India

Lymphatic filariasis is a major health problem in India. It is endemic and persistently occurs in the states Uttar Pradesh, Bihar, Jharkhand, West Bengal, Andhra Pradesh, Odisha, Tamil Nadu, Gujarat, Kerala and union territories of Lakshadweep and Andman and Nicobar islands. Two types of lymphatic filarial infections namely *Wuchereria bancrofti* and *Brugia malayi* occur in India. Bancroftian filariasis or filariasis caused by *W. bancrofti* is responsible for about 98% of the infection in India.

Transmission

Lymphatic filariasis is transmitted by mosquitoes which serve as vectors for the parasitic worms. Humans are the main hosts for the parasite and mosquito is the carrier, an intermediate host. Migration of people in search of work from worm infested areas, and urbanisation, industrialisation, ignorance, poor housing and inadequate sanitary conditions facilitate its transmission. After infection, the larvae circulate in the blood stream of the infected person. Adult worms freely live in the human lymph system, which maintains the body's fluid balance and fights infection. An adult worm may live for about 7 years.

Symptoms of lymphatic filariasis

The incubation period for lymphatic filariasis is not known for certain. However, the disease symptoms appear about 18-16 months after the mosquito bite. Most of the signs and symptoms of lymphatic filariasis is result of the adult worms invading in the lymph system. Tissue damage caused by the worms restricts the normal flow of lymph fluid. This results in swelling (lymphoedema), scarring and infections. The legs and groin are the most affected part of the body. Lymphatic filarial infection is manifested by a general body weakness, headache, nausea, low-grade fever and recurring attacks of itching.

Lymphatic filariasis is rarely fatal, however it can cause recurring infections, fevers, severe inflammation of the lymph system and a lung condition called 'tropical pulmonary eosinophilia' (symptoms of pulmonary eosinophilia include cough, shortness of breath and wheezing). The legs become swollen in about 5% of infected persons. This condition is known as elephantiasis. Lymphatic filariasis can lead to severe disfigurement, decreased mobility and long-term disability.

Lymphatic filariasis also causes hydrocele (accumulation of fluid in the scrotum). The patient also may have their testicles swollen, a condition called filarial scrotum. Milky urine is also seen in some patients. In females, breast or external genitals are affected. In some cases fluid accumulation is found even in the pericardial space (the space between heart and its thin membrane covering).

Detection of lymphatic filariasis

The microfilariae of the parasite can be detected in blood by microscopic examination. The microfilariae had to be detected in blood samples obtained late at night, since in most part of the world the parasites have a 'nocturnal periodicity' that restricts their appearance in the blood to the hours around midnight. It has also been discovered that the appearance of parasites in blood is related to sleep habits of the person. Serologic techniques provide an alternative to microscopic detection of microfilariae for the diagnosis of lymphatic filariasis. Patients with active filarial infection typically have increased levels of anti-filarial IgG4 (Immunoglobulin G4) in the blood and these can be detected using routine assays.

Control of lymphatic filariasis

In India occurrence and spread of lymphatic filariasis is a matter of serious concern and needs attention. Since lymphatic filariasis is rarely fatal, it is not receiving much attention. If lymphatic filariasis is not treated early enough, the disease leads to severe disability. In the later stages, amputation of the affected part is only surgical treatment. Long-term exposure and repeated infections can cause severe damage to the lymph system and serious complications like gangrene of the foot.

Elephantiasis is common among those who walk barefoot. Therefore, footwear could reduce the risk of infection. Diethylcarbamazine citrate (DEC) is the drug of choice for controlling the filarial infection. The drug paralyses the filarial worms. The paralysed worms are destroyed by the white blood cells of the body. In lymphatic filariasis endemic areas the regular use of DEC-fortified salt can prevent occurrence of new infection. Besides DEC, albendazole and ivermectin are the other two anti-filarial drugs which can be used to prevent the occurrence of disease.

Since the disease is transmitted by mosquitoes, the control of mosquito population will eliminate the chances of infection. Indoor and outdoor application of insecticides may help to protect human populations in endemic regions from infections.

