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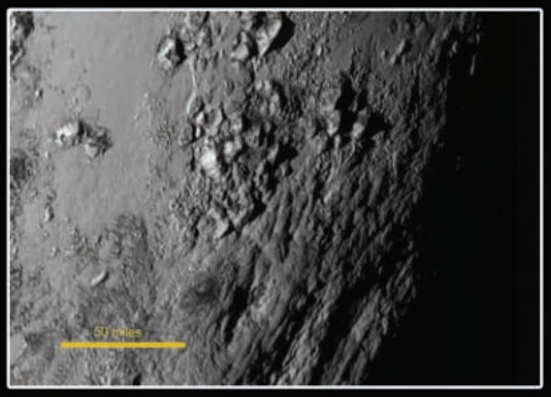
International Year of Light 2015

Pluto: new makeover



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

Citizen Science and human values

Dr. R. Gopichandran

A lot has been written about citizen science with reference to principles of engagement, issue-specific approaches, outcomes and challenges. Interestingly, this is a means of empowering citizens with a scientific outlook through interactions with systems and applications of science and technology in their immediate environs. This could encompass as wide a set of contexts as biodiversity, water and soil quality, ecosystem services and importantly, the opportunity to comprehend the dynamics of interactions and hence the open-endedness and resilience they exhibit. Dietz rightly argues that decisions are guided by facts and values. Communicators have to recognise values that are unique to cultures and socioeconomic settings and hence the preponderance of certain biases. The uniqueness of these values have to be respected and at best harmonised with agendas of science that are intended for common good. Science Centres can also serve as valuable platforms to infuse the spirit and practice of science through the citizen science approach.

In the above referred context I wish to highlight the opportunity to also learn from nature and systems about consistency that drives equilibrium and chaos. It is well known that truth alone succeeds in science. Manipulations or wilful wrongs in reporting naturally are weeded out through the tenacity and wisdom of truth along with misinterpretations. These are incredible values for human interactions too and have to be the cornerstones of communication initiatives. Institutions and individuals in the field of science communication should draw valuable lessons from the interpretation of parameters that appear to determine the dynamics of perception and learning in the interface of values and science.

My fundamental premise is that engagement with science should be seen as an opportunity to infuse human values of mutual and robust co-existence within a framework of dynamic equilibrium. That there is space for all to establish themselves with mutual respect is another take away with the commitment to abide by values of common good and be guided by truth alone. This submission is inspired by the framework of moral neutrality of science. Truth and morality for common good do not allow pretences of any kind and insolence in particular.

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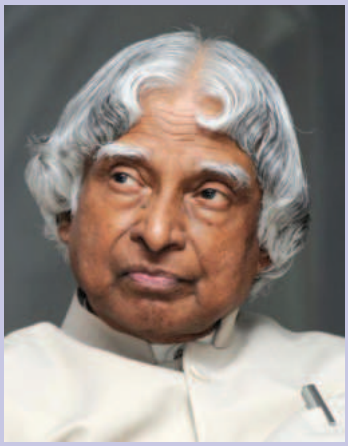
Bharat Ratna A.P.J. Abdul Kalam passes away (1935-2015)



The sudden passing away of Dr. A.P.J. Abdul Kalam, former President of India on 27 July 2015 at the age of 83 takes away one of the most versatile technologists, educationists and statesmen of modern times. He died of a cardiac arrest while addressing students of Indian Institute of Management Shillong, in Meghalaya, where he was a Visiting Professor. Popularly known as the "Missile Man" of India, Dr. Kalam rose from humble beginnings to become the "people's President" who endeared himself to one and all, especially the young. He was conferred with Bharat Ratna, India's highest civilian honour, in 1997 for his immense and valuable contribution to country's scientific research and modernisation of defence technology.

VP pays its tributes to Dr. Kalam.

[Read more about Dr. Kalam in the next issue – Editor]

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Pluto: new makeover

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6:22:03 am IST; 15 July, 2015. … Thirteen hours since New Horizon's close flyby to Pluto and subsequent radio silence. The spacecraft, after nine and half years of space journey, had reached Pluto flew-by at 12,472 km on 14 July at about 17:19 hrs IST. To make most of this opportunity, scientists had oriented New Horizons' antenna towards Pluto and away from Earth. Since the Plutonium-powered spacecraft had only limited power, in order to make most of it, scientists had decided to concentrate on gathering data rather than sending it back to Earth. As a result the spacecraft was on autopilot for about eight hours with no signal sent back to Earth.

Mission control room breaks into joy as the signal from New Horizons is received indicating the health of the spacecraft.

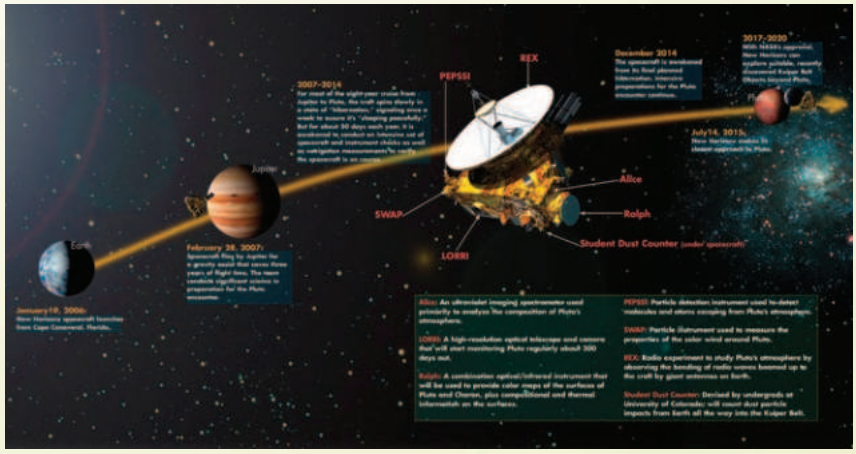
Planetary geologists had speculated that Pluto and its moons formed out of collision millions of years ago. If that were true, then such a cataclysmic event would have resulted in large numbers of small and big rocks in the neighbourhood posing danger to the spacecraft and hence space scientists were anxious and worried. Will the New Horizons phone back home?

The clock ticked away.. and the tension was building. Seconds felt minutes and minutes hours. The strain and stress were writ large on every face.

As one watched the events unfold in NASA-TV, magically the frazzled atmosphere was electrified; mission controllers at the Johns Hopkins University Applied Physics Laboratory could be seen to jump out of their chairs, stand, and clap in unison. One could hear sighs of relief, joyous shrills, boisterous boos. Signal from the spacecraft arrived as anticipated, confirming that the probe had indeed survived its history-making Pluto flyby. The Deep Space Network antenna in Spain received the signals sent across 4.88 billion km and received at Earth four hours and 25 minutes later. The audience stood up, applauded and waved American flags as, one by one, mission controllers reported "normal" status for the hardware that was their responsibility. The spacecraft is in good health.

The Mission

So far, even with best of the telescopes Pluto and its companion Charon were merely just blobs of light, hiding their surface features, if any. The New Horizon, first ever mission to Pluto, is expected to remove the veil and reveal its full glory. Launched way back on 19 January 2006, the New Horizon mission was to study Pluto and Kuiper belt objects. The spacecraft is small, just the size of a piano, weighing under 480 kg and just 2.5 metres across. Yet the suite of seven powerful scientific instruments on-board including the first ever 'student' built and 'flown' scientific payload, Student Dust Counter (SDC) along with three optical instruments, two plasma instruments, and a radio science receiver, are potent. After making a five billion-kilometre-long journey the spacecraft had to reach a point near Pluto with an accuracy of about 100-150 km on 14 July 2015. It flew by Pluto at 12,500 km and its by biggest moon Charon at 28,800 km. These close-up shots are expected to reveal surface features and provide geological, and atmospheric data.



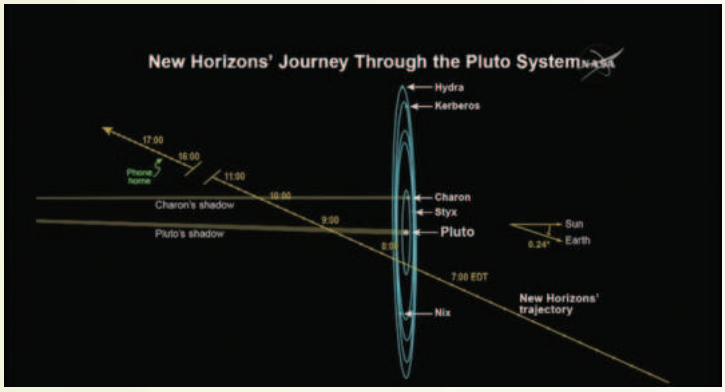
About nine and half years and 5-billion-kilometre-long journey to Pluto

Bulletproof vest

New Horizon hurling at a breakneck speed of almost 54,000 km/h could break into pieces if it collided with space rocks or debris. Further collision with micro meteoroids could puncture the instruments. To protect the instruments, the spacecraft is adorned with a bulletproof vest made out of 18 layers of Dacron mesh cloth sandwiched between aluminised Mylar and Kapton film, which also acts as a thermal blanket. Space is a very very cold place. For electronic equipment to work a minimum heat is required and New Horizons' unique "thermos bottle" design retains heat and keeps the spacecraft operating at room temperature without the need for power hungry large heaters.

Why just a brief rendezvous?

One may wonder why after this arduous ten-month journey the spacecraft spent just 30 minutes close by Pluto. Why could it not orbit once or twice around the dwarf planet? It will take 700 years for even the fastest jet to reach Pluto at 7.5 billion km. After its launch from Cape Canaveral on 19 January 2006, the probe entered into an escape trajectory featuring a speed of 16.26 kilometres per second (58,536 km/h), setting a new record for the highest launch speed of a human-made object flung from Earth. Flung by the gravity of Jupiter subsequently, it attained an additional 4 km/s (14,000 km/h). Once



Close flyby of the spacecraft was a success

at the Pluto-Charon system, the spacecraft passed through at a velocity of about 13.8 km/s relative to the dwarf planet (49,680 km/h). At this speed one would be able to traverse the distance between Chennai and Trichy under a minute. If you have to make this racing spacecraft to orbit around Pluto then one has to reduce its speed by about 90%, for that one would require 1,000 times more fuel in the spacecraft.

