

## Air and Space this Week

### Item of the Week

# CERES AND THE SEVEN DWARFS

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**KEY WORDS:** Ceres Pluto Charon Quaoar Orcus Haumea Eris Makemake Sedna Gongong

*Everyone has an opinion on whether or not Pluto is a "Planet" or not. It's not. There is no logical definition under which Pluto would be a planet, and Ceres not be. However, Ceres and Pluto aren't alone in the newest category, "dwarf planets!" This is their story.*

### THE DISCOVERY OF PLUTO

The start of our story is actually the discovery of Uranus.

Ancient peoples were quite familiar with the night sky and the movements of the Sun, Moon, and stars. Any given star was known to follow the same path across the sky, rising and setting at the same points on the horizon, just at a different time of day during the year. But there were seven objects in the sky that did not follow that pattern: the Sun, the Moon, and five others. We know them from the names given them from Roman mythology: Mercury, Venus, Mars, Jupiter, and Saturn. [That there were seven objects that moved relative to the stars is the reason that we have a calendar divided into seven-day weeks!]

Astronomer William Herschel was making maps of the stars and other objects in the sky with his telescope around the time of the Revolutionary War. He and his sister would find a number of nebulae and even a few comets. But on March 13, 1781, he found an object unlike any other. It looked like a tiny greenish disc, not a sharp point of starlight. He went back to it on several successive nights and realized with a shock that it was moving slowly relative to the background stars. He made careful measurements and sent them to a mathematician, Anders Lexell, a member of the Russian Academy of Science and a friend of math genius Johann Euler, had worked on preparations for the 1769 transit of Venus international effort (see [here](#)).

Lexell was on a scientific tour and happened to be in London when Herschel found the little green disc. Herschel gave him the observational data collected, and from it, Lexell was startled to calculate that Herschel's disc was in orbit around the Sun, farther from it than was Saturn!

Herschel (and everyone else) was amazed; a new planet had "swum into his ken!" Most astronomers had royal patrons in those days, as did Herschel, and he quickly moved to curry favor (and moola) from George III by naming this new planet "George's Star." The rest of Europe snorted their disgust. Greek mythology saved the day. Mercury, Venus, and Mars were all Olympians; Jupiter was their leader (if not father). Saturn (Cronos) was nominally Jupiter's

father. So who's Saturn's dad? Let's name the new planet after him, to keep it all in the mythological family. That would be Uranus, and so the new planet became known.

Astronomers continued observing the new planet to mathematically describe its orbit more precisely. After a while, they noticed that Uranus wasn't following the exact orbital path it should. Astronomers trusted their observational and computational methodology, but what could be wrong?

A few astronomers realized that the gravity of yet another planet farther from Sun than Uranus could possibly produce the small deviation observed. Two made calculations and sent them to an observatory/authority to see if it could be found. The British one languished, the French one went to Germany, and very soon thereafter, a new planet was found. In the telescope, it had a bluish color, and astronomers, running out of Olympian begats, turned to the deep blue sea and agreed to name the new planet Neptune.

Percival Lowell, of Mars Canal (in)fame, thought that if there was an eighth planet, there might be a ninth, discoverable by the mathematical techniques that led to Neptune. He had an observatory (still in robust operation!), made careful measurements, and found what he was looking for: a deviation from which the location of the ninth planet could be derived. He made his calculations, and hired an astronomer by the name of Clyde Tombaugh, whose systematic study of the areas indicated turned up another planetary body, in 1930. A school student suggested "Pluto," in keeping with the Roman Gods theme, and it was quickly adopted by the International Astronomical Union (IAU), the governing authority on such things. Walt Disney gave Micky Mouse a dog with that name a few months later.

Eight decades would pass before we got a close look at this strange object.

We knew that it had an orbit unlike the others in the Solar System, one more eccentric and much farther from the plane near which all the planets follow. We knew that it had a moon that was much larger relative to the size of its planet than all of the others in the Solar System, except for Earth.

One person was determined to find out more by sending a spacecraft to fly by it, Alan Stern. He was the genesis and sparkplug behind the New Horizons mission, which has been an overwhelming success. We got a good look at a strange planet. (But it has "heart!") Find out more about *New Horizons* [here](#).