The aquatic weed *Pistia lanceolata* favours the breeding of mosquitoes therefore the weed should be destroyed using physical, biological or chemical method of weed control in rainy season. Biological control agents such as fishes, bugs, meso-cyclops, biolarvicides, and fungi should be used to control the mosquito population. The two larva-eating fishes namely *Gambusia affinis* and *Poecilia reticulata* have been used extensively almost throughout the world for control of mosquito breeding. Fishes such as *Aplocheilus blochi, Danio rario, Rasbora daniconius* and *Orzias melastigma* have good potential to kill larvae hence they can also be used to control the mosquito population.

Biolarvicides formulations of certain bacteria such as *Bacillus sphaericus* and *Bacillus thuringiensis* may be used for the control of mosquitoes. The fungi *Coelomomyces, Lagenidium* and *Metarhizium*, and the nematodes *Romanomermis culicivorax* and *Romanomermis iyengari* can be used to control mosquito breeding in aquatic habitats.

Several aquatic insects have been reported as natural enemies of mosquitoes such as water scorpion, water boat, water bug, etc. can also be used to control the mosquito population. An aquatic fern *Azolla pinnata* has also been reported to control mosquito breeding in rice fields, as it forms a thick layer on water surface to inhibit deposition of mosquito eggs and also act as bio-fertiliser by fixing elemental nitrogen. Hence *Azolla pinnata* may be used to curb the mosquito population.

Mosquito nets and mosquito repellent ointments can be used regularly to avoid the mosquito bite. Staying indoors between dusk and nightfall and wearing long pants and long-sleeved shirts also provide protection against mosquito bite.

Conclusion

As discussed above, lymphatic filariasis is a serious disease of tropical and sub-tropical countries of the world. Though the disease does not causes mortality, it does lead to disfigurement of the body parts, reduces mobility and causes long term disability. Therefore it is utmost need to control the disease by employing all possible control measures.

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Continued from page 32 **(A giant interplanetary leap to Mars)**

thereby severing the radio communications link between the spacecraft and ground controllers. The duration of the mission-critical MOI burn occurred while communications with the spacecraft were blocked.

After the MOI burn

Once the MOI burn was completed, the spacecraft began reorienting itself to point its main communications antenna toward the location where Earth will be when the spacecraft emerged from the communications blackout period. With MOI burn successfully accomplished, the *Mars Orbiter* entered a highly elliptical orbit around the red planet at 07:30 IST on 24 September 2014, marking the success of the first Indian interplanetary mission.

International cutting edge

Despite being a technology demonstration, the MOM will morph into a truly scientific mission as it carries five sophisticated equipment. The Mars Colour Camera (MCC) is the "eye of the mission", meant to capture images and information about the surface features and composition of the Mars. MCC has already captured and sent back global view and detailed views of Mars.

The global scientific community is very excited about India's effort to send the first dedicated methane gas sensor to Mars. The presence of methane gas, also called "marsh gas", on Earth is one of the clinching signs of the presence of carbon-based life forms.

Findings of ISRO's *Mars Orbiter* will be vital in supplementing the findings of *MAVEN* and other spacecraft orbiting Mars and surface rovers like *Curiosity* and *Opportunity*. With new data, global scientific community would be one step closer in unfolding the mystery of the red planet. Through spearheading cutting edge technology demonstration like MOM, ISRO has once again proved the science and technology capability of India.

Way ahead

ISRO can now look forward with confidence to its other future missions the second Moon mission - *Chandrayaan*-2 that is to land a rover on the Moon's surface, possibly in 2017; launching *Aditya*-1 – a spacecraft to study the Sun; and the ambition of putting Indians in Earth orbit as part of its Human Spaceflight Programme.

Nobel Prizes 2014

Biman Basu
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Physics

The 2014 Nobel Prize in Physics has been awarded jointly to Isamu Akasaki and Hiroshi Amano of Nagoya University, Japan and Shuji Nakamura of the University

Shuji Nakamura

Hiroshi Amano

Isamu Akasaki

of California, USA, for "the invention of efficient blue light-emitting diodes, which has enabled bright and energy-saving white light sources." Light emitting diodes, or LEDs, are the most energy-efficient lighting devices. Red- and green-emitting diodes have been around for a long time, but nobody knew how to make a blue one, which was needed for blending with the others to create white light. Red and green LEDs were useless for general lighting. This year's laureates, working together and separately, found a way to produce blue light from semiconductors that finally made white LEDs possible. The key was to grow high-quality crystals of gallium nitride, a semiconductor for producing blue light – a process that had frustrated researchers.