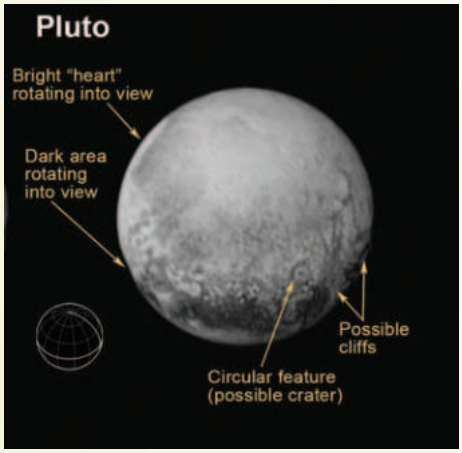
Pluto

Inner planets such as Mercury, Venus, Earth and Mars are terrestrial planets rich in metals such as iron. The gaseous planets such as Jupiter and Saturn are less dense and are essentially filled with lighter elements such as hydrogen and helium. Uranus and Neptune are frozen gaseous planets mostly made up of hydrogen and helium, but rich in frozen methane.

Pluto, at the far reach of solar system at 7.5 billion kilometres, is an icy planet frozen at about minus 233 degrees Celsius, with large percentage of ammonia, water ices, and other compounds such as methane. This is the same composition that comets have. Pluto has a very thin atmosphere, just one part in one lakh of Earth's atmosphere. Pluto's atmosphere is rich in nitrogen just like Earth, but Pluto's atmosphere is rich in methane and carbon-dioxide and is devoid of oxygen. Its largest moon is Charon is locked gravitationally with Pluto and hence unlike only one face of Moon being visible from any place on Earth, only one face of Charon is visible from only one place on Pluto. Four additional moons were discovered only recently and they ensemble around Pluto in a curious orbits.

To be or not to be a planet?

Since the discovery of Neptune in 1846, astronomers had predicted that there would be a ninth planet in the Solar System, which they called Planet X. After a massive hunt with ingenious contraptions, Clyde W. Tombaugh, then just 22 years old, discovered Pluto using the Lowell Observatory in Flagstaff, Arizona. At the time of discovery and subsequently, this tiny celestial object has remained an odd curiosity.



Even while only about 2% of data collected has been received, our knowledge of Pluto has increased many-fold

It's an irony that although it was still considered a planet when the New Horizon was launched in January 2006, within a few months, astronomers from across the world, who gathered for the congress of the International Astronomical Union in 2006, removed Pluto from the list of planets and re-classified it as a 'dwarf planet'.

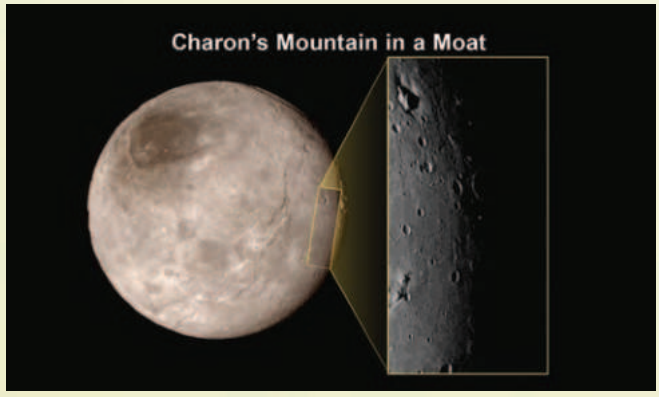
Over the last few decades, powerful new ground and space-based observatories have unravelled hitherto unknown parts of our solar system. Instead of being the only planet in its region like the the other planets of the Solar System, Pluto and its moons are now known to be just one among the large collection of objects called the Kuiper Belt objects (KBOs), found in a region beyond Neptune and extending out to 55 astronomical units (55 times the distance of the Earth to the Sun).

One estimate places the number of KBOs to be 70,000 icy objects, all with the same composition of Pluto and many measuring more than 100 km across. The discovery of a bigger KBO called Eris – 2,600 km across and about 25% more massive than Pluto – nailed the debate.

Although bats fly, it is a mammal; Penguins cannot fly, but are expert swimmers, yet they are birds. The re-classification of Pluto as dwarf planet is similar to this. A planet has to go around the Sun and have enough mass (gravity) to form a spherical shape. Pluto meets both these criteria. However, according to astronomers, for an object to be classified as a planet it had to satisfy another crucial criteria – that it needs to have "cleared its neighbourhood". This is where Pluto fails.

What does "cleared its neighbourhood" mean? When a proto-planet forms and evolves, it becomes the dominant gravitational body in its orbit, sweeps up the rest of the materials around and grows in size. In the end either it consumes almost all the objects near it or slings them away with its gravitational interactions. However Pluto is only 0.07 times the total mass of the other objects in its orbit. The Earth, in comparison, has 1.7 million times the mass of other objects in its orbit.

Any object that does not meet the astronomers' third criterion is classified as a dwarf planet. And so, Pluto is a dwarf planet.



Charon, the largest moon of Pluto, is not just an ice-ball, but appears to have surface features

All eyes and ears

The instruments on New Horizons were all designed to work together to give us a comprehensive picture of

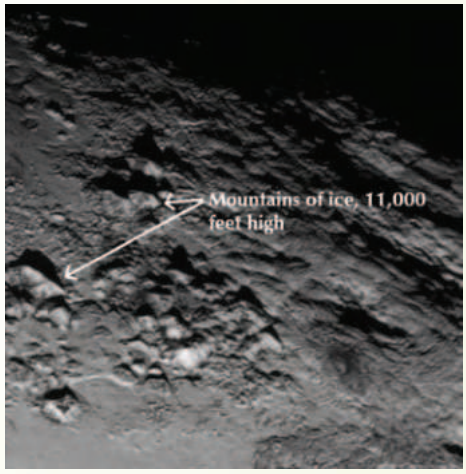
the Pluto system. Seven instruments – Venetia Burney Student Dust Counter (SDC), Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI), Solar Wind Around Pluto (SWAP), Long Range Reconnaissance Imager (LORRI), Radio Science Experiment (REX), Ralph and Alice – together will help scientists study Pluto's geology, surface composition, temperature and atmosphere, as well as its five moons. All the instruments aboard the spacecraft were in sleep mode until April 2015 and one by one they were woken-up.

It is official: Pluto is the bigger

It is not an exaggeration to say that we have learnt more about Pluto since April 2015, when the instruments on-board New Horizons were awakened than in the last 85 years since its discovery in 1930. Even with the trickling-in data still being analysed, researchers on the New Horizons team have processed enough flyby data to start nailing down many new details about Pluto.

To begin with we have been able to nail its diameter as 2,370 kilometres with an accuracy of +/- 12 km, somewhat larger than many prior estimates using stellar occultation method. When Pluto occults, or hides, a distant star, the duration of the eclipse is precisely measured to find the size. However, such methods for estimating Pluto's size were fraught with uncertainty because the thin atmosphere which blurred the boundaries of just how big the dwarf planet is. Images acquired with the Long Range Reconnaissance Imager (LORRI) were used by the astronomers to make this new estimate for Pluto and its various moons. The measurement obtained by LORRI and by earlier stellar occultations tallied at 1,212 +/- 1.6 km for Charon lacking atmosphere enhancing the reliability of this technique. Earlier estimates of Pluto at 2,302 was much less than 2,336 +/- 12 km of Eris lacking in atmosphere, making it the largest KBO, partly influencing the decision to demote Pluto's planetary status.

LORRI images were also used to compute the size of Nix and Hydra, two other moons of Pluto. Their diameters are estimated to be 35 km and 45 km respectively. However, a new mystery has cropped up as to how such small objects have such a high albedo, fuelling speculation that perhaps surfaces are quite bright,



Icy and young mountains imply Pluto is geologically active

possibly due to the presence of ice cover on their surface.

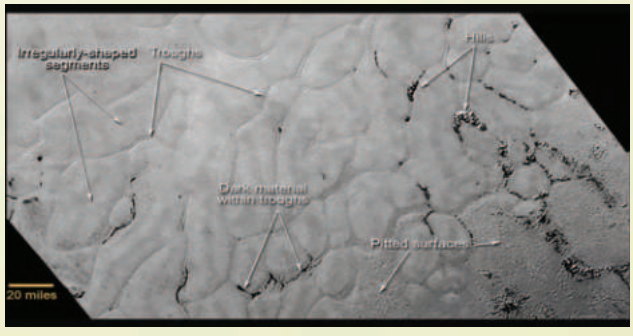
Even the dimensions of Kerberos and Styx tiniest moons could be teased out of the data that we would receive. The complex dynamic 'cosmic dance' these five moons do around Pluto would also come to light once we are able to download sufficient data from the spacecraft.

X-raying Pluto

Further confirmation awaits return of the data from the exciting Radio Science Experiment, (REX) to determine the sizes and densities of Pluto, Charon, and a future Kuiper Belt object as well as measure the temperature (both during the day and at night) and density of Pluto's atmosphere at various heights as well as the density of Pluto's ionosphere.

The "uplink radio experiment" technique of REX involves powerful radio signals from NASA's Deep Space Network aimed at New Horizons when it is bang behind Pluto. The radio waves will pass through Pluto's atmosphere and will bend certain ways depending on the temperature and molecular weights of gasses encountered. These signals would be received by the New Horizons and relayed back to Earth for further analysis.

The current estimates, unless overturned by the REX, makes the Pluto the largest object discovered in the Kuiper Belt so far and put an end to the debate as to whether Eris was actually bigger than Pluto.



High-resolution images of Pluto indicate tectonic activity

Pluto in new light

If indeed Pluto is slightly larger than we thought then it leads to a whole train of new conclusions. Bigger size paired with the mass that we already knew very well, connotes lower density which in turn implies higher proportion of ice than we previously thought. If indeed Pluto has more ice layered on its rocks then it hint troposphere lower than we had thought. A larger diameter also makes its atmosphere thinner than anticipated.

These results would impel a complete revision of the atmospheric as well icy and rocky interior models of Pluto. Smaller- but- 27% heavier Eris means greater density contrast between it and Pluto hinting at very different histories for the two worlds.