## THE DEBATE AND THE DECISION

Learning more about Pluto, as well as other objects in the Solar System, had posed a problem for the IAU.

The process of scientific inquiry was in play here. The Greeks knew only about five planets in the sky. They couldn't ever see any more, until the telescope was invented and, years later, another planet was found by accident. They knew planets, moons, and stars. That's it. So if anything new came along it would be initially classed as one or the other. *But if it was really, really new, the classification scheme would have to change to accommodate it.*

Our ground-based observational technology has advanced greatly in since Tombaugh's time. We now know that Pluto isn't the only other body like it out there beyond Neptune. One of them, Eris, may even be larger than Pluto. They all have highly-elliptical orbits.

Meanwhile, an object much closer to the Sun than Pluto was garnering a lot of attention. The very first asteroid ever discovered, 1 Ceres, was one of the targets of the *DAWN* spacecraft. Ceres is also the largest asteroid, so big that its gravity caused it to have a spherical shape. Altering the Greek system to include "asteroids" (a terrible name because they are not "little stars" at all!) was bad enough, but now one of them was different than the others.

The Solar System was getting more complicated than the Greeks could have imagined!

Astronomers realized that the Greek "planet-moon-star-asteroid" view could not accommodate the diversity of bodies being discovered, and the IAU struggled to come up with a refinement of the classification needed. They came up with the following definition of what constitutes a "planet." A planet:

- Orbits its host star directly (our Sun)
- Is massive enough to approach hydrostatic equilibrium (be spherical)
- Is massive enough to clear its orbit of other bodies

Ceres, Pluto, and the other trans-Neptunian bodies all meet the first criterion. Ceres, Pluto, Eris, and perhaps others meet the second. None of them, however, meet the third. That would suggest strongly the need for a more comprehensive classification system for Solar System objects.

The IAU did recognize that Ceres, Pluto, *et al.*, were important in the understanding of the creation and evolution of the Solar System. Except for Ceres, the others had significant similarities of composition and movement to warrant putting them in a new, separate class, "Dwarf Planets." IMHO, it's an unfortunate choice of name, but the distinctness of the grouping made creation of a separate category necessary.

The upshot of the nomenclature decision "promoted" Ceres from "asteroid" to "dwarf planet." Nobody squawked. But Pluto was "demoted" from "planet" to "dwarf planet." Problems ensued! People felt kinship to little Pluto, a classic example of an underdog. Having Disney PR behind your name didn't hurt, either. A generation that learned the planets from, "My Very Education Mother Just Served Us Nine Pizzas" became lost. [How about, "My Very Economical Mother Just Served Us Nada?"]

The IAU could come up with no objective set of criteria that would allow Pluto to be a "planet" and not allow at least Ceres to have the same status. It was never a case to be made for there to be nine planets again by fiat; it was either eight or "many!"

## **CERES AND THE SEVEN DWARFS**

### **CERES**

The discovery of 1 Ceres in 1801 (**224 years ago on 1/24!**) by Giuseppe Piazzi was covered in detail in an earlier Item of the Week ([here](#)). The DAWN mission and the present state of knowledge of Ceres will be the topic of a future Item. It's the only Dwarf Planet in the inner Solar System; the rest are all trans-Neptunian Objects. In addition to Ceres, the IAU has approved Dwarf Planet status for Pluto, Quaoar, Haumea, and Makemake. Eris is a shoo-in for the designation, because it rivals Pluto in size and mass. Planetary scientists, if not the IAU, also include Orcus, Gonggong, and Sedna.

## **PLUTO/CHARON**

The story of the discovery of Pluto was related briefly above, and in more detail [here](#) and in many other resources. Its large satellite, Charon, was discovered in 1978. Charon may be just large enough to be considered a “dwarf planet” but fails on the second criterion, so it remains officially a “moon,” albeit an odd one because it is so large compared to the object it orbits.

## **QUAOAR**

The first of the other trans-Neptunian objects discovered was Quaoar. It's about half the size of Pluto. Its rounded shape is ellipsoidal, but not so much as to disqualify it from “dwarf planet” status. We know its surface has water ice and ammonia hydrate, and it has a very thin atmosphere of methane. Quaoar has a moon, named “Weywot,” discovered in 2007. The names come from the Tongva people in southern California; Quaoar is their creator deity and Weywot is his son.