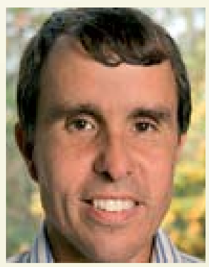
Light-emitting diodes are already ubiquitous – in pockets and purses, in smartphones, as well as in televisions, lasers and optical storage devices. "The LED lamp holds great promise for increasing the quality of life for over 1.5 billion people around the world who lack access to electricity grids," the Nobel committee said. "Due to low power requirements, it can be powered by cheap local solar power."

Chemistry

The 2014 Nobel Prize in Chemistry is to be shared by three scientists – two American and one German – for their work enabling optical microscopes to peer at the tiniest structures within living cells. Eric Betzig of the Howard Hughes Medical Institute in Virginia, USA, Stefan W. Hell of the Max Planck Institute for Biophysical Chemistry in Germany, and William E. Moerner of Stanford University in California, USA, were able to bring "optical microscopy into the nano-dimension," enabling scientists to "study living cells in the tiniest molecular detail".

A fundamental law of optics known as the 'diffraction limit' states that the resolution can never be better than half the wavelength of light being looked at. As a result, how small an optical microscope can see is limited by the wavelength of light and the smallest object that can be resolved is about 0.2 millionths of a metre. Smaller objects such as bacteria, viruses and proteins cannot be resolved. But this year's Nobel laureates found a way to work round the diffraction – by making parts of the molecules glow. By lighting up and then turning off parts of the organism, they could combine images that brought the tiniest of molecules into clear view. The technique allows biologists to look at the mechanism of biological processes such as how DNA folds and unfolds within living cells using optical microscopy. In fact, over the past 10 to 15 years there has been increasing use of optical methods to look at single molecules at the nano level.

William E. Moerner



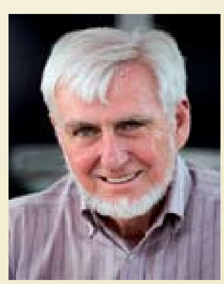
Eric Betzig

Stefan W. Hell

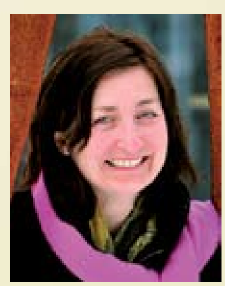
Physiology or Medicine

Three scientists – British-American researcher John O'Keefe, and Norwegian couple May-Britt Moser and Edvard I Moser – have been jointly awarded the 2014 Nobel Prize in Physiology or Medicine for their discoveries related to an internal positioning system in the brain that works like an inner 'GPS' that makes it possible for us to orient ourselves in space. O'Keefe will get half the prize amount while the other half will be shared between the Moser couple. The first component of this positioning system was discovered by O'Keefe in 1971. He found that in rats, specific nerve cells in an area of the brain called the hippocampus were activated depending on the position of the rat in a room, which made him conclude that these "place cells" in the brain formed a map of the room.

More than three decades later, in 2005, May-Britt and Edvard Moser identified another type of nerve cell, which he called "grid cells" and which formed another key component of the brain's positioning system. They found that these cells generate a coordinate system and allow for precise positioning and path-finding. Their subsequent research showed how place and grid cells make it possible to determine position and to navigate. The work of the three Nobel laureates has answered a long-standing question that has bothered philosophers and scientists for centuries – how does the brain create a map of the space surrounding us and how can we navigate our way through a complex environment? The discoveries may also provide clues to how strokes and Alzheimer's affect the brain. ■



John O'Keefe



May-Britt Moser

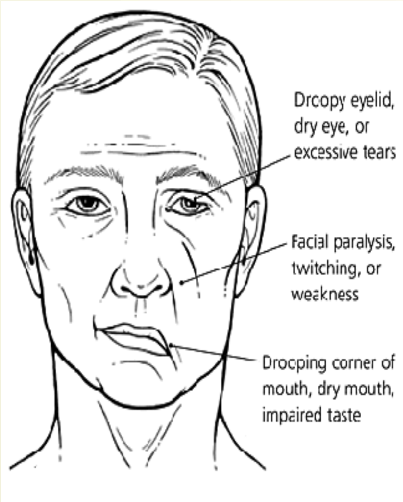
Edvard I Moser

Bell's palsy

Causes, symptoms and treatments

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

Bell's palsy is a sudden weakness of muscles of one half of the face. This makes the face to droop on one side, the million-dollar smile to suddenly lose its charm, and the eye to stay open despite the person trying to shut it close. The problem comes up so suddenly, that you think a catastrophe has struck. Worried, you and your family begin to think if you will ever be normal.