Pluto is not dead

First of high-resolution close-up images of the Pluto show number of mountains which are about young, icy and about 3,353 metres tall. Astronomers estimate that the mountains ascend from bedrock of water-ice and are likely less than 100 million years old; younger than the Himalayas.

Scientists have expected to find ice geysers and cryovolcanoes, but no evidence seems to be present in these images. New Horizons has confirmed the existence of a polar cap on Pluto. Spectral measurements have shown that the methane absorption bands are much weaker in the dark regions as compared to the polar regions indicating that polar regions are compositionally very different from the dark regions. Further images reveal a potential snow cap, a mysterious elongated dark feature at the equator, which has been dubbed the "whale", and a large heart-shaped bright region measuring about 2,000 km across. To honour the discoverer of Pluto, the heart shaped region has been named after Clyde W. Tombaugh. Zoom into these high-resolution images surprisingly show not a single impact crater.

Although small, tectonic activity was seen in Europa generated by the 'tidal action' of its companion massive Jupiter. Pluto in contrast is even smaller and bereft of massive companion. Models suggest it's too small to still have large amount of radioactive materials left over from its creation (these materials decay over time, releasing heat). However, mysteriously it appears to be geologically active generating fresh terrain and features over time, perhaps even volcanic plumes. Ultimately, Pluto's activity remains a big mystery at the moment.

New Face of Charon

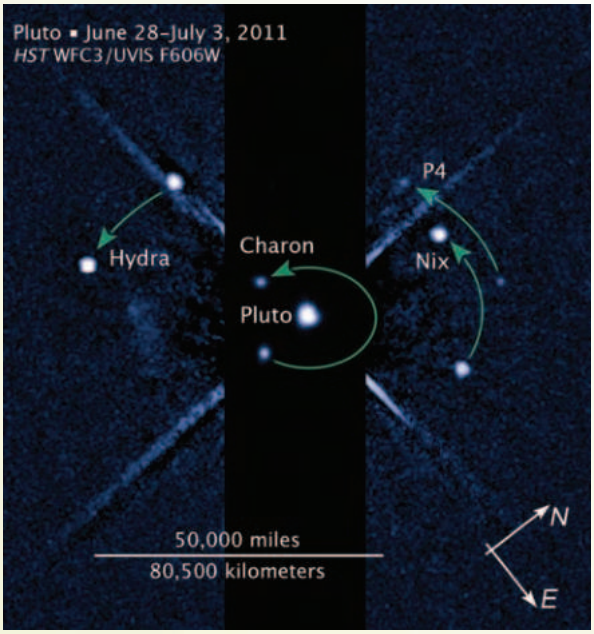
The high-tech spacecraft has also pictured Pluto's largest moon, Charon, and given scientists their clearest ever look at the giant ball of ice. Surprisingly it is young and with varied topography. The new images reveal a barren landscape of vast craters and chasms – the largest of which is believed to be kilometres deeper than Earth's own Grand Canyon. The most prominent crater on Charon is about 100 km across and lies near the South Pole of the moon. There is the incipient evidence of geologic activity such as faulting and surface disruption on Charon, which was thought to be a nearly featureless ball of ice until now.

Scientists suspect Pluto, Charon and their four small moons, all discovered in Hubble images after New Horizons was launched, formed after an ancient collision of two icy bodies. That theory will be tested with the new evidence of the tumbling, wobbly moons, and observations by New Horizons.

Nitrogen mystery

Pluto is one of only three objects in the solar system known to have a nitrogen-rich atmosphere, joining Earth and Saturn's moon Titan. Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI), a compact, lowest-power directional energetic particle spectrometer aboard the New Horizons was to search for neutral atoms that escape Pluto's atmosphere and become charged by their interaction with the solar wind. Chemical molecules such as molecular nitrogen, carbon monoxide and methane become ionised after absorbing the Sun's ultraviolet light were expected to be blown away from Pluto by the solar wind.

Astronomers had expected this instrument to get the first taste of Pluto's atmosphere when the spacecraft was close to Pluto at 1 to 2.5 million km. Yet, to much surprise of the planetary-geologists, PEPPSI started to sniff nitrogen escaping from Pluto five days before the close-flyby at about 6 million km. This perhaps indicate Pluto's thin atmosphere may be escaping the planet faster than expected or concentration of nitrogen in Pluto is many times stronger than we had estimated. It could also



Pluto and its five moons

means something more exotic, like a yet-to-be-determined process concentrating the escaped gas and our probe just coincidentally intercepting the stream. Further data from the spacecraft would help us learn what else is in Pluto's atmosphere, and if Charon and Pluto actually share an atmosphere within their odd little system.

Patience is virtue

The mission is not complete after its date with Pluto on 14 July 2015. It is only the first step for the spacecraft in its quest. As it recedes away from Pluto, just like the famous Raja Ravi Verma's Shakuntala painting, it turned to take a look at the night side of Pluto. In the silhouette of the Sun's rays examined the thin atmosphere as well as searched for rings around the planet. The probe gathered lots of scientific data during the flyby on Pluto's atmosphere, temperature, and geology, and has transmitted just about 2-3% of it. All the data would be received by Earth over the next 16 months.

The spacecraft uses a 2.1 metre-wide high-gain antenna to send signals to Earth. But the high-gain beam is only 0.3 degrees wide; this means New Horizons must be pointing precisely straight at the Earth in order for us to receive its signal. 70-metre dishes which farm part of the Deep Space Network are deployed to receive weak signals from the spacecraft.

Pluto is far away -- very far away, more than 30 times Earth's distance from the Sun – hence signals from New Horizons' are weak. Weak signal means low data rates: at the moment, New Horizons can transmit at most 1 kilobit per second! A typical high-resolution image is about 2.5 Megabits and at 1 kilobit per second: it takes 42 minutes to return one photo to Earth. Hence we have to wait with patience to download all the data from the spacecraft. The pace of discoveries will only quicken over the next few months as New Horizons starts sending home its observations.

Picture abhi baki hai

Pluto is not the last stop for New Horizons mission. The mission is to venture into unexplored territory of Kuiper Belt, which is thought to be consisting of objects left-over from the building blocks of the solar system. But where to head was a challenging question. The target beyond Pluto has to be somewhere near the path the spacecraft is taking and the remaining fuel should be sufficient to reach there. To the scientists' relief, in October 2014 the search team announced three potential targets named PT1(2014 MU69), PT2 (2014 OS393) and PT3(2014 PN70). About billion kilometres beyond Pluto two of them are brighter and so probably bigger (40-70 km) and the third although smaller (25 km) will be easier to reach. Currently the preferred flyby target is PT1, a 40–70 km object, but PT3, a slightly bigger object, could also be targeted for a flyby, with the decision to be made in August 2015. PT2 is no longer under consideration. In coming months, scientists will decide the spacecraft's next target and send signals from Earth to New Horizons to thrust its rockets to tweak its trajectory. If all goes well, it may then head into the Kuiper Belt for a possible flyby of a second object in 2019.

Being Pluto

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Discovery of Pluto

The discovery of the Neptune in 1846 led to widespread speculation that another planet might exist beyond its orbit. The search began in the mid-19th century and in the beginning of the 20th century American astronomer Percival Lowell gave it further impetus. Lowell believed like many others that such a planet should exist and it was given the name 'Planet X'. At that time several apparent discrepancies in the orbits of the giant planets, particularly Uranus and Neptune were to be explained. It was thought the tug of a hitherto unseen trans-Neptune object was responsible for this. Later this was proved wrong, but nevertheless inspired the search for Pluto. The surveys were on but Lowell died in 1916. With driving force gone the search was almost abandoned until in 1929 the then director of Lowell Observatory Vesto Melvin Slipher made a young 23-year-old man, a new recruit, in-charge of the mission. His name, Clyde Tombaugh. That the job was given to a very junior person in a big observatory clearly shows that the quest of Planet-X was not being carried out with any vigour, it was merely for the sake of honouring the wish of the founder of the observatory.

Tombaugh's task was simple yet painstaking. He was to photograph regions of the sky where the Planet-X was suspected to be located at different time intervals and then compare them two at a time. The device used for this comparison is called 'Blink comparator'. Here you put two photographic plates side by side, align the plates properly so that objects seems to overlap in the two views and view then alternately using a rapid shutter mechanism. The two images appear as if it is one fused image but any object that has shifted in position appears to jump. If such an object is found and its position does not match with that of a known object then you are sure onto something. Either you have discovered a new asteroid, comet, or a planet.

A year had gone by and the search seemed to have no end or result. Thousands of photographic plates must have been scanned by blink comparator. Tombaugh's eyes must have been in constant pain. Then finally on 18 February 1930 Tombaugh found something jumping in his view. These were the photographic plates taken on 23 and 29 January of the year 1930. An object was found that had changed position within the six days. Confirmation was required. He took out a photograph taken on 21 January and compared it with those of 23rd and 29th. That too showed this object in a slightly different location. Further confirmatory photographs were quickly taken on subsequent nights. And, now was the time to tell the world that a new planet had 'arrived'.

After a decade long journey through the solar system, NASA's New Horizons spacecraft made its closest approach to Pluto on 14 July 2015 at approximately 12,400 km above Pluto's surface - roughly the same distance from New York to Mumbai. It became the first-ever spacecraft to explore a world so far from Earth. Courtesy: NASA

The naming of the new object seemed to be as tough as the discovery itself. While the Lowell people and particularly the widow of Percival Lowell – Constance Lowell – wanted to have it their way; they had proposed 'Zeus', 'Constance', in addition about 1,000 suggestions had been received from all over the world. The astronomical community at large disregarded all these suggestions and accepted that of a then 7-year-old British girl, Venetia Burney (1918–2009), an enthusiast of classical mythology. She suggested its currently accepted name after the god of the underworld. The object was officially given this name on 24 March 1930.

It was initially thought that this was a victory for Lowell's hypothesis. But in 1978 as Pluto's size had been conclusively estimated it was realised that the gravity of such a small object would be too feeble to affect the orbits of giant planets. Does that mean there was something else out there to account for the discrepancies? Initially it was thought so and a brief search for a tenth planet ensued and was given up by the early 1990s. Now was the turn for *Voyager* 2 spacecraft to intervene in this matter. *Voayger*-2's measurements clearly indicated that the irregularities observed in Uranus's orbit were due to an earlier overestimation of Neptune's mass. So the Lowell hypothesis was discarded.

