

THE DEMOTION OF PLUTO

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How did we discover the existence of Pluto? Why have we reclassified Pluto as a dwarf planet? What do we know of other dwarf planets? How do we decide if a celestial body is to be classified as a planet or not? Read on for a first-hand account by Pluto.

Life is not fair, I tell you. I used to live my life peacefully, far, far away from all of you. My life was uncomplicated here, in the far reaches of the solar system. Then one day, you ‘discovered’ me, and bestowed on me the honour of calling me a planet. But since then, you have systematically belittled me – today, I have even been booted out of the planetary club! This is so unfair.

You human beings searched for me for quite some time before finally discovering me. It all started in the early 19th century, when astronomers from your planet, identified some perturbations in the orbit of Uranus that could only be explained by the gravitational force exerted by an undiscovered planet beyond its orbit. Their search for this unknown planet led them to Neptune. But in the late 19th century, their calculations suggested that Neptune’s presence was not sufficient to explain the extent of these

perturbations. Your astronomers predicted another planet, and that is how the search for a so-called ‘Planet X’ started. Finally, in 1930, Clyde Tombaugh ‘discovered’ me.

You named me Pluto, after the Greek god of the underworld. I was happy to see that you gave me immediate entry into the elite club of the solar system, consisting of the planets. It is not my fault that you had

Charon, Pluto’s moon is half as massive as Pluto. This high mass ratio is quite unique for a planet - satellite system in the Solar system. Because of this, the centre of mass of the two bodies lies outside Pluto, in between Pluto and Charon. So in effect, Charon is not orbiting around Pluto; instead, Pluto and Charon, together, are circling their common centre of mass every 6.5 Earth days.

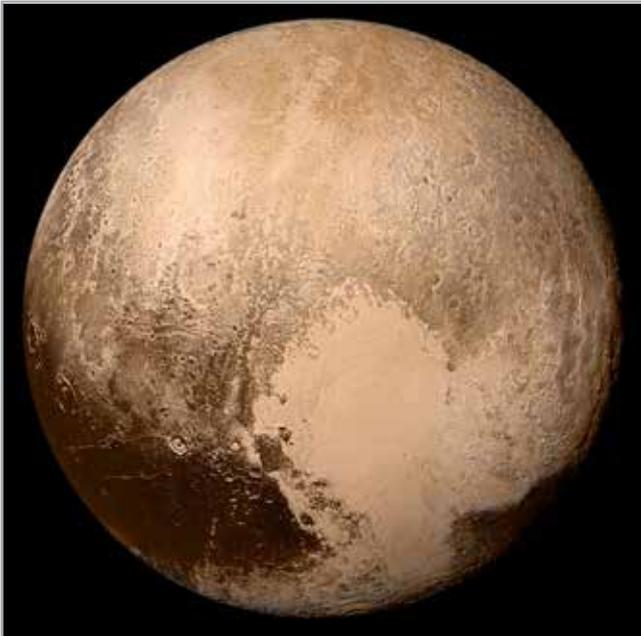


Figure 1. Pluto - New Horizons - July 14, 2015. Four images from *New Horizons*, an interplanetary space probe launched to perform a flyby study of Pluto. The images were taken when the spacecraft was 450,000 kilometers away and show features as small as 2.2 kilometers. Credits: Applied Physics Laboratory/Southwest Research Institute, NASA/John Hopkins University. URL: https://en.wikipedia.org/wiki/Pluto#/media/File:Nh-pluto-in-true-color_2x_JPEG-edit-frame.jpg. License: In Public Domain.



Figure 2. Pluto, the Plutoids, and the Kuiper Belt. Source: NASA (NASA.gov). URL: <https://i.ytimg.com/vi/2kNZ6bbHunU/maxresdefault.jpg>. License: CC-BY-NC

over-estimated my mass! At first, you thought my mass was equal to that of your home planet, Earth. Then, in 1948, with better calculations, you brought down this estimate to about the same mass as Mars. Later, in 1978, you discovered Charon, my satellite. Studying Charon's orbit, you were able to infer my actual mass as being not 0.1 or 0.01, but 0.00218 times the mass of Earth!

That is not all. With an improvement in your methods to study space, you started discovering many of my companions - objects that are at about the same distance from the Sun as I am. I remember you discovering the first of these in 1992. These numerous objects (about 100,000 of them), known to you as the Kuiper Belt, circle the Sun at a distance of 30AU to 50AU from it.

AU (Astronomical Unit)– is a unit of distance and is defined as approximately the average distance of the Earth to the Sun. Today, AU has been given a precise value of 149,597,870,700 meters or approximately 150 Million km.

While I was happy to see that you'd discovered many of my companions, this was the beginning of a further downfall in my status. Your scientists started questioning whether I could really be thought of as a planet, when I seemed like one of so many other celestial bodies. My orbit at 0.249 eccentricity, as they pointed out, is more eccentric than that of all the other planets; and at 17.14°, so is my inclination. In both of these characteristics, I am more like one of the KBOs (Kuiper Belt Objects). Thus started a further series of

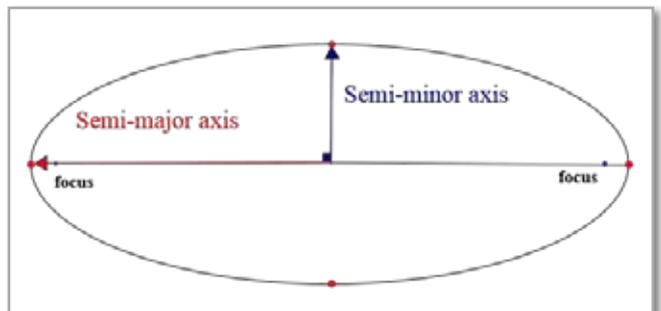


Figure 3. Major Axis and Minor Axis of an Orbit. Credits: Sae1962, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/Semi-major_axis#/media/File:An_image_describing_the_semi-major_and_semi-minor_axis_of_ellipse.svg. License: CC-BY-SA.

Semi Major Axis, Aphelion, Perihelion, Eccentricity and Inclination

Planets (and dwarf planets/comets) orbit the Sun in an elliptical orbit. The major axis of the orbit is the longest diameter of the ellipse. Half of this is called the **semi-major axis**. The **aphelion** is the distance from the Sun to the farthest point on the orbit and the **perihelion** is the distance from the Sun to the closest point on the orbit. **Eccentricity** is a parameter that defines how 'squashed' an ellipse is. When the ellipse is not 'squashed' at all, it is a circle and the eccentricity is 0. The eccentricity of an ellipse varies from 0 to 1. The **inclination** of a planet (or dwarf planet/comet) is defined as the angle between its orbital plane and Earth's orbital plane.

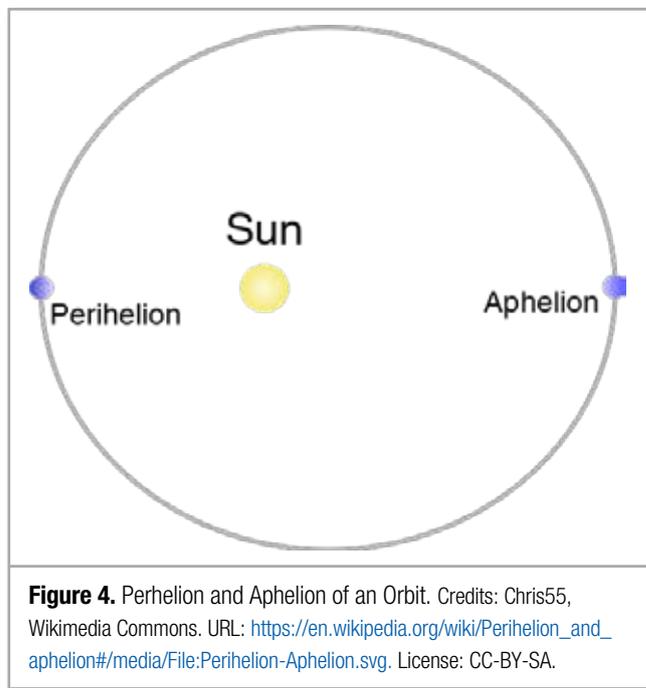


Table 1: Distance from the Sun, Eccentricity and Inclination of some Celestial Bodies

Celestial Body	Minimum distance from the Sun (Perihilion) (AU)	Maximum distance from the Sun (Aphilion) (AU)	Eccentricity	Inclination (degree)
Mercury	0.307	0.466	0.205	7.005
Venus	0.718	0.728	0.007	3.394
Earth	0.983	1.016	0.017	0.000
Mars	1.381	1.666	0.093	1.851
Jupiter	4.950	5.454	0.048	1.305
Saturn	9.024	10.086	0.054	2.484
Uranus	18.33	20.11	0.047	0.770
Neptune	29.81	30.33	0.008	1.769
Pluto	29.66	49.32	0.249	17.14
Eris	37.91	97.65	0.440	44.04

Source: Wikipedia, individual pages of each planet/dwarf planet.

insults - your astronomers and planetariums started omitting me from the list of planets!
The final nail in the coffin was the discovery of my cousin, Eris. She is way more eccentric than I am. Her eccentricity is 0.44. (she really travels quite a bit every

revolution, going as far away from the Sun as 97AU, but coming as close as 38AU – which is even closer than my orbit at times). But what is worse is that, even though she is slightly smaller than me in size, it turns out she has about 27% more mass than me.

Additional Resources:

The multimedia link on the New Horizons mission page (<http://pluto.jhuapl.edu/>) has many colourful resources on Pluto.

This link on the New Horizons mission page (<http://pluto.jhuapl.edu/Participate/teach/Activities.php>) has several lesson plans and classroom activities for school students - a useful resource for teachers.

The discovery of two other objects, similar to me in size - called Sedna and Quaoar - forced astronomers to either call all of them planets or demote me too. That was all that was needed. You started baying for my blood.

Finally, at the meeting of the International Astronomical Union, on 24th August 2006, the assembly voted to reclassify me as a Dwarf Planet. I can tell you this - I was devastated. The folks at IAU also came up with some criteria for defining various objects in the solar systems, which makes my re-entry as a planet seem pretty difficult.

1. A planet is a celestial body that: (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

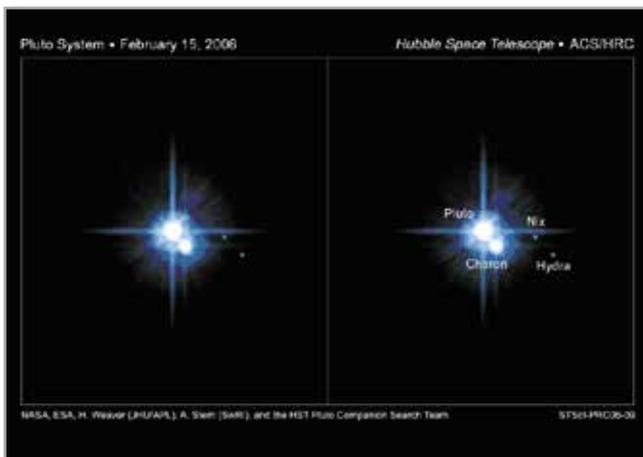


Figure 5. Other companions of Pluto - Nix and Hydra. We are able to see them at visible wavelengths because they are reflecting sunlight, despite their enormous distance from the Sun - suggesting that their surfaces could be icy and shiny. Source: Hubble Space Telescope.

2. A 'dwarf planet' is a celestial body that: (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.
3. All other objects orbiting the Sun shall be referred to collectively as 'Small Solar System Bodies'.

As you can see, I am very clearly not category 3. Unfortunately, I was born into a very busy neighbourhood, with tens of thousands of other objects near me. So while I fulfil the criteria of orbiting the Sun, and have sufficient mass for my self-gravity to overcome rigid body forces and give me a nearly round shape, I have not been able to clear my neighbourhood. So, on 24th August 2006, I was summarily booted out of the planetary club.

What gives me hope is the huge outcry by other, the non-astronomer kind, people on your planet about my demotion (at least 7 popular songs lament my humiliation) that forced the high and mighty astronomers to quickly make some concessions. They created a separate category of celestial bodies, named Plutoids, in my honour.



Figure 6. Two more companions of Pluto, P4 and P5 (subsequently named Kerberos and Syx), were discovered in 2010. We are able to see them also at visible wavelengths because they are reflecting sunlight, despite their enormous distance from the Sun - suggesting that their surfaces could be icy and shiny. Source: Hubble Space Telescope.

Plutoids are celestial bodies in orbit around the Sun at a semi-major axis greater than that of Neptune, with sufficient mass for their self-gravity to overcome rigid body forces and assume a hydrostatic equilibrium (near-spherical shape), but have not cleared the neighbourhood around their orbit.

Well, so what if I am not a Planet?! Look at the planet you call home - while it is part of the planetary club, with heavyweights like Jupiter and Saturn around, it seems like just an insignificant dot in that group. In contrast, I am king among the Kuiper Body Objects (KBO) and even have a group named after me. I want you to remember one thing - about four billion years

from now, the Sun will run out of all its fuel, with all its hydrogen fused into helium. Once this happens, the outer shell of the Sun will expand outwards as it becomes a red giant. Mercury, Venus and most probably your Earth will all be swallowed up by that monster. I, on the other hand, will be safe, far away from all the destruction, and still undisputed King of the KBOs!

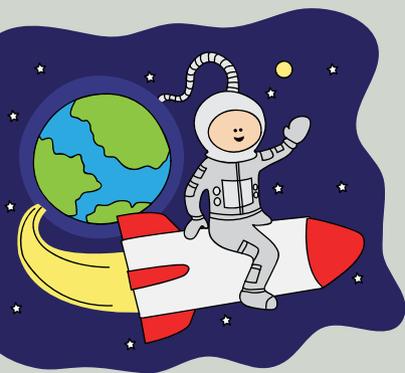


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Solid Gases and Metal Vapours

– Vignesh Narayan

Among the many wonders of space are planets. They come in all sizes, colours and most strikingly, chemicals. Extremes of temperature, gravitational forces and velocities cause chemicals to behave in ways that are rarely seen on Earth.

NASA's New Horizons spacecraft displayed the first ever images of Pluto, the dwarf planet, in 2015, after a 9-year voyage in space. These pictures show smooth plains of nitrogen ice arising from Pluto's 'heart' meeting mountains several kilometres high. These mountains are actually gargantuan icebergs that are resting, and move around on layers of solid nitrogen below them.

Closer to the sun, Mercury actually has thin vapours of sodium and potassium gas above its surface. Jupiter, known as a gas giant, has no surface at all! The top quarter of the planet is faced with such high temperatures and pressure that hydrogen atoms are stripped of their electrons to form a liquid metal. What makes the atmosphere of Jupiter even more interesting is a layer of ammonia and hydrogen sulphide crystals sandwiched between water ice at the bottom and ammonia ice on top. The planets Uranus and Neptune have clouds made of crystalline methane. Since methane absorbs all wavelengths other than blue, both planets appear blue in colour when seen by space probes and telescopes.

None of the planets or moons in the Solar System has an atmosphere similar to that of Earth. This means that if humans travel to other planets, they will have to take their own atmosphere along in order to survive!

Vignesh is a Ph.D. student in molecular biology at the Indian Institute of Science, Bangalore. He is passionate about research and popular science writing. His area of expertise is in biology, with a special focus on molecular biology and microbiology of diseases. You can reach him at vigneshnarayan313@gmail.com.