Recognising the signs

Bell's palsy, also known as facial palsy, can occur at any age. The signs and symptoms of Bell's palsy come on all of a sudden, and may include:

- Rapid onset of mild weakness to total paralysis on one side of the face — occurring within hours to days — that causes it to droop, make it difficult to smile or close the eye on that side of the face.
- Eye problems, such as excessive tears or a dry eye
- Distorted facial expression
- Drooling of saliva from the corner of the mouth
- Pain around the jaw or in or behind the ear
- Increased sensitivity to sound
- Loss of ability to taste
- Changes in the amount of tears and saliva

In the case of most people, the weakness is temporary. Symptoms usually start to improve within a few weeks, with complete recovery in about six months. However, a small number of people continue to have some Bell's palsy symptoms for life. Rarely, Bell's palsy can recur.

What is the cause?

Named after Sir Charles Bell, the famous Scottish anatomist, the condition was first described in the 19th century. It is apparent from the symptoms that the weakness must result from damage to the facial nerve. This is a major nerve that passes through narrow corridor of bone on its way to the face and controls the facial muscles on that side.

What may cause the facial nerve to temporarily "trip" and produce the one-sided weakness, however, is still much an unsolved puzzle. Medical researchers think Bell's palsy may be closely linked to one or the other viral infections, which may leave the nerve swollen and inflamed as a part of a reactive phenomenon. The culprit viruses can be many, and they may include the following:

- Adenovirus (which causes respiratory illnesses)
- Influenza B virus (which causes flu)
- Herpes simplex virus (which causes cold sores and genital herpes)
- Herpes zoster virus (which causes chickenpox and shingles)
- Epstein-Barr virus (which causes infectious mononucleosis)
- Rubella virus (which causes German measles)
- Mumps virus (which causes mumps)
- Coxsackie virus

What makes a person vulnerable?

Bell's palsy occurs more often in people who:

- Have an upper respiratory infection, such as the flu or a cold
- Are pregnant, especially during the third trimester, or who are in the first week after giving birth

Complications

Although a mild case of Bell's palsy normally passes off within a month, recovery from a case involving total paralysis varies. Complications may include:

- Irreversible damage to the facial nerve
- Misdirected regrowth of nerve fibres, resulting in involuntary contraction of certain muscles when the person is trying to move others (synkinesis) — for example, when such a person tries to smile, the eye on the affected side may close
- Partial or complete blindness of the eye that won't close, due to excessive dryness and scratching of the cornea, the clear protective covering of the eye

When to see a doctor

Seek immediate medical help if you experience any type of paralysis because you may be having a stroke. Bell's palsy is not caused by a stroke. See your doctor if you experience facial weakness or drooping, to determine the underlying cause and severity of the illness.

You'll likely start by seeing your family doctor or a general practitioner. However, in some cases when you call to set up an appointment, you may be referred immediately to a neurologist.

Tests and scans

There's no specific test for Bell's palsy. Your doctor will look at your face and ask you to move your facial muscles by closing your eyes, lifting your brow, showing your teeth and frowning, among other movements.

Other conditions — such as a stroke, infections, and tumours — can also cause facial muscle weakness, mimicking Bell's palsy. If it's not clear why you're having the symptoms you are, your doctor may recommend other tests, including:

Electromyography (EMG)

This test can confirm the presence of nerve damage and determine its severity. An EMG measures the electrical activity of a muscle in response to stimulation and the nature and speed of the conduction of electrical impulses along a nerve.

Imaging scans

X-ray imaging, magnetic resonance imaging (MRI) or computerised tomography (CT) may be needed on occasion to rule out other possible sources of pressure on the facial nerve, such as a u or skull fracture.