Pluto moves in a frigid world, billions of kilometres from Earth, and is 30 times less massive than planet Mercury that was for quite some time regarded as the smallest known planet. Photographs taken from Earth by the imaging techniques of those times showed it as a much bigger object than it finally turned out to be when space-borne imaging took over. Soon discovery of its five satellites began. The first to be discovered was its largest satellite, Charon, in 1978. The other four and smaller ones were discovered using the Hubble Space Telescope in 2005, 2011 and 2012. Charon is a very large moon - almost half Pluto's size. The distance between them is only 19,591 km.

Pluto is about two-thirds the diameter of Earth's moon and probably has a rocky core surrounded by a mantle of water ice. More exotic ices made from frozen gases like methane and nitrogen frost coat its surface. Owing to its size and lower density, Pluto's mass is about one-sixth that of Earth's moon. Pluto is more massive than Ceres – the dwarf planet that resides in the asteroid belt between Mars and Jupiter – by a factor of 20. Pluto moves in a 248-year-long elliptical orbit and that is so elongated that it goes as far as 49.3 (AU) from the Sun. From 1979 to 1999, Pluto was actually closer to the Sun than Neptune, and in 1989, Pluto came to a close 29.7 AU of the Sun. This gave a rare opportunity to study this small, cold, distant

Pluto timeline:

1930	Discovery by American astronomer Clyde Tombaugh
1977-1999	During this period the highly elongated orbit of Pluto brought it inside the orbit of Neptune thus making Pluto the 8th planet though temporarily for 22 years. This circumstance shall repeat after 230 years.
1978	Pluto gets company. Astronomers James Christy and Robert Harrington discover Pluto's unusually large moon, Charon.
1988	Pluto's atmosphere is detected for the first time.
2005	HST reveals two more moons – Nix and Hydra.
2006	NASA's *New Horizons* mission is launched to explore Pluto and the Kuiper Belt region on a nine-year-long journey.
2006	Pluto declared a non-planet rechristened as a dwarf planet by the International Astronomical Union.
2011-2012	HST observations reveal a fourth and fifth moon orbiting Pluto. They are named Kerberos and Nix.
2015	The *New Horizons* mission flies-by Pluto and begins observations. Its closest approach was on 14 July 2015.

Pluto vital-statistics

Discovered by	Clyde Tombaugh
Date of discovery	18 Feb 1930
Orbit size around Sun (semi-major axis)	39 AU (1 AU or mean Sun-Earth distance = 149.6 x 10^6 km)
Perihelion (closest)	4,436,756,954 km = 30.162 x Sun-Earth distance
Aphelion (farthest)	7,376,124,302 km = 48.496 x Sun-Earth distance
Sidereal orbital period (Length of year)	247.92065 Earth years
Orbital circumference	3.653 x 10^{10} km = 38.8 x Earth's circumference
Average orbital velocity	16,809 km/h = 0.157 x Earth's orbital velocity
Orbit eccentricity	0.2488273 = 14.89 x Earth's eccentricity
Orbit inclination (to Earth's orbital plane)	17.14 degrees
Equatorial Inclination to orbit	122.5 degrees (retrograde rotation) = 5.23 x Earth
Mean radius	1,151 km= 0.1807 x Earth's radius
Equatorial circumference	Metric: 7,231.9 km = 0.1807 x Earth's eq. circumference
Volume	6.39 x 10^9 km^3 = 0.006 x Earth's volume
Mass	1.3 x 10^{22} kg = 0.002 x Earth's mass
Density	2.050 g/cm^3 = 0.372 x Earth's density
Surface area	1.6648 x 10^7 km^2 = 0.033 x Earth's surface area
Surface gravity	0.66 m/s^2 (If you weigh 100 kg on Earth, you would weigh 6.6 kg on Pluto.
Escape velocity	1.2 km/s (Earth 11.2 km/s)
Sidereal rotation period (Length of day)	-6.387 Earth days (retrograde)
Minimum/Maximum surface temperature	-233/-223 °C

world in some detail. Its average distance is 5.9 billion kilometres or 39.5 AU.

It has a thin extended atmosphere (as gravity is low) having two distinct layers.

If the Sun were a 1.5-metre-diameter sphere, then Earth would be the size of a five-rupee coin and dwarf planet Pluto would be about the size of a pinhead.

Dwarf Planets

A spate of new discoveries was set in 1992 and that changed our concept of Solar System. It was now no longer a domain of just nine planets. More than 1,000 new objects were found circling the Sun beyond the orbit of Neptune. These were called the Trans-Neptunian Objects (TNOs). It was now only a matter of time and an object that would challenge the status of Pluto as planet was waiting to be discovered. This happened on 21 October 2003. Astronomers at the Palomar Observatory in the US in their quest for searching the 'edge' of the Solar System found a moving object that was 2,500 km in diameter. It was bigger and more massive than Pluto. It was given the name Eris. Later its satellite was also found. Should all these Sun-circling objects be called planets? A hot debate began.

Barring the exception of one (Ceres) all the dwarf planets are located in a scattered disc-type zone of the Solar System beyond the orbit of Neptune from 30 AU to 50 AU. Estimates are that up to 200 dwarf planets may be lurking in the Kuiper belt that is yet to be explored. This number may one day exceed 10,000 when objects scattered outside the Kuiper belt are added.

The International Astronomical Union (IAU) currently recognises five dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris. Only Pluto and Eris have been studied so far in detail. The IAU accepted Eris as a dwarf planet because it is more massive than Pluto. As per the naming procedure of IAU adopted in 2006 only two more objects Haumea, Makemake met that criterion and were classified as dwarf planets. Ceres, of course, we all know is the largest object of the asteroid belt – the region between the orbits of Mars and Jupiter. Ceres is the the only object within the orbit of Neptune that has been classified as a dwarf planet.

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Clyde Tombaugh and his icy world

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Pluto, which has turned out to be an "interesting and complex world" as found by NASA's piano-sized *New Horizons* spacecraft, appeared as just a speck of light when Clyde William Tombaugh discovered it in 1930. Tombaugh couldn't have imagined at that time that the ninth "planet" which he had discovered would someday be demoted to the status of a dwarf planet. Nor could he imagine that his ashes would be flown near the icy world he discovered.

When *New Horizons* rocketed away from Cape Canaveral on 19 January 2006 Pluto was the ninth planet in our Solar System. It was demoted to the "dwarf" status just about seven months later, in August 2006 by the International Astronomical Union. Discovery of Pluto

Tombaugh discovered Pluto when he was barely 24 years old while working at the Lowell Observatory. It was long before he attended college (he earned his bachelor's as well as master's degree in astronomy in 1936 and 1938 respectively from the University of Arizona). Tombaugh had a fascination of peering through the telescope even when he was a child. In 1916, when he was barely ten years old, his uncle Lee had gifted him a 3-inch (7.6-cm) reflector telescope using which he watched the night sky and looked for astronomical objects like stars and planets.

After finishing his high school, Tombaugh built his own telescope in 1926, according to specifications published in a 1926 issue of *Popular Astronomy*. However, not satisfied with the performance of this telescope, he decided to master optics. In the next two years, he built two more telescopes – a 7-inch (18-cm) reflector and a 9-inch (23-cm) refractor-grinding his own lenses and mirrors and further honing his skills.

Using the 9-inch refractor telescope, Tombaugh made observations of Jupiter and Mars and sent sketches of these planets to the Lowell Observatory in Flagstaff, Arizona. Astronomers at Lowell Observatory, especially its director Vesto M. Slipher, were so impressed with the young amateur's power of observation that they invited him to work in the Observatory with a job offer.

Clyde Tombaugh, discoverer of Pluto here shown with his homemade 9-inch telescope. (Credit: Wikipedia)

At Lowell Observatory, Tombaugh was assigned the job to perform a systematic search for the trans-Neptunian planet (also called planet X) which had been predicted by a businessman-turned astronomer Percival Lowell. To carry out the task, Tombaugh used the new 13-inch (33-cm) f/5 photographic camera (called astrograph), which was actually a telescope, to photograph the same area of the sky for different nights, at intervals of 3-6 days. Using an instrument, called blink comparator, he then examined the photographic plates for signs of a potential planet. In fact, by shifting between two frames, a star would appear to be stationary while a planet would appear to jump from one position to another. After working painstakingly for several nights under a cold dome, on 18 February 1930 his observations finally confirmed that he had actually been able to pinpoint the planet X, which had an orbit lying beyond Neptune's, as predicted by Lowell. On 13 March 1930, Lowell Observatory announced the discovery of the new planet.

Clyde Tombaugh, the discoverer of Pluto, at the Lowell Observatory in Arizona. (Credit: Wikipedia)

Naming the new planet

Names were invited by the Lowell Observatory for the planet discovered by Tombaugh. Several names were received including Percival, Constance (Percival Lowell's wife), Minerva, Cronus and Pluto. Of these, however, only three were shortlisted – Minerva, Cronus and Pluto. The name Pluto was suggested by Venetica Burney, an 11-year-old school girl from Oxford, England. It is said that she suggested this name to her grandfather Falconer Madan at breakfast table. The name Pluto was suggested after the Roman god of the Underworld who was able to render itself invisible-probably similar to how Pluto hadn't been seen earlier. The name Pluto was officially adopted on 1 May 1930. One more reason why the name was selected was that Percival Lowell's initials (PL) formed the first two letters of Pluto. It is interesting to note that Venetica was given a 5-pound note as prize for suggesting the name. She later grew up to be an English teacher. She died in April 2009 at the age of 90, having lived to see the re-classification of Pluto as a dwarf planet. Incidentally,

Tombaugh's wife Patricia, who died in 2010 at age 99, also watched Pluto getting demoted to a dwarf planet.

Tombaugh's widow and his two children – daughter Annette Tombaugh-Sitze and son Alden Tombaugh – offered an ounce (about 28 grams) of his ashes for the journey to Pluto on-board *New Horizons*. . His ashes were kept in an aluminium capsule about 2-inch (5.0 cm) wide and 1.5-inch (3.8 cm) tall that was attached to the inside of the spacecraft's upper deck. The capsule was inscribed with these words: "Interned herein are remains of American Clyde W. Tombaugh, discoverer of Pluto and the Solar System's third world. Adella and Muron's boy, Patricia's husband, Annette and Alden's father, astronomer, teacher, punster, and friend: Clyde Tombaugh (1906-1997)."

