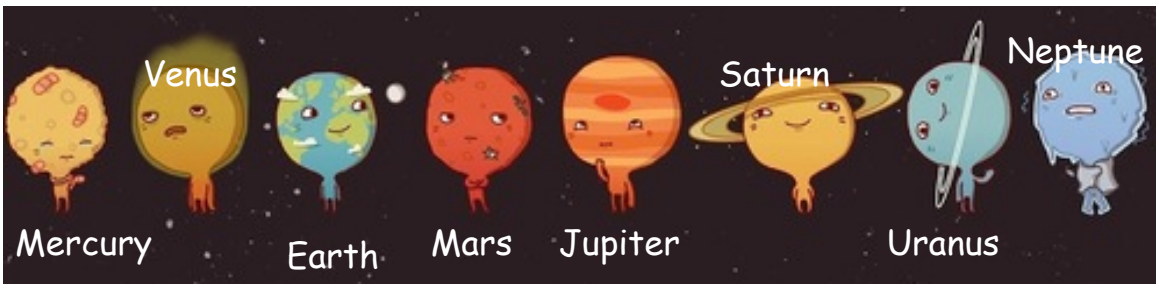
Astronomy book amendment - for books published before 2006.
Forward to NASA -Pluto, Classification and Exploration.

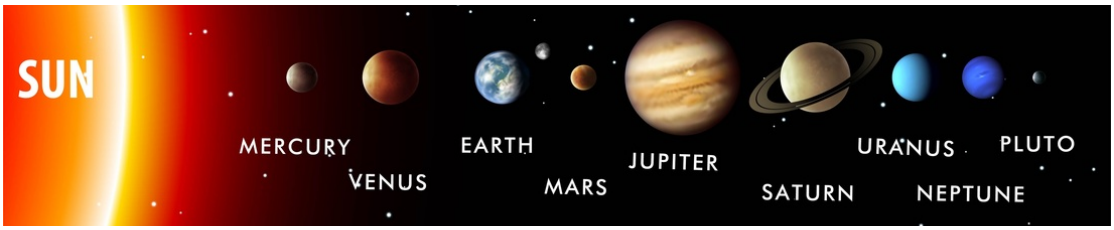
In 2006 the International Astronomical Union (IAU) changed the 'rules' for being a planet.
Now, the list of classic planets in our solar system includes:
Mercury, Venus, Earth, Mars, Jupiter, Saturn, Neptune and Uranus.

**[NEW]**




So until 2006 Pluto was a planet and the order was:
Mercury, Venus, Earth, Mars, Jupiter, Saturn, Neptune, Uranus and Pluto.

[OLD]




People used to use this acronym to remember the order of the planets:
My Very Easy Method Just Speeds Up Naming Planets.
Can you think of your own without the 'p' at the end?

**What's a planet?** A planet is a body that orbits the Sun, is massive enough for its own gravity to make it round, and has "cleared its neighbourhood"[1] of smaller objects around its orbit. Under this new definition, Pluto and the other trans-Neptunian[2] objects do not qualify as planets. The IAU's decision has not resolved all controversies, and while many scientists have accepted the definition, some in the astronomical community have rejected it outright.

For any extra help ask your class teacher.

J.T. Ferdinand

[1] An object being the dominant mass in its vicinity, for instance Earth being many times more massive than all of the Near Earth Asteroids combined, and Neptune "dwarfing" Pluto and the rest of the KBOs
[2] Objects past Neptune