Home remedies

Home treatments can help ease the situation. You must not lose your cool, and be rational in your approach. The key idea is not to allow oneself to come to harm while the palsy lasts.

Measures to relieve facial pain

- **Take over-the-counter pain relievers:** Aspirin, ibuprofen or paracetamol can help with pain.
- **Apply moist heat:** Putting a washcloth soaked in warm water on your face several times a day may help relieve the pain.
  Protecting the eye that won't close
  If the eye doesn't close completely, try the following tips:
- **Try to close your eye:** Use your finger to close your eye repeatedly throughout the day.
- **Keep your eye moist:** Using lubricating eye drops during the day and an eye ointment at night will help keep your eye moist.
- **Wear eye protection:** Wear eyeglasses or goggles during the day to protect your eye.
- **Wear an eye patch at night:** This can protect your eye from getting poked or scratched.

General measures

Some people with the condition may benefit from the following basic measures and alternative treatments:

- **Meditation and yoga:** Relaxing by using techniques such as meditation and yoga may relieve muscle tension and chronic pain.
- **Vitamin therapy:** Vitamins B-12, B-6 and zinc may help rejuvenate the nerve.
- **Acupuncture :** Placing thin needles into specific point in your skin helps stimulate nerves and muscles, which may offer some relief.
- **Biofeedback training :** By teaching you to use your thoughts to control your body, you may help gain better control over your facial muscles.

Treatments

Most people with Bell's palsy recover fully — with or without treatment. There's no one-size-fits-all treatment for Bell's palsy, but your doctor may suggest medications or physical therapy to help speed your recovery. Surgery is rarely an option for Bell's palsy.

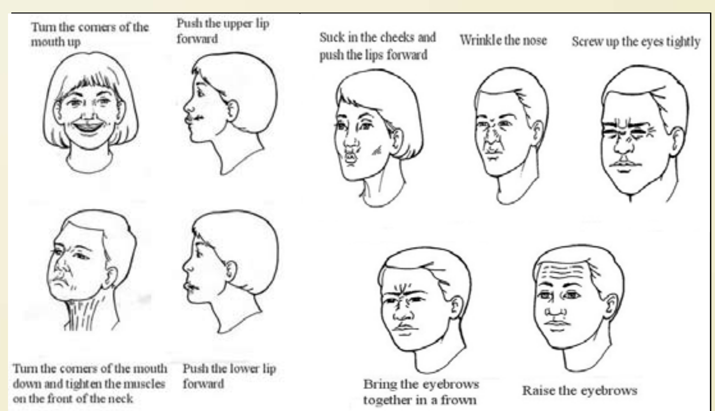
Medications

Commonly used medications to treat Bell's palsy include:

- **Corticosteroids,** such as methyl prednisone, are powerful anti-inflammatory agents. If they can reduce the swelling of the facial nerve, it will fit more comfortably within the bony corridor that surrounds it. Corticosteroids may work best if they're started within several days of when your symptoms started.
- **Antiviral drugs,** such as acyclovir or valacyclovir, may stop the progression of the infection if a virus is known to have caused it. This treatment may be offered only if your facial paralysis is severe.

Physical therapy

Paralysed muscles can shrink and shorten, causing permanent contractures. A physical therapist can teach you how to massage and exercise your facial muscles to help prevent this from occurring. These exercises are quite simple and you can do them at home.



Surgery

In the past, decompression surgery was used to relieve the pressure on the facial nerve by opening the bony passage that the nerve passes through. Today, decompression surgery isn't recommended. Facial nerve injury and permanent hearing loss are possible risks associated with this surgery.

In rare cases, however, plastic surgery may be needed to correct lasting facial nerve problems.