Early life and education

Clyde William Tombaugh was born in a farming family on 4 February 1906 in Streator in northern Illinois, about 145 km southwest of Chicago, USA. He was eldest of six children born to Muron Tombaugh, a farmer and Adella Pearl Chritton Tombaugh. Tombaugh's family often visited his uncle Lee, an amateur astronomer. He had a 3-inch (7.6-cm) refractor telescope, a kind that uses a lens to gather faint light from the stars and planets. Lee shared it with Tombaugh. Thanks to this telescope, Clyde developed an early interest in astronomy. He used to look at stars, planets and constellations (groups of stars) through this telescope. However, due to the smallness of the telescope, Clyde could only see Jupiter and its moons, Saturn, Venus and the Moon. Besides his uncle letting him borrow the telescope, he possessed a small astronomy book which he loaned to Clyde. The book fascinated Clyde very much. He could read about Galileo, Herschel and Lowell from this book. These astronomers became the instant heroes of young Clyde.

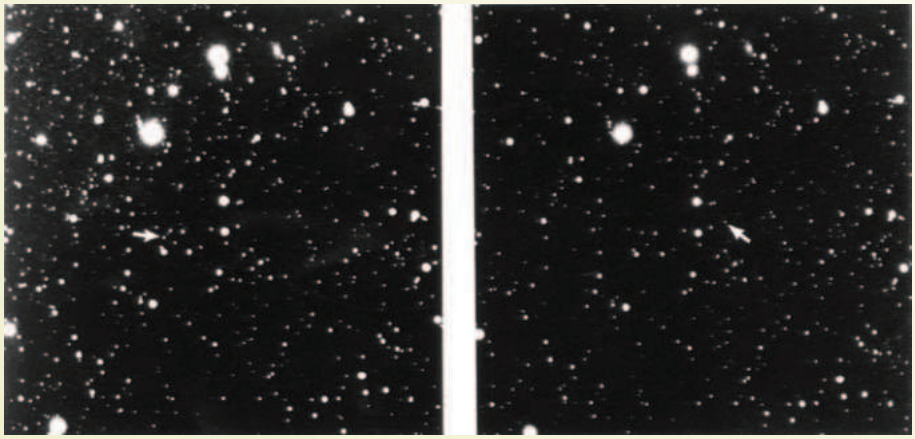
Clyde's father owned a farm in Streator. It was time towards the end of World War I when there was an acute shortage of manpower. As a result, Clyde had to work on the farm. He learned to work hard at a young age, helping his father cultivate corn, thresh oats and wheat and carry out other arduous tasks of farming life. As times became a little worse for Clyde's family, his father decided to try his luck farming in Kansas. In 1922, family moved to Burdett, Kansas where they got a 250-acre rented wheat and corn farm.

Tombaugh created his photographic plates using this 13-inch astrograph. (Credit: Wikipedia)

Before Clyde's family moved to Kansas, his uncle bought a 2.25-inch (5.75-cm) achromatic (light correcting) telescope which was smaller than a 3-inch telescope, but was better on many counts. Clyde's uncle gave it to his father when they moved. Kansas had much clearer skies than Illinois. This proved to be a blessing in disguise for the young Clyde who spent many more hours observing the skies.

Clyde was a student of Burdett High School. While in school, he played track-and-field, "drabbled in Latin" and played football with his friends on weekend afternoons. His fellow high school seniors of 1925 wrote in their yearbook that Clyde had his heads "in the stars."

Clyde graduated from high school in 1925. He wanted to go to the college to study astronomy. Unfortunately, his parents did not have the money to send him to college. In addition, as the crop yields were low, his help was needed on the farm. It looked as though instead of studying in college Clyde would end up with a regular farm job for the rest of his life. Clyde knew that he would like going to college and working at a university, but he also knew that it was out of his reach. Nevertheless, he worked harder in the farm hoping to raise finances for his college education. Unfortunately, a devastating hailstorm destroyed the entire crop. And with this his plans of going to the college also crashed.



The photographic plates that were used to discover Pluto (indicated by arrow) at apparent magnitude +15.4. The image on left was captured on 23 January 1930 and the one on right was taken on 29 January 1930. (Credit: Wikipedia)

However, Clyde did not lose heart. He continued to learn by spare-time projects of "home study". He made two telescopes from discarded farm machinery and shaft from his father's car (a 1910 Buick).In 1927, he built a 7-inch reflector and in early 1928 he finished building a 9-inch refractor telescope. For making these telescopes, he mastered optics and grinded his own mirrors and lenses. The 1928 telescope proved to be of superior quality and peering through this telescope Clyde was able to make sketches of Jupiter and Mars. He sent these sketches to the Lowell Observatory hoping to receive comments and observations. However, what

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Facts about Pluto: The once upon a planet

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• Till 2006, Pluto was counted as the ninth and outermost planet of the solar system, and the smallest of them all. It is even smaller than our Moon. In 2006, it was re-classified by International Astronomical Union as a dwarf planet.

• The search for a ninth planet began after the orbits of Uranus and Neptune were found to have anomalies that could be explained only by the gravitational pull of a planet beyond Neptune.

• In 1905, the American astronomer Percival Lowell postulated that gravitational pull of some unknown planet might be disturbing the orbits of Neptune and Uranus. In 1915, he predicted the location of the new planet and began searching for it from his observatory in Flagstaff, Arizona, USA.

• Lowell used a telescope to photograph the area of the sky where he thought the planet would be found and did actually photograph it on two occasions – on 19 March and on 7 April in 1915. But Lowell failed to notice the 9th planet in the photographs. He died in 1916, without finding it.

• In 1929, a 22-year-old American amateur astronomer named Clyde W. Tombaugh was hired by the Lowell Observatory specifically to search for the unseen planet. He used the predictions made by Lowell and other astronomers and photographed the sky with a more powerful, wide-field telescope. On 18 February 1930, he found Pluto's image on three of the photographs.

• The new planet was named Pluto after the Greek god of wealth. The name also honours Percival Lowell, whose initials are the first two letters of Pluto.

• Pluto's highly eccentric orbit surprised the astronomers of the time. The distance between Pluto and the Sun was found to range from 4.4 billion kilometres when closest to 7.4 billion kilometres when farthest. – a difference of 2,950 million kilometres.

• The orbit of Pluto is the most unusual of the solar system, because it tilts at an angle of 17° to the plane of the ecliptic.

• From Pluto, the Sun would look like a tiny dot in the sky.

• Pluto completes one orbit around the Sun in 248.54 Earth-years.

• When it was discovered, Pluto was the only planetary object farther from the Sun than Neptune. But every 248 years, Pluto moves inside Neptune's orbit for about 20 years, during which it comes closer to the Sun than Neptune.

• Pluto last crossed Neptune's orbit on 23 January 1979, and remained within it until 1 February 1999. Pluto will remain the outermost member of the Solar System until the year 2227, when it will again cross Neptune's orbit and come closer to Sun.

• Neptune and Pluto are locked together into what astronomers call a 'stable resonance orbit'. While Pluto takes 248.54 years to go around the Sun, Neptune takes 165 years, or exactly two-thirds as long. So every time Neptune completes three revolutions of the Sun, Pluto completes two orbits, and they are back to their original starting positions, relative to each other.

• Even though Pluto cuts inside the orbit of Neptune, it will never collide with Neptune because Pluto's orbit is so tilted that it always misses Neptune!

• The distance of Pluto from Earth varies from 4.3 billion kilometres to 7.5 billion kilometres.

• Pluto's mass is about 1/500th of the mass of the Earth. The gravity on Pluto is 8 per cent of the gravity on Earth. So, if you weigh 50 kilograms on Earth you'd weigh just 4 kilograms on Pluto!

• Till July 2015, when *New Horizons* flew by it, Pluto was the only Solar System planetary object that had not been approached by space probes and not much was known about it.

• Before the *New Horizons* mission, astronomers could find little about Pluto's size or surface conditions from telescopic observations because of its extreme distance from Earth.

• The first glimpses of Pluto's surface with some hazy details were available only in 1996 from images taken by the Hubble Space Telescope, which showed about 12 large bright and dark areas. But the Hubble images could not reveal much about Pluto.

• A major discovery about Pluto was made in 1979, when James Christy of the United States Naval Observatory noticed that photographs of Pluto taken earlier showed a bulge on one side. When he looked at photographs taken a few days before, he noticed the bulge was on the other side. He immediately guessed that Pluto had a moon. He named the new moon Charon after his wife Charlene.

• Pluto spins on its axis from east to west once in 6.39 Earth days; the same time it takes its only moon Charon to go round once. As a result, like a geostationary satellite on Earth, Charon appears motionless in Pluto's sky.

• Charon is about 1,270 kilometres across; that is, about half the diameter of Pluto. It is the largest moon in the solar system compared to the planet it orbits.

• Because the two bodies are so close in size, and because they orbit about a centre of mass that is outside Pluto's surface, Pluto-Charon pair is considered a double planet – the only one in our Solar System.

• Pluto and Charon rotate around each other 19,640 kilometres away from each other. If you were on Pluto, you'd see Charon in the sky only from a certain area of the planet, always in the same position in the sky, without ever rising or setting!

• From the surface of Pluto, the view of Charon would be fantastic – it would appear 100 times larger than our Moon – motionless in the sky!

• Pluto has four other moons named Nix, Hydra, Styx, and Kerberos, which are much smaller.

• Since 1989, when Pluto came closest to the Sun, it has been moving farther away from the Sun along its highly elliptical orbit. And as it moves farther from the Sun, Pluto could get so cold that its atmosphere might freeze. Its daytime temperature was already a frigid −223°C and was dropping.