## Why We Explore

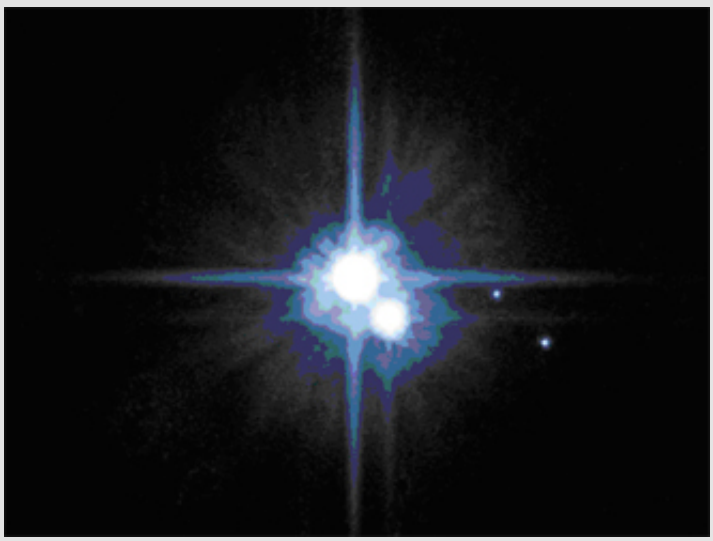
**Pluto, Classification and Exploration** **09.05.06**


***Editor's Note:*** *This is the 23rd in a series of essays on exploration by NASA's Chief Historian, Steven J. Dick.*

The recent General Assembly of the International Astronomical Union in Prague, where I voted with the majority to demote Pluto from planet to dwarf planet status, gives us pause to reflect on Pluto and the purpose of exploration. Even as the vote was taken in Prague, NASA's New Horizons spacecraft was speeding toward the edge of the solar system, some three billion miles away, to explore the nature of the object so much in dispute. At the time New Horizons launched in January, 2006, Pluto was the only planet in our solar system not yet visited by spacecraft. It will now become the first dwarf planet to be visited, in July, 2015, unless the Dawn spacecraft reaches Ceres (now also designated a dwarf planet) a few months earlier. In any case, Pluto is the vanguard of an entire new class of Trans-Neptunian Objects that are part of the Kuiper belt (or the Edgeworth-Kuiper belt, in another interesting dispute over nomenclature as opposed to definition). That status seems proper to me, and I believe that, despite a messy procedure and a definition that still requires some clarification, in the end the IAU made the right decision.

**Pluto**

History helps clarify the present situation. When Clyde Tombaugh discovered Pluto in 1930 using the 13-inch telescope at Lowell Observatory, it was only a point of light, detected among the background stars by its extremely slow motion. That motion translated to a 248-year orbital period, placing it at the edge of the solar system. It was a fantastic discovery, but Pluto at that time was not recognized as a new class of object, nor could it be, without knowing its mass. The mass, size and density of Pluto were for decades considered to be similar to the planet Mars. But this was very uncertain until James W. Christy, using the 61-inch astrometric reflector of the U. S. Naval Observatory (also in Flagstaff, four miles from Lowell Observatory), discovered its satellite Charon in 1978. Using Kepler's laws of motion, Pluto was then determined to have a mass only 1/400th of the Earth and a diameter of less than 1,500 miles, considerably smaller than our Moon. A low-grade debate began even then about the status of Pluto.



Pluto, center and it's previously known moon Charon, below Pluto and right of center, shine brightly. Two newly discovered moons, first imaged between May 15 and May 18, 2005, appear more faintly to the right of the pair. A team of astronomers, led by Hal Weaver of the Johns Hopkins Applied Physics Laboratory in Laurel, Md., and Alan Stern of the Southwest Research Institute in Boulder, Colo., made the new observations on Feb. 15, 2006, with Hubble's Advanced Camera for Surveys (ACS). Credit: NASA

The situation ramped up considerably in the early 1990s, when astronomers began to discover a variety of objects beyond Pluto, in what is known as the "Kuiper belt" to most Americans, or the "Edgeworth-Kuiper belt" to most Europeans. Objects given names like Sedna, Orcus, and Quaoar began popping up, all slightly smaller than Pluto. The situation was brought to a head in 2003 when Caltech astronomer Michael Brown discovered an object larger than Pluto, designated 2003

UB313. Was it the 10th planet, or was Pluto not a planet? And since many more similar objects are now known to exist in our solar system beyond Pluto, with more sure to be discovered, what is their status? The IAU General Assembly meets only every three years; thus these questions were brought up for a vote in Prague in 2