Recent developments in science and technology

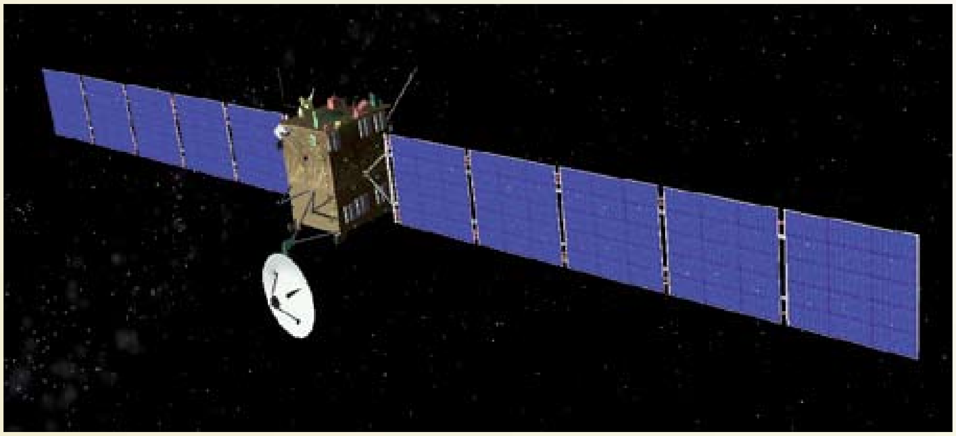
Biman Basu E-mail: bimanbasu@gmail.com

Rosetta becomes first spacecraft to orbit a comet

Comets are icy bodies that release gas or dust. They are leftover remnants from the formation of the solar system. They are often compared to dirty snowballs. Comets contain dust, ice, carbon dioxide, ammonia, methane and more. Scientists believe they delivered a vast quantity of water to Earth. They may have also seeded Earth with organic molecules – the building blocks of life as we know it.

Comets orbit the Sun, but most are believed to inhabit in an area known as the Oort cloud, far beyond the orbit of Pluto. Occasionally a comet streaks through the inner solar system; some do so regularly, some only once every few centuries. Halley's Comet is one of the most famous comets that return to Earth's neighbourhood every 76 years. It was last seen in 1986 when a European spacecraft named *Giotto* flew past it and took the first photographs from close range. *Giotto* approached within 596 km of the nucleus of Halley's Comet.

In August this year another spacecraft of the European Space Agency named *Rosetta* did much better. It went into orbit round a comet called Comet 67P/Churyumov-Gerasimenko and will study the comet over a period of one year during which it will also release a lander to touch down on the comet's surface. Eventually, *Rosetta* will attempt a close, near-circular orbit at an altitude of 30 km from the surface of the comet and, depending on the activity of the comet, perhaps come even closer.

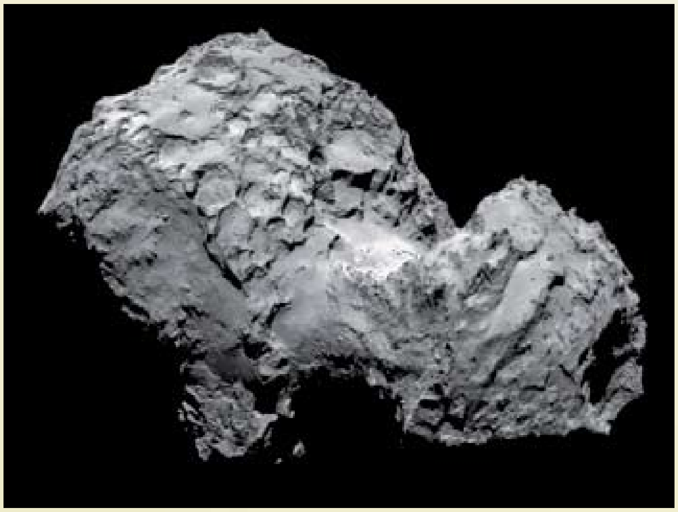


Rosetta spacecraft (Credit: ESA)

After travelling for 10 years, five months, and four days and clocking up 6.4 billion kilometres, *Rosetta* reached Comet 67P/Churyumov-Gerasimenko on 6 August 2014. However, the journey to the comet was not straightforward. Since its launch in 2004, *Rosetta* had to make three gravity-assist flybys of Earth and one of Mars to help it gather speed on course to its rendezvous with the comet. This complex course also allowed *Rosetta* to pass by asteroids Steins and Lutetia, obtaining unprecedented views and scientific data on these two objects. According to the European Space Agency, *Rosetta* is the first spacecraft in history to rendezvous with a comet. The probe is carrying a small lander designed to touch down on the comet nucleus around mid-November 2014, take samples and conduct experiments.