The discovery of Quaoar was the result of a systematic search for Kuiper Belt Objects (KBOs), the Caltech Wide Area Sky Survey. A moving object was observed by Chad Trujillo and Michael Brown, who searched a variety previous survey images in order to calculate its orbit. The two earliest images that had the new object on them but not recognized were acquired in 1983 as part of a systematic search for the hypothesized “Planet X.” Brown/Trujillo cut some corners on the IAU-sanctioned process for reporting and naming such things, but the IAU's official announcement of the discovery was October 7, 2002.

Recent stellar occultation observations by Quaoar show that it has a faint ring system. Houmea's rings had been discovered already by that point, even if Quaoar itself was discovered and rated as a dwarf planet first.

The actual discovery of an until-then-only-hypothesized KBO got people thinking about how to classify it/them.

## **ORCUS**

The team of Mike Brown and Chad Trujillo was joined by David Rabinowitz soon after the discovery of Quaoar. The first two named were working out of the two Gemini Observatories; Rabinowitz was from Yale. They found a moving object on February 17, 2004, were able to find a number of precovery (“previous to discovery”) images at Palomar and elsewhere, which enabled them to determine its orbit. They had learned the process of making such a discovery

official, and Orcus was accepted by the IAU on November 26, 2004. Orcus was the Etruscan “Punisher of the Condemned.” Orcus was found to have a moon on March 30, 2005, via examination of images acquired by the *HST*; it would be named Vanth, a winged female entity of the Etruscan Underworld.

Orcus, like Pluto, it is in a 2:3 orbital resonance with Neptune, ranging from 30 to 48 AU from the Sun over the course of its year (245 Earth years). Its diameter is ~600 miles; Vanth’s is about half that. Orcus is at the lower limit of size necessary to retain heavier volatiles like ammonia and methane. Its surface spectrum is similar to that of Charon and the five larger moons of Uranus, but ascertaining the surface composition directly is difficult, apart from the presence of water ice.

If Orcus and Vanth are considered together, they should have enough mass to rate “dwarf planet” status, but as of the time of this writing, the IAU has not made that determination formally.

## **HAUMEA**

Two teams claimed credit for the discovery of the next dwarf planet. On December 28, 2004, the Brown team had identified a moving object in data they had acquired earlier in the year. They published an on-line abstract about it in July, 2005, and applied for telescope time to confirm the discovery so they could announce its discovery at a conference in September. Meanwhile, a team at the Sierra Nevada Observatory in Spain found the same body on images they had acquired on March 7-10, 2003, guided in their search by the abstract, and they submitted the discovery report through proper channels. When the Brown team found out, they claimed the credit. Chaos ensued. Solomonicly, the IAU established a joint committee for naming the new find. No discoverers were named officially, the Spanish observatory was credited with the images that led to the discovery, and the name chosen was from the Brown team. “Haumea” is the matron goddess of Hawai’i, identified both with Papa, the Goddess of the Earth, and the wife of Wākea, God of Space.

Haumea spins on its axis very rapidly, causing it to have a strongly-ellipsoid shape, confirmed by observations of it passing in front of a background star. If its rotation were much faster, Haumea would fly apart. Its density is low, 1.8 g/cc, meaning it is composed largely of ices. That, and its high albedo, suggest Haumea is covered largely by crystalline ices, without a lot of darker materials present on some other KBOs, which would be consistent with a surface produced by cryovolcanism, eruptions of water and icy spray. The same occultation that revealed its shape also revealed the fact that Haumea has a faint ring system, well inside its Roche Limit. It’s the first KBO with rings, discovered with the same technique (but better equipment) that found Uranus’ rings (see [here](#)).

Haumea has two small moons, named Hi’iaka and Namaka, named for daughters of Haumea. Their orbits around Haumea, and their spectra, suggest they are fragments of Haumea detached via a relatively-recent impact event. The two orbit in different planes, and cause perturbations in each other’s movements.

## ERIS

Eris was discovered on January 5, 2005, again by the Brown team in survey images acquired at Palomar fifteen months earlier. Their unofficial name for their find was "Xena." I suppose a warrior princess might have an appeal to a lonely astronomer.... Eris was about the same size as Pluto, perhaps larger, but its highly elliptical orbit took it much farther from the Sun than Pluto. Eight months later, astronomers determined that Eris, like Pluto, had a moon; "Gabiella," of course.