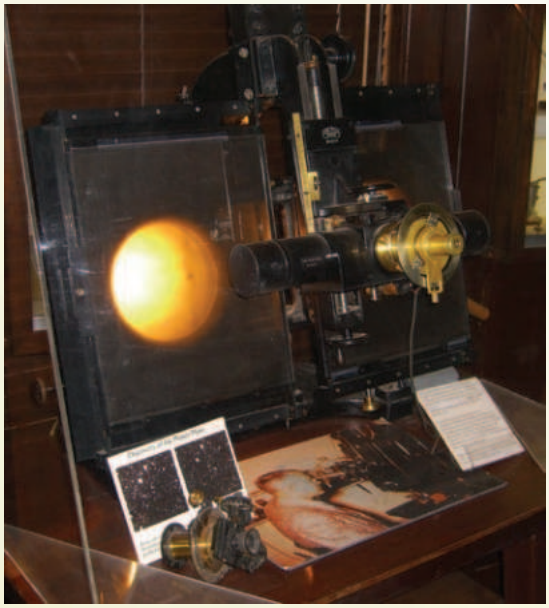
- That is why *New Horizons* needed to reach Pluto before 2020 when its atmosphere could become a giant ice shell, blocking the probe from studying the dwarf planet's surface and the dynamics of its atmosphere.
- Close-up images sent back by *New Horizons* during the flyby were revealing. So far, a series of pictures from the spacecraft have revealed curious surface features, from a dark shadowy whale figure to a bright heart shaped area.
- The close-up of Pluto makes clear that the dwarf planet has water ice that is as hard as rock. According to mission scientists, the mountains on Pluto were likely formed no more than 100 million years ago, making them younger than the Himalayas and suggesting the region may still be geologically active today.
- The scarcity of craters suggests that both Charon and Pluto have seen geological activity in the relatively recent past that may have erased the traces of earlier impacts.
- One important outcome of the *New Horizons* mission has been the revised estimate of Pluto's diameter, which was shown to be about 3 percent larger – 2,370 km rather than 2,302 km estimated earlier. This makes Pluto larger than the dwarf planet Eris, which has a diameter of 2,336 km.
- Following *New Horizons*' history-making sweep past Pluto on 14 July 2015, the mission has released maps of Pluto and Charon with preliminary names for the features found on them. Pluto now has features informally named after Tenzing Norgay, Edmund Hillary and Clyde Tombaugh. Many features are named after science fiction characters, particularly from Star Trek and Star Wars. However, the International Astronomical Union (IAU) still has to approve the names before they become official.

Clyde Tombaugh and his icy world *(Continued from page 27)*

he got instead was a job offer from the Observatory.

Further search at Lowell

After discovery of Pluto in 1930, Tombaugh continued to work at the Lowell Observatory for 13 years. He could not find any other planet, but he discovered hosts of new variable stars, several new asteroids, new star clusters, and clusters of galaxies including one supercluster of galaxies stretching from Andromeda to Perseus. He also discovered a periodic comet 274P Tombaugh-Tenagra. In some literature on astronomy, he is also credited with the discovery of another comet; however, its name is not known. It seems that he probably misidentified this comet with an asteroid.



Tombaugh compared his photographic plates using this blink comparator. (Credit: Wikipedia)

Beyond astronomical career

In 1943, Tombaugh was called to service during World War II. He taught navigation to U.S. Navy personnel at Arizona State College in Flagstaff from 1943 to 1945. After the war, Lowell Observatory was unable to rehire Tombaugh due to a funding shortfall. So, in 1946, he returned to work for the military at the ballistics research laboratories of the White Sands Missile Range in Las Cruces, New Mexico, where he supervised the optical instrumentation used in testing new missiles. In the course of this work, Tombaugh designed many new instruments including a super camera called IGOR (Intercept Grand Optical Recorder) which remained in use at White Sands for 30 years before it was finally improved upon.

After nine years at White Sands, Tombaugh left the missile range in 1955. He joined the faculty of New Mexico State University in 1955 in Las Cruces. He continued teaching there till his retirement in 1973. Even after the retirement he remained involved with the academics of the University. To raise funds for an astronomy post-doctoral research programme, started by the New Mexico State University, Tombaugh toured the U.S. and Canada from 1985 to 1990 delivering public lectures.

In his extensive lecture tours, he would recount his childhood days as a farm boy, comparing the discovery of Pluto to finding a needle in a haystack. He would say it was a tedious job but better than pitching hay on his father's farm.

Tombaugh never lost his passion for stargazing even after retirement. Once, the Smithsonian Institution in Washington, D.C. requested him to lend them his old 9-inch telescope that he had used when he was quite young. He replied to them that he was still using it.

Awards and honours

In recognition of his contributions, Tombaugh was awarded Hannah Jackson-Gwilt Medal and Gift in 1931 by the Royal Astronomical Society. His other honours include an honorary doctorate from Northern Arizona University (1960), the Distinguished Alumni Certificate from the University of Kansas (1966), the Regent's Medal (1980) and Crouch Award (1990) from New Mexico State University and the NASA Distinguished Public Service Award (1980). He was also awarded the Medal of the Pioneers of White Sands Missile Range. In 1982, the University of Kansas Observatory was named the Clyde W. Tombaugh Observatory. To honour Tombaugh, a heart-shaped feature on Pluto has recently been named "Tombaugh Regio". Asteroid 1604 Tombaugh has been named in his honour.

Tombaugh died of congestive heart failure on 17 January 1997 at his home in Las Cruces, New Mexico, U.S.A.

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Fibromyalgia:
Sutras to Win Over the Aches and Pains

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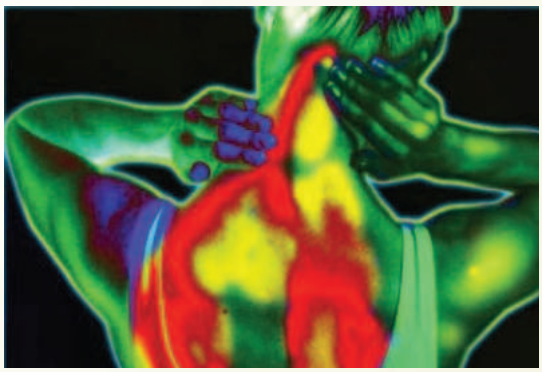
Fibromyalgia is a chronic illness that causes widespread muscle pain and stiffness in the body, easy tiredness, sleep and mood disturbances, and a host of other problems. It affects millions of people worldwide. Women between the ages of 25 and 60 years are the most likely sufferers, and outnumber men by seven to ten times. The illness is a bag of mystery; nobody quite knows what triggers it, even as modern day research suggests it's caused by a glitch in the way the body perceives pain. The X-rays and lab tests including blood tests draw a naught and do not show any abnormality, but the pain is real and interferes with work, physical activity, and daily chores.



The diagnosis of fibromyalgia rests singularly on its tell-tale symptoms and clinical bedside exam. Specific tender points in certain locations in the body are distinctive features. When these points are pressed, people with fibromyalgia feel pain, while people without the condition only feel pressure. Classically, these points of tenderness exist on both sides of the body in a symmetrical fashion.

What causes fibromyalgia?

There are many theories about what may be the true cause of fibromyalgia, but doctors are still not sure of the exact culprit. Most experts think that fibromyalgia results from a combination of factors, rather than a single cause.

Chemical or hormonal imbalances

Many researchers believe fibromyalgia occurs due to chemical or hormonal imbalances in the body which disrupt the way nerves signal pain. The hypothesis is that people with fibromyalgia have a low pain threshold. This possibly happens because of lower levels of a brain neurotransmitter called serotonin in the body. Serotonin has a calming, anxiety-reducing action. Low serotonin levels may lead to lowered pain thresholds and an increased sensitivity to pain.

A second hypothesis proposes that this low pain threshold may be caused by reduced effectiveness of the body's natural morphine-like painkillers called endorphins and the increased presence of a chemical called "substance P". Substance P amplifies pain signals and makes life miserable in people with fibromyalgia.

Chronic stress

Many researchers think that prolonged, chronic stress coupled with poor physical conditioning; or a sudden traumatic psychological event may act to increase a person's susceptibility of developing fibromyalgia.

Genetic factors

Some people may also suffer from a genetic predisposition towards fibromyalgia. The hypothesis is simple: A pool of genes may be instrumental in regulating the way the body processes the painful stimuli. People with fibromyalgia may inherit genes that cause them to react intensely to such stimuli that most people would not perceive as painful. Such genes may pass from a mother to a daughter. When people with genetic tendency are exposed to certain emotional or physical stressors—such as a traumatic crisis or a serious illness—their body's exaggerated response to stress results in body's higher sensitivity to develop pain and tenderness.

Fibromyalgia triggers

Some factors, including weather conditions, especially cold or humid weather, too much or too little physical activity, too much stress, and poor sleep or lack of sleep can worsen the symptoms of fibromyalgia.

Identifying the common triggers that makes the condition worse is an important first step to exercise a restrain on the illness. In some people, symptoms begin after a physical trauma, surgery, infection or significant psychological stress. In other people, symptoms gradually accumulate over time with no single triggering event.

Knowing the symptoms

Fibromyalgia can be associated with a variety of symptoms. These include:

Chronic muscle pain, muscle spasms, or tightness

The most typical symptom is constant muscle pains and aches which develop slowly over weeks and usually follow a distinct pattern around the body. The pain is distributed in the head, lower neck, upper back, near the shoulder blades, thighs, tummy, and hips.

If pressure is applied on the tender points in the body, it causes considerable pain. These pressure areas are called trigger points. They are generally symmetrical and most common in the following places in the body:

- A point in the back portion of the head
- A point in the upper end of the neck
- A point near the shoulder blade
- A point where the second rib joins the breastbone
- A point two inches below the outer back portion of the elbow
- A point in the upper outer quarter of the buttock
- A point on the hipbone on which a person sits
- A point on the fat pad above the inner joint line of the knee

You may also experience stiffness upon waking or after staying in one position for too long.

Easy tiredness and fatigue

Most people with fibromyalgia complain of reduced energy and moderate or severe fatigue. This is a common debilitating symptom. This fatigue is not the normal tiredness that follows a busy day, but a lingering feeling of exhaustion. People with fibromyalgia may feel tired first thing in the morning, even after hours spent in bed. The fatigue may be worse on some days than others and can interfere with the routine.

Insomnia

Many people with fibromyalgia have sleep problems, including trouble falling asleep or frequent awakenings during the night. Studies suggest some patients remain in a shallow state of sleep and never experience restful, deep sleep. This deprives the body of a chance to repair and replenish itself, creating a vicious cycle. Poor sleep may make pain seem worse, and pain can lead to poor sleep.

Some people also face other sleep disorders, such as restless legs syndrome and sleep apnoea.

Cognitive difficulties

Some people with fibromyalgia face difficulty in remembering, concentrating, and performing simple mental tasks. These symptoms, commonly referred to as "fibro fog", impair the ability to focus, pay attention and concentrate on mental tasks.

Irritable bowel syndrome

Some people with fibromyalgia also complain of abdominal pain, bloating, nausea, and constipation alternating with diarrhoea.

Stress related symptoms

Many people who have fibromyalgia also have tension or migraine headaches, jaw and facial tenderness, and other anxiety driven symptoms, such as sensitivity to one or more of the following: odours, noise, bright lights, medications, certain foods, and cold; numbness or tingling in the face, arms, hands, legs, or feet; increase in urinary urgency or frequency (irritable bladder); and a feeling of swelling (without actual swelling) in the hands and feet. These symptoms represent the adrenaline-sparked high inner stress, which affects both the body and mind.

Constantly fighting pain and fatigue can make people irritable, anxious, and depressed. You may have trouble staying on task at work, taking care of children, or keeping up with household chores.

Depression

Nearly a third of people with fibromyalgia also have major depression when they are diagnosed. This may be a result of the chronic pain and fatigue, or abnormalities in brain chemistry that may lead to both depression and an unusual sensitivity to pain.

Symptoms of depression may include difficulty concentrating, hopelessness, and loss of interest in favourite activities. Exercise or hobbies such as gardening may seem daunting. Exhaustion and irritability can also lead to missing out on visits with friends. Fortunately, there are effective treatments that help many patients get back to the activities they enjoy.

Seeing the doctor

You may consult a family physician, rheumatologist, physiatrist or an orthopaedic surgeon. Your doctor may diagnose fibromyalgia after hearing your symptoms and doing a physical examination. While there is no lab test to confirm a diagnosis of fibromyalgia, your doctor may want to rule out other conditions that may have similar symptoms. These blood tests may include:

- Complete blood count
- Erythrocyte sedimentation rate
- Thyroid function tests

These tests would draw a blank, but will help to rule out such major conditions as rheumatoid arthritis and lupus, which require a different line of treatment.

Treatment sutras

The goal of fibromyalgia treatment is to minimise pain, and alleviate sleep and mood disturbances. The emphasis is on minimising symptoms and improving general health. No one treatment works for all symptoms. In general, treatments for fibromyalgia include both medication and self-care.

Medications

Medications can help reduce the pain of fibromyalgia and improve sleep. Common choices include:

Pain relievers

Over-the-counter pain relievers such as paracetamol, ibuprofen or naproxen sodium may be helpful. Your doctor might also suggest a prescription pain reliever such as tramadol. Narcotics are not advised, because they can lead to dependence and may even worsen the pain over time.

Antidepressants

Duloxetine and milnacipran may help ease the pain and fatigue associated with fibromyalgia. Your doctor also may prescribe amitriptyline or fluoxetine to help promote sleep.

Anti-seizure drugs

Medications designed to treat epilepsy are often useful in reducing certain types of pain. Gabapentin is sometimes helpful in reducing fibromyalgia symptoms, while pregabalin is the first approved drug used to treat fibromyalgia.

Counselling Therapy

Talking with a counsellor can help strengthen your belief in your abilities and teach you strategies for dealing with stressful situations.

Alternative therapies

Complementary and alternative therapies for pain and stress management have been practised for thousands of years. But their

use has become more popular in recent years, especially with people who have chronic illnesses, such as fibromyalgia. Several of these treatments do appear to safely relieve stress and reduce pain, and some are gaining acceptance in mainstream medicine.

Meditation and yoga

These ancient Indian practices combine meditation, slow movements, deep breathing and relaxation. Both have been found to be helpful in controlling fibromyalgia symptoms. Besides dealing with the pain and fatigue of fibromyalgia, these may also help you tide over the other stress related bodily and psychological disturbances.

Massage therapy

This is one of the oldest methods of health care still in practice. It involves use of different manipulative techniques to move your body's muscles and soft tissues. Massage can reduce your heart rate, relax your muscles, improve range of motion in your joints and increase production of your body's natural painkillers. It often helps relieve stress and anxiety.

Rubbing, kneading, or stroking all seem to help. A significant other can learn to provide regular massages — and a 20-minute session may be long enough to get results.

Acupuncture

Acupuncture is a traditional Chinese medical system based on restoring normal balance of life forces by inserting very fine needles through the skin at key points on the body. According to Western theories of acupuncture, the needles cause changes in blood flow and levels of neurotransmitters in the brain and spinal cord. Some studies indicate that acupuncture helps relieve fibromyalgia symptoms.

What you can do?

Self-care is critical in the management of fibromyalgia. The following measures may do you a world of good.

Reduce stress

Develop a plan to avoid or limit overexertion and emotional stress. Allow yourself time each day to relax. That may mean learning how to say no without guilt. But try not to change your routine completely. People who quit work or drop all activity tend to do worse than do those who remain active. Try stress management techniques, such as deep-breathing exercises or meditation.

Get enough sleep

Since fatigue is a major complaint in fibromyalgia, getting sufficient sleep is essential. In addition to allotting enough time for sleep, practice good sleep habits, such as going to bed and getting up at the same time each day and limiting daytime napping.

Exercise regularly

Exercise can relieve several fibromyalgia symptoms. Physical activity can reduce pain and improve fitness. Exercising just three times a week has also been shown to relieve fatigue and depression. But it's important not to overdo it. At first, exercise may increase your pain. But doing it gradually and regularly often decreases symptoms.

Appropriate exercises may include walking, swimming, and biking. A physical therapist can help you develop a home exercise programme. Stretching, good posture and relaxation exercises also are helpful.

Pace yourself

Keep your activity on an even level. If you do too much on your good days, you may have more bad days. Moderation means not overdoing it on your good days, but likewise it means not self-limiting or doing too little on the days when symptoms flare.

Eat healthy foods

Certain foods, including aspartame, MSG, caffeine, and tomatoes, seem to worsen symptoms in some people. But avoiding these foods won't help everyone. To find out what works for you, try eliminating foods one at a time and recording whether your symptoms improve.

Maintain a healthy lifestyle

Do something that you find enjoyable and fulfilling every day. Many people with fibromyalgia find that their symptoms and quality of life improve substantially as they identify the most effective treatments and make lifestyle changes. While fibromyalgia is a chronic condition, the good bit is it does not damage the joints, muscles, or internal organs. ■

Dream 2047 listed among world's popular science magazines in Wikipedia

Dream 2047 has been included in the list of 66 science magazines from 22 countries around the world, published in Wikipedia recently. *Dream 2047* is among the four popular science magazines selected from India in the list. The other three are *Science Reporter*, published by CSIR-NISCAIR from New Delhi; *Current Science*, published by Indian Academy of Sciences from Bengaluru; and *Sandarbh*, a bimonthly popular science magazine in Hindi published by Eklavya from Bhopal.
(https://en.wikipedia.org/wiki/List_of_science_magazines)

In a separate entry, Wikipedia describes *Dream 2047* as a "monthly popular science magazine published by Vigyan Prasar, an autonomous institution under Department of Science and Technology, Government of India. It is sent free to schools, colleges and individuals interested in science and technology communication. The objective of Vigyan Prasar is to "promote scientific and rational outlook" amongst stakeholders in all sectors and especially relevant for growth and sustainable development of India. This is aligned with the Scientific Policy Resolution 1958, Science and Technology Policy 2003, and Science Technology & Innovation Policy 2013. The special focus on scientific temper and rational outlook is to help improve preparedness of stakeholders comprehend the scope of appropriate and verifiable action."
(https://en.wikipedia.org/wiki/Dream_2047_published_by_Vigyan_Prasar)

Recent Developments in Science and Technology

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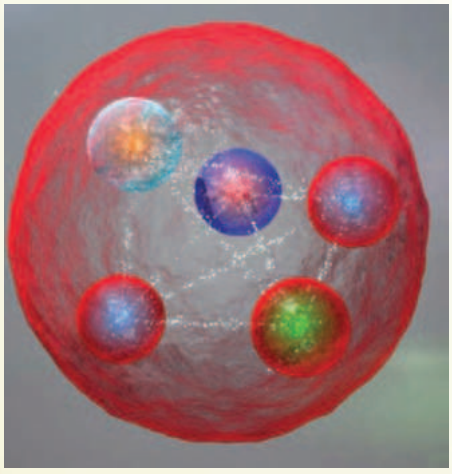
Pentaquark discovered at LHC

After the historic discovery of the elusive Higgs boson in 2013, the Large Hadron Collider at CERN has spotted yet another long-sought subatomic entity called the pentaquark. It was first predicted to exist in the 1960s but, much like the Higgs boson before it, the pentaquark eluded discovery for decades until its detection at the LHC. The discovery, which amounts to a new form of matter, was made by the Large Hadron Collider's LHCb experiment. The LHC was restarted in April this year after a two-year shutdown to complete a programme of repairs and upgrades.

The LHC researchers were studying how baryons (particles made of three quarks) break down, but during the particle decay the quarks were forming intermediate structures. After examining all possibilities for the signals detected the researchers concluded that they could only be explained by pentaquark states (*Physical Review Letters*, 2015, arXiv:1507.03414 (hep-ex)). So far, physicists have observed only one type of pentaquark in the LHC data, but there could be many other varieties.

For more than 50 years, physicists had suspected that more exotic subatomic particles might exist, but they could not find any. In 1964, two physicists – Murray Gell-Mann and George Zweig – had independently proposed that the groups of particles known as baryons and mesons were actually made up of still tinier charged subatomic particles known as quarks and antiquarks. The proton and neutron are each composed of three quarks while mesons are made up of two quarks bound by the strong force. The theory also implied that even more complex quark structures could form larger particles. For example, if three quarks made a proton or neutron, then what could five or six or seven quarks form? The existence of pentaquarks was thus not unexpected.

Quarks are tiny particles that bind together to form different types of larger subatomic particles such as protons and neutrons. Quarks come in six "flavours": up, down, top, bottom, strange and charm. Anti-quarks also come the same six flavours. Both protons and neutrons are made up of three quarks bound together by the strong force. When five quarks combine, it is called a pentaquark, which is a hypothetical



An artist's rendering of what a pentaquark structure might look like. (Credit: CERN)

subatomic particle consisting of four quarks – two up quarks, one down quark, a charm quark – and one anti-charm quark, bound together.

The first claim of pentaquark discovery was recorded at the 8-GeV Laser Electron Photon (LEP) Experiment in Japan in 2003. Thereafter several experiments in the mid-2000s also reported discoveries of other pentaquark states. However, others were not able to replicate the LEP results, and the other pentaquark discoveries were not accepted because of poor data and statistical analysis. The breakthrough came on 13 July 2015, when the LHCb collaboration at LHC reported results consistent with pentaquark states in the decay of bottom Lambda baryons.

The binding mechanism for pentaquarks is not yet clear. According to the researchers, "They may consist of five quarks tightly bound together; but it is also possible that they are more loosely bound and consist of a three-quark baryon and a two-quark meson interacting relatively weakly with each other via pion exchange (the same force that binds atomic nuclei) in a 'meson-baryon molecule'".

According to the researchers, "The pentaquark is not just any new particle… It represents a way to aggregate quarks, namely the fundamental constituents of ordinary protons and neutrons, in a pattern that has never been observed before in over fifty years of experimental searches. Studying its properties may allow us to understand better how ordinary matter, the protons and neutrons from which we're all made, is constituted."

Largest ever winged dinosaur discovered

The fossil of the largest ever dinosaur with bird-like wings and feathers was discovered recently in China. The nearly complete skeleton of the large winged dinosaur – a sleek, bird-like creature adorned with multiple layers of feathers all over its arms and torso that lived 125 million years ago – was found in northeast China's Liaoning province. The fossil, almost two metres long, is so well preserved that scientists have been able to reconstruct its impressive plumage, from the tiny feathers on its head and neck, to the larger quill pen-like feathers that sprout from its tail and substantial wings. The specimen was found by a local farmer near Sihedang in Jianchang, Liaoning Province. Sun Zhenyuan of the Jinzhou Paleontological Museum made the anonymous farmer donate it to the Museum. The fossil was studied by paleontologists Junchang Lü of the Chinese Academy of Geological Sciences in Beijing and Stephen Brusatte of the University of Edinburgh in the United Kingdom. The specimen has been named *Zhenyuanlong suni*, which means "Zhenyuan's dragon" (after Zhenyuan Sun, who procured the fossil from the farmer).

The *Zhenyuanlong* was large compared to other carnivorous dinosaurs found around the same time and place, and it had relatively shorter arms than its close

The beautifully preserved skeleton of the winged and feathered dinosaur Zhenyuanlong suni discovered in China. (Credit: Junchang Lü)

relatives. According to the researchers, the bird-like dinosaur was similar to the Velociraptor of Jurassic Park fame and may have weighed around 20 kilograms. The heavy weight, along with its very short arms almost indicates that certainly it could not fly. Yet, unlike most feathered dinosaurs, *Zhenyuanlong* sported a full set of wings and complex, quill-like feathers typical of those of modern birds (*Scientific Reports*, 16 July 2015 | doi: 10.1038/srep11775).

Now the question arises: If they could not fly, then what could the wings have been used for? According to the researchers, one possibility is that *Zhenyuanlong* evolved from dinosaur ancestors that could once fly, like today's flightless birds such as ostriches and penguins that evolved from flight-capable ancestors. But more likely, they think, the wings and feathers served some other function, such as appealing to the opposite sex – much as peacocks do today – or to protect and warm their eggs. The long arm feathers could also be useful in giving the *Zhenyuanlong* a better grip on inclined surfaces while running as well as keeping small prey down.

According to palaeontologists, "The new specimen is particularly important because it helps confirm that the evolution of dinosaur wings, and therefore the wings of birds, was not necessarily tightly coupled to the evolution of flight. Its wings could still have helped it jump down from ledges or run up steep inclines, so-called 'wing assisted' behaviours seen in flightless birds today".

Why parrots are such good vocal imitators

Many animals – including seals, dolphins and bats – are able to communicate vocally. But parrots are one of the few birds considered 'vocal learners', meaning they can imitate members of another species including human speech. For long, scientists have been trying to figure out why some bird species are better imitators than others, but could not find any differences except in the sizes of particular brain regions. A recent study by an international team of researchers led by Mukta Chakraborty of Duke University, Durham, USA, has brought to light key structural differences in parrot brains that may help explain the birds' unparalleled ability to imitate sounds and human speech. The study has been able to pinpoint the region in the brain that may be allowing this to happen – the region that is also involved in controlling movement. The finding could perhaps also explain the fact that parrots, just like humans, can talk and dance (*Plos One*, June 24, 2015. DOI: 10.1371/journal.pone.0118496). The team included researchers from Denmark and the Netherlands who donated precious bird brain tissue for the study.

An artist's impression of the new short-armed and winged feathered dinosaur Zhenyuanlong suni found in China that lived in the early Cretaceous period. (Credit: Chuang Zhao)

By examining gene expression patterns in nine different species of parrot, the researchers discovered that parrot brains are structured differently than the brains of songbirds and hummingbirds, which also exhibit vocal learning. It was known that birds that sing had well-defined centres in the brain called "cores" that control vocal learning. But, exclusively in parrots, around these there are outer rings, or "shells", which are relatively bigger in species of parrots that are well known for their ability to imitate human speech. Surrounding this is a third region that supports movement. The researchers found that parrots, when compared to other birds, have a complex pattern of specialised gene expression in all three parts of its brain. That means that most of the vocal learning that is specific to parrots, such as imitation, must be taking place in the shell region and the part of the brain that controls movements. The researchers also examined songbirds and hummingbirds and found that the shell regions were indeed unique to the parrots.

According to the researchers, parrots evolved vocal learning systems at least 29 million years ago. They hypothesise that this shell structure evolved after the core system for singing in birds was duplicated in the brain, with the shell centre developing new functions such as mimicking. So studying the shell structure in parrots could help us identify other mysterious duplications that could have led to certain brain functions in humans.

A surprising fact about parrots is that imitation of speech requires significant brain power and complex, specialised processes. But there is currently no evidence suggesting that parrots have any special kind of speech organ for producing spoken language. So, their brains must be doing the extra work.

The study has been described as a big step forward in our effort to understand what makes parrots so different from other birds. Indeed, the researchers themselves say

Parrots are excellent vocal learners because of a special structure in their brains.

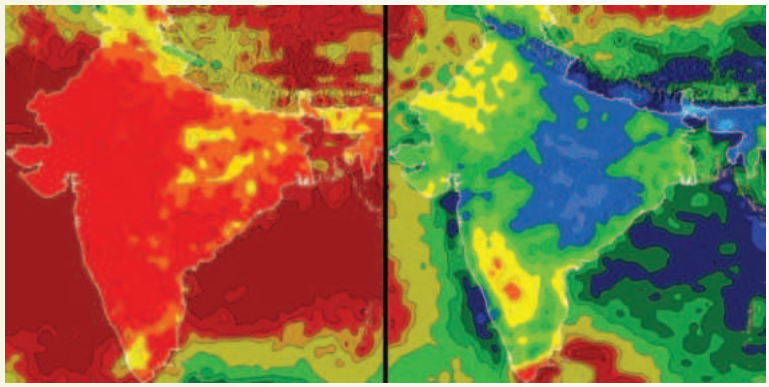
they were surprised that the brain structures they discovered had gone unrecognised for so long. "This finding opens up a huge avenue of research in parrots, in trying to understand how parrots are processing the information necessary to copy novel sounds and what are the mechanisms that underlie imitation of human speech sounds", says Chakraborty.

Harvesting rainwater could save rupees

Harvested rainwater could not only help tackle water scarcity in India but could also help people earn money, according to a recent study by scientists looking at NASA satellite data. The study is based on rainfall data collected during the Tropical Rainfall Measuring Mission (TRMM), a joint mission between NASA and the Japan Aerospace Exploration Agency, which provided observations of rainfall over the tropics and subtropics from 1997 to 2015. The study found that collecting rainwater for vegetable irrigation could "reduce water bills, increase caloric intake and even provide a second source of income for people in India".

Before the mission ended in April this year, TRMM delivered a unique 17-year dataset of global tropical rainfall and lightning. TRMM observed rainfall rates over the tropics and subtropics, where two-thirds of the world's rainfall occurs. The TRMM dataset has become the space standard for measuring precipitation, and led to research that improved our understanding of tropical cyclone structure and evolution, convective system properties, lightning-storm relationships, climate and weather modelling, and human impacts on rainfall. The data also supported operational applications such as flood and drought monitoring and weather forecasting.

Daniel Stouta of the Department of Civil Engineering at the University of Utah, USA, and his colleagues used TRMM data sets collected every three hours from 1997 to 2011 to determine how much precipitation, on average, was available for collection and supplementation in each of the six test Indian cities of Bangalore, Delhi, Hyderabad, Kolkata, Mumbai, and Srinagar to provide three ecosystem services: water supplementation for indoor use, water supplementation for food production and groundwater recharge in the Indian subcontinent. The team examined the possibilities if Indians collected precipitation in cheap 900-litre tanks that they could easily engineer to fit in densely populated urban areas. The team inputted the TRMM data into algorithms that Stouta had developed to determine the benefit to each of two scenarios: indoor use and outdoor vegetable irrigation. The results indicated significant ecosystem services benefits were possible from rainwater harvesting in India.



Rainfall in India varies significantly from season to season. The red in the image above indicates low rainfall, which is evident in winter. Blue indicates high rainfall, which is abundant in the image of monsoon season. (Credit: NASA/Hal Pierce)

For indoor use, the researchers estimated each person would require an average of about 160 litres of water per day. For an average household of five people, demand would be about 800 litres daily. Outdoor vegetable irrigation would require less water. The team found that rainwater harvesting could provide for nearly 20 percent of the average indoor demand overall, though some seasons, such as south-eastern monsoon season, could provide more.

The team estimated that rainwater harvesting could provide sufficient water source for vegetable irrigation, which demands less water than indoor use. The researchers ultimately judged that this use of rainwater provided the most benefit. They estimated that after a one-year payback period, rainwater harvesting for irrigation in a 20 m^2 plot to grown tomato and lettuce would provide a profit of between Rs.1,548 and Rs.3,261 per year and a total cost savings of between Rs.2,605 and Rs.4,522 per year. Besides, groundwater recharge could also provide substantial benefits. ■