Rosetta is the first mission designed to both orbit a comet and drop a lander on its surface. The main objective of the *Rosetta* mission is to conduct the first *in situ* analysis of the grains of dust particles emitted from the comet's nucleus and determine their physical and chemical characteristics, including whether they are organic or inorganic – in essence what the cometary dust material is made of and how it differs from the surface composition. A previous sample-return mission named *Stardust* to Comet Wild 2 in 2004 had found particles of organic matter that are building blocks of life.

After dropping the lander, *Rosetta* will continue to accompany the comet until its closest approach to the Sun in August 2015 and beyond, watching its behaviour from close quarters to give scientists a unique insight and real-time experience of how a comet works as it hurtles around the Sun.



Comet 67PChuryumov-Gerasimenko (Credit: ESA/Rosetta).

Solar cells made from old car batteries

Lead-acid storage batteries are widely used on a mass-scale in all parts of the world – in cars, trucks, buses, boats, trains, etc. During power-cuts, lead-acid batteries provide emergency power for households, shops and also for critical operations such as air-traffic control towers, hospitals and military installations. All batteries used in vehicles and 95 percent of industrial batteries are lead-acid

Lead from old car batteries can be turned into solar cells for clean energy.

storage batteries.

The lead in lead-acid batteries is a highly toxic metal that produces a range of adverse health effects particularly in young children. Exposure to excessive levels of lead can cause damage to brain and kidney, impair hearing; and lead to numerous other associated problems. On average, each automobile battery contains more than ten kilograms of lead, which needs to be recycled after the battery becomes unusable. At present, the lead from old batteries is used to make new electrodes for storage batteries. But with the lead-acid batteries being gradually being replaced by less toxic and more efficient lithium ion batteries, the demand for lead for making batteries is likely to go down, creating problem of safe disposal of lead from used batteries.

Scientists at Massachusetts Institute of Technology (MIT) in USA have now come up with an attractive option of turning the lead from used car batteries into solar panels. It is based on a recent development in solar cells that makes use of a compound called perovskite – specifically, organo-lead halide perovskite – a technology that has rapidly progressed from initial experiments to a point where its efficiency which is good enough to rival some commercial crystalline silicon solar cells (*Energy and Environmental Science*, 23 July 2014 | doi: 10.1039/C4EE00965G).

'Perovskite' is a general term used to describe a group of materials that have a distinctive crystal structure. In the past few years, researchers have demonstrated that solar cells that use this mineral can reach a solar energy conversion efficiency of up to 19%, comparable to silicon technology that is somewhere between 21% and 25%. Moreover, manufacturing perovskite solar cells is more efficient energy-wise than the silicon-based variety, as it does not require nearly the same kind of temperatures and pressure.

The MIT scientists used a multi-step process to synthesise perovskite solar material using the electrodes straight out of a used lead-acid battery. Lead from the anode is dissolved in nitric acid and the lead oxide (made from the lead dioxide cathode) is dissolved in acetic acid. Then each compound is mixed with potassium iodide. The lead iodide formed is then purified and deposited on a thin flexible film, which acts as the substrate for the solar cell. Because it is a relatively simple process, the researchers are optimistic that it can work at large scale economically. And because each of the perovskite cells are just half a micrometre (0.5×10^{-6} m) thick, the researchers estimate that a single car battery could produce enough solar panels to provide electric power for 30 households. Besides, by using recycled lead from old car batteries, the manufacturing process can be used to divert toxic material from landfills and reuse it in photovoltaic panels that could go on producing power for decades.

In a finished solar panel, the lead-containing layer would be fully encapsulated by other materials, as many solar panels are today, limiting the risk of lead contamination of the environment. When the panels are eventually retired, the lead can simply be recycled into new solar panels.

Gene mutation key to high-altitude adaptation

It is common knowledge that people living in the plains often suffer from difficulty in breathing due to hypoxia (deficiency of oxygen) when they travel to a high-altitude destination such as Ladakh in India. This happens mainly because at high altitudes the air is much thinner than at sea level. As a result, a person inhales fewer oxygen molecules with each breath. Symptoms of hypoxia, sometimes known as mountain sickness, include headaches, vomiting, sleeplessness, impaired thinking, and an inability to sustain long periods of physical activity.

It is also known that people habitually living at high altitudes such as Tibetans and Sherpas of Nepal do not suffer from hypoxia. They are able to carry out their daily chores at normal pace in their oxygen-deficient environment.

It was once believed it was only a matter of adaptation. People from the plains do get adapted to high-altitude environment in a few days. Some studies had shown that the adaptation involves increase in haemoglobin concentrations in the blood, which enables it to carry more oxygen through the blood system in a low-oxygen environment.

A recent study has brought to light a genetic factor responsible for adaptation to high altitudes, especially in Tibetans.

A mutated gene gives Tibetans the ability to live at high altitudes without suffering from hypoxia.

The study, led by scientists of the University of Utah, USA, is the first to find a genetic cause for the adaptation – a single DNA base pair change that dates back 8,000 years – and demonstrate how it contributes to the Tibetans' ability to live in low-oxygen conditions at a height of more than 4,500 metres. The researchers discovered that about 8,000 years ago, a gene called EGLN1 in the DNA of Tibetans changed by a single DNA base pair. Today, 88% of Tibetans have this genetic variant, but it is virtually absent from closely related lowland Asians. The researchers found that the newly identified genetic variation protects Tibetans by decreasing the over-response to low oxygen that causes hypoxia in plains dwellers. The findings indicate that the genetic variation endowed its carriers with a specific advantage (*Nature Genetics*, 17 August 2014; doi: 10.1038/ng.3067).

In an earlier study in 2010, researchers had discovered that Tibetans have several genes that help them use smaller amounts of oxygen efficiently, allowing them to deliver enough of it to their limbs while exercising at high altitude. According to Josef Prchal, a professor of internal medicine at the University of Utah who was part of the present study team, "These findings help us understand the unique aspects of Tibetan adaptation to high altitudes and to better understand human evolution.... These discoveries are but one chapter in a much larger story. The genetic adaptation likely causes other changes to the body that have yet to be understood. Plus, it may be one of many as of yet unidentified genetic changes that collectively support life at high altitudes".

Parasitic plants communicate using mRNA

Parasitic plants usually draw sustenance from their host plants using tiny root-like structures called haustoria. *Cuscuta* or dodder, known as '*Amar bel*' in Hindi, is a common parasitic weed often seen covering entire trees with yellow mats of spaghetti-like threads. These plants use the haustoria to suck water and nutrients from their plant hosts. The haustoria of *Cuscuta* develop from the stem of the parasite, where it coils around the host, penetrating host tissues and ultimately forming vascular connections. It was previously known that these connections allow transfer of water and nutrients into the parasite from the host plant, but recent research has shown that they are also used by the parasitic plants to exchange macromolecules, including mRNAs and proteins with the host plant. This is a totally new finding. Messenger RNA, or mRNA, is typically used within living cells to pass along the genetic instructions from DNA for producing proteins. Movement of RNAs between cells of a single plant is well documented, but not much was known about cross-species RNA transfer between a parasite and its host plant.

Parasitic plant Cuscuta covering an entire tree.

The study was done by a team of researchers led by James Westwood, a plant scientist at Virginia Polytechnic Institute and State University, popularly known as Virginia Tech, in USA. The researchers studied dodder's chemical exchanges with tomato plants as well as a widely studied mustard plant known as Arabidopsis. They found that thousands of types of mRNA molecules were exchanged between the dodder plants and the hosts as the parasites tightened their grip (*Science*, 18 August 2014 | doi: 10.1126/science.1253122). According to the researchers, the parasitic weeds may be using an RNA-based "language" to communicate with their host plants – perhaps to get them to lower their defences. A wide variety of plants are known to be capable of mounting chemical defences to fend off parasites. In this case, one possibility is that the dodder plant may be telling the hosts to lower those defences using a genetic language.

Parasitic plants are serious problems for legumes and some other crops that help feed some of the poorest regions in Africa and elsewhere. In this context, the Virginia Tech findings have exciting implications, in addition to shedding new light on host-parasite communication, for the design of novel control strategies based on disrupting the mRNA information that the parasite uses to reprogram the host. By interpreting the genetic language correctly, scientists may be able to disrupt the communication channels and help food-producing plants protect themselves from nutrient-sucking pests. The researchers believe understanding the language of plants could well open up a new frontier for increasing crop yields worldwide.

Cuscuta has been found to exchanges RNA with its host plant in a sort of conversation. (Credit: Virginia Tech)