It was Xena that spurred the IAU to action, and on August 26, 2006, after long debate, the "dwarf planet" category was created. And the IAU, in a rather wry spirit, named the new dwarf planet, "Eris," after the Greek Goddess of Discord! Her name means "strife," she was the daughter of Zeus and Hera, the sister of Ares, and it was she who threw the three [Apples of Discord](#), an act that led directly to the Trojan War. Gabiella became Dysnomia, the demon goddess daughter of Eris.

Astronomers have ascertained only a few basic facts about Eris: its year is 557x longer than Earth's; its mean distance from the Sun is ~68 AU, but varies due to the eccentricity of the orbit; its month (Dysnomia) is 16 Earth days; and its day is 25.9 Earth hours. The diameter of Eris is ~1440 miles, which is large enough to earn IAU "dwarf planet" status. Eris appears to have a very thin atmosphere that will at times freeze out on the surface. There is some evidence for the presence of a sub-surface ocean of liquid on Eris, as is the case for Pluto and ...

## MAKEMAKE

The Brown team found this object on March 31, 2005. They named it "Makemake," the creation deity for the Rapa Nui people (Easter Island), in anticipation of IAU recognition. It's the largest classical KBO (objects whose entire orbit lies outside that of Neptune, as opposed to plutinos, whose perihelia are inside Neptune's orbit). Its orbit is inclined 29° to the Ecliptic Plane, and its year is 306 Earth years long. Its spectrum shows strong absorption bands due to methane. Its surface is partially covered by highly-reflective nitrogen and methane ices, but there are some darker areas, too. Like Pluto and Eris, there is some evidence of geothermal activity and the presence of a sub-surface ocean. Makemake is known to have one small moon, "MK2."

## SEDNA

The seventh object likely to receive Dwarf status is Sedna, in addition to Ceres and Pluto, discovered by the Brown team on November 14, 2003. Sedna is somewhat of an oddball; its orbit is very large and very elliptical, resulting in a year approximately 11,400 Earth years long. Its perihelion is 76 AU and its aphelion is a whopping 937 AU. Determination of its size is difficult; it appears to be slightly smaller than Charon. It is the only dwarf planet candidate that does not have a known moon. Its surface color is distinctly red, almost as red as Mars, suggesting that it has a cover of organic (not biologic) material, called [tholins](#). Ethane ice has also been identified on the surface, and compounds like methanol may also be present.

Sedna's orbit poses some problems for astronomers. Its perihelion distance is too great for it to have been influenced by Neptune's gravity, as some of the other KBOs seem to have been. The leading idea is that Sedna lies on the dividing line between the outer Kuiper Belt and innermost Oort Cloud. Astronomers think that the Sun formed along with a loose cluster of other stars that have dispersed in Space since their formation; their gravity could have had a great influence on objects at Sedna's distance from the Sun, at least in the early days of the Solar System.

Ceres and the Seven Dwarfs: **Pluto**, **Quaoar**, Orcus, **Haumea**, **Eris**, **Makemake**, and Sedna. Those with bold names are IAU official Dwarf Planets. Orcus and Sedna will likely get that status eventually. But wait! There's more! There's always more.

## GONGGONG

The Brown team scored again with the discovery of Gonggong on July 17, 2007 (announced in January 2009). Less is known about it, but it has an elliptical orbit (34 x 101 AU) and enough mass to likely to be nearly-spherical. It was named after a water god in Chinese mythology, one responsible for creating chaos and catastrophe. Gonggong's sidekick was a nine-headed poisonous snake monster named Xiangliu, so when Gonggong's moon was discovered, naming it was easy. Gonggong is as large as the larger dwarfs, making it likely that its near-spherical in shape. Its size and shape make it a likely candidate for inclusion on the IAU's Dwarf Planet roster.

## CODA

Altering a scientific classification scheme is something that is supposed to happen as more data and other information are obtained. It happens all the time, because it is a fundamental property of the process of scientific inquiry. ***The publicity regarding the "demotion" of poor little Pluto gives us a great chance to inform the public of the operation of the process of scientific inquiry, how Science marches on!***

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