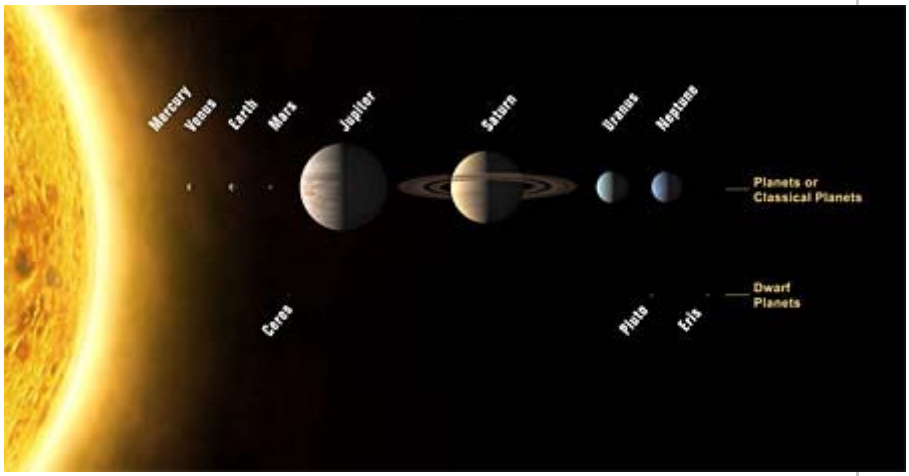
Pluto and the Developing Landscape of Our Solar System

The discovery of Pluto

Nearly eighty years ago an astronomer working at the Lowell Observatory in the United States made a discovery that would ultimately initiate a dramatic change in the way we look at our Solar System. The young astronomer was Clyde Tombaugh, an observing assistant working at the observatory made famous by the great astronomer Percival Lowell. Tombaugh was continuing the search for an elusive planet – planet X – that Lowell had believed (incorrectly) to be responsible for perturbing the orbits of Uranus and Neptune.

Within a year, after spending numerous nights at the telescope exposing photographic plates and months tediously scanning them for signs of a planet, Tombaugh saw what he was looking for. At around 4pm on the afternoon of 18 February 1930 Tombaugh began comparing two plates taken in January that year showing a region in the constellation of Gemini. As he flicked from one plate to the other, trying to see if something moved slightly between the two (the tell-tale sign of the planet he was hunting), he spotted something. In one part of the frame a small object flitted a few millimetres as he switched between the two plates. Tombaugh had found his new planet! (Stern & Mitton, 2005)

The changing landscape of the Solar System



The object Tombaugh had discovered was named Pluto, a name officially adopted by the American Astronomical Society, the Royal Astronomical Society in the UK and the IAU. It is a frigid world, billions of kilometres from Earth, and 30 times less massive than the then-smallest known planet, Mercury. But Pluto was not alone. It was found to have three satellites. The largest, Charon, was discovered in 1978. The smaller two were discovered using the Hubble Space Telescope in 2005 and officially named Nix and Hydra by the IAU in early 2006 (read more).

The view of our solar system's landscape began to change on August 30, 1992 with the discovery by David Jewitt and Jane Luu from the University of Hawaii of the first of more than 1000 now known objects orbiting beyond Neptune in what is often referred to as the transneptunian region. More generally these bodies are often simply labelled as transneptunian objects (TNOs).

With so many transneptunian objects being found, it seemed inevitable that one or more might be found to rival Pluto in size. On the night of the 21 October 2003, Mike Brown from Caltech, Chad Trujillo from the Gemini Observatory and David Rabinowitz from Yale University were using a telescope and camera at the Palomar Observatory in the US to search the edge of the Solar System. That night they imaged a region of sky showing an object moving relative to the background stars. Later analysis showed that they had discovered another cold world, around 2500 km across, orbiting the Sun. Subsequent observations showed that the new object, initially named 2003 UB_{313} according to the International Astronomical Union's protocol on the initial designation of such objects, was more massive than Pluto and that it too had a satellite (read more). With an object larger and more massive than Pluto now beyond Neptune and ever more of these transneptunian objects being discovered, astronomers were beginning to ask: "Just what constitutes a planet?"

A new class of objects and how to define a planet

The IAU has been responsible for the naming and nomenclature of planetary bodies and their satellites since the early 1900s. As Professor Ron Ekers, past president of the IAU, explains:

Such decisions and recommendations are not enforceable by any national or international law; rather they establish conventions that are meant to help our understanding of astronomical objects and processes. Hence, IAU recommendations should rest on well-established scientific facts and have a broad consensus in the community concerned.(read the full article)

The IAU decided to create a committee to gather opinions from a broad range of scientific interests, with input from professional astronomers, planetary scientists, historians, science publishers, writers and educators. Thus the Planet Definition Committee of the IAU Executive Committee was formed and quickly went about preparing a draft resolution to put to the members of the IAU. After the final meeting in Paris the draft resolution was completed. One crucial aspect of the resolution is described by Professor Owen Gingerich, Chair of the IAU Planet Definition Committee: "On the scientific side, we wanted to avoid arbitrary cut-offs simply based on distances, periods, magnitudes, or neighbouring objects". (read more)

The final resolution

The first draft proposal for the definition of a planet was debated vigorously by astronomers at the 2006 IAU General Assembly in Prague and a new version slowly took shape. This new version was more acceptable to the majority and was put to the members of the IAU for a vote at the Closing Ceremony on the 24 August 2006. By the end of the Prague General Assembly, its members voted that the resolution B5 on the definition of a planet in the Solar System would be as follows:

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.

(read more)

Dwarf Planets, plutoids and the Solar System today

The IAU Resolution means that the Solar System officially consists of eight planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. A new distinct class of objects called dwarf planets was also decided on. It was agreed that planets and dwarf planets are two distinct classes of objects. The first members of the dwarf planet category are Ceres, Pluto and Eris, formerly known as 2003 UB_{313}. Eris was named after the IAU General Assembly in 2006 (read more) Eris is the Greek god of discord and strife, a name which the discoverer Mike Brown found fitting in the light of the academic commotion that followed its discovery.

The dwarf planet Pluto is recognised as an important prototype of a new class of transneptunian objects. The IAU has put given a new denomination for these objects: plutoids.

Today the resolution remains in place and is a testament to the fluid nature of science and how our view of the Universe continues to evolve with changes made by observations, measurements and theory.

References:

Stern, A., & Mitton, J., 2005, *Pluto and Charon: Ice Worlds on the Ragged Edge of the Solar System*, Wiley-VCH 1997

Planets, Dwarf Planets and Small Solar System Bodies

Questions and Answers

Q: **What is the origin of the word planet?**
A: The word planet comes from the Greek word for "wanderer", meaning that planets were originally defined as objects that moved in the night sky with respect to the background of fixed stars.

Q: **Why is there a need for a new definition for the word planet?**
A: Modern science provides much more information than the simple fact that objects orbiting the Sun appear to move with respect to the background of fixed stars. For example, recent new discoveries have been made of objects in the outer regions of our Solar System that have sizes comparable with and larger than Pluto. Historically Pluto has been recognised as the ninth planet. Thus these discoveries have rightfully called into question whether or not the newly found transneptunian objects should also be considered as new planets.

Q: **How did astronomers reach a consensus for a new definition of planet?**
A: The world's astronomers, under the auspices of the International Astronomical Union, deliberated on a new definition for the word planet for nearly two years. The results of these deliberations were channelled to a Planet Definition Committee and ultimately proposed to the IAU General Assembly. Continued evolution of the definition through debate and further discussion allowed a final consensus and vote.

Q: **What new terms are used in the official IAU definition?**
A: There are three new terms adopted as official definitions by the IAU. The terms are: planet, dwarf planet and small Solar System body.

Q: **In plain language, what is the new definition of planet?**
A: A planet is an object in orbit around the Sun that is large enough (massive enough) to have its self-gravity pull itself into a round (or near-spherical) shape. In addition a planet orbits in a clear path around the Sun. If any object ventures near the orbit of a planet, it will either collide with the planet, and thereby be accreted, or be ejected into another orbit.

Q: **What is the exact wording of the official IAU proposed definition of planet?**
A: 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.

Q: **Does a body have to be perfectly spherical to be called a planet?**

A: No. For example, the rotation of a body can slightly distort the shape so that it is not perfectly spherical. Earth, for example, has a slightly greater diameter measured at the equator than measured at the poles.

Q: **Based on this new definition, how many planets are there in our Solar System?**
A: There are eight planets in our Solar System; Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune. Mnemonic: ***M**y **V**ery **E**ducated **M**other **J**ust **S**erved **U**s **N**achos.*

Q: **Is that all, only eight planets?**
A: No. In addition to the eight planets, there are also three known dwarf planets. Many more dwarf planets are likely to be discovered soon.

Q: **What is a dwarf planet?**
A: A dwarf planet is an object in orbit around the Sun that is large enough (massive enough) to have its own gravity pull itself into a round (or nearly round) shape. Generally, a dwarf planet is smaller than Mercury. A dwarf planet may also orbit in a zone that has many other objects in it. For example, an orbit within the asteroid belt is in a zone with lots of other objects.

Q: **How many dwarf planets are there?**
A: Currently there are three objects accepted as dwarf planets. Ceres, Pluto and Eris.

Q: **What is Ceres?**
A: Ceres is (or now we can say it was) the largest asteroid, about 1000 km across, orbiting in the asteroid belt between Mars and Jupiter. Ceres now qualifies as a dwarf planet because it is now known to be large enough (massive enough) to have self-gravity pulling itself into a nearly round shape. (Thomas, 2005) Ceres orbits within the asteroid belt and is an example of the case of an object that does not orbit in a clear path. There are many other asteroids that can come close to the orbital path of Ceres.

Q: **Didn't Ceres used to be called an asteroid or minor planet?**
A: Historically, Ceres was called a planet when it was first discovered in 1801, orbiting in what is known as the asteroid belt between Mars and Jupiter. In the 19th century astronomers could not resolve the size and shape of Ceres, and because numerous other bodies were discovered in the same region, Ceres lost its planetary status. For more than a century, Ceres has been referred to as an asteroid or minor planet.

Q: **Why is Pluto now called a dwarf planet?**
A: Pluto now falls into the dwarf planet category on account of its size and the fact that it resides within a zone of other similarly-sized objects known as the transneptunian region.

Q: **Is Pluto's satellite Charon a dwarf planet?**
A: For now, Charon is considered just to be Pluto's satellite. The idea that Charon might qualify to be called a dwarf planet in its own right may be considered later. Charon may receive consideration because Pluto and Charon are comparable in size and orbit each other, rather than just being a satellite orbiting a planet. Most important for Charon's case as a dwarf planet is that the centre of gravity about which Charon orbits is not inside of the system primary, Pluto. Instead this centre of gravity, called the barycentre, resides in free space between Pluto and Charon.

Q: **Jupiter and Saturn, for example, have large spherical satellites in orbit around them. Are these large spherical satellites now to be called dwarf planets?**
A: No. All of the large satellites of Jupiter (for example, Europa) and Saturn (for example, Titan) orbit around a common centre of gravity (called the "barycentre") that is deep inside of their massive planet. Regardless of the large size and shapes of these orbiting bodies, the location of the barycentre inside the massive planet is what defines large orbiting bodies such as Europa, Titan, etc. to be satellites rather than planets. [Actually, there has been no official recognition that the location of the barycenter is involved with the definition of a satellite.]

Q: **What was 2003 UB_{313}?**
A: 2003 UB_{313} was a provisional name given to a large object discovered in 2003 that resides in an orbit around the Sun beyond Neptune. It is now called Eris and is recognised as a dwarf planet.

Q: **Why is Eris a dwarf planet?**
A: Hubble Space Telescope images have resolved the size of Eris showing it to be as large as, or larger than Pluto, Brown (2006).More important, Eris was found to have a satellite, which was later named Dysnomia, after the Greek demon of lawlessness who was Eris' daughter. In 2007, the mass of Eris was determined to be $(1.66 \pm 0.02)\times10^{22}$ kg, 27% greater than Pluto, based on observations of the orbit of Dysnomia. Eris also orbits within the transneptunian region - a region that has not been cleared out. Therefore Eris is a dwarf planet.

Q: **What is an object called that is too small to be either a planet or dwarf planet?**
A: All objects that orbit the Sun that are too small (not massive enough) for their own gravity to pull them into a nearly spherical shape are now defined as being small Solar System bodies. This class currently includes most of the Solar System asteroids, near-Earth objects (NEOs), Mars and Jupiter Trojan asteroids, most Centaurs, most transneptunian objects (TNOs) and comets.

Q: **What is a small Solar System body?**
A: The term "small Solar System body" is a new IAU definition to encompass all objects orbiting the Sun that are too small (not sufficiently massive) to satisfy the definition of planet or dwarf planet.

Q: **Is the term minor planet still to be used?**
A: The term "minor planet" may still be used. But generally the term small Solar System body will be preferred.

Q: **How will an official decision be reached on whether or not to call a newly discovered object a planet, dwarf planet, or a Solar System body?**
A: The decision on how to classify newly discovered objects will be made by a review committee within the IAU. The review process will be an evaluation, based on the best available data, of whether or not the physical properties of the object satisfy the definitions. It is likely that for many objects, several years may be required to gather sufficient data.

Q: **Are there additional planet candidates currently being considered?**
A: No. None appear likely in our Solar System. But there are planet discoveries galore around other stars.

Q: **Are there additional dwarf planet candidates currently being considered?**
A: Yes. Some of the largest asteroids may be candidates for dwarf planet status and some additional dwarf planet candidates beyond Neptune will soon be considered.

Q: **When will additional new dwarf planets likely be announced?**
A: Probably within the next few years.

Q: **How many more new dwarf planets are there likely to be?**
A: There may be dozens or perhaps even more than a hundred waiting to be discovered.

Q: **What are plutoids?**
A: Plutoids are celestial bodies in orbit around the Sun at a semimajor axis greater than that of Neptune that have sufficient mass for their self-gravity to overcome rigid body forces so that they assume a hydrostatic equilibrium (near-spherical) shape, and that have not cleared the neighbourhood around their orbit. Satellites of plutoids are not plutoids themselves, even if they are massive enough that their shape is dictated by self-gravity. The two known and named plutoids are Pluto and Eris. It is expected that more plutoids will be named as science progresses and new discoveries are made. (Read more)

Q: **Can a satellite orbiting a plutoid be a plutoid too?**
A: No, according to the IAU Resolution B5 a dwarf planet can not be a satellite, even if they are massive enough that their shape is dictated by self-gravity.
(Read more)

References

Brown, M. et al. 2006, Astrophysical Journal, 643, L61

Thomas, P. et al. 2005, Nature, 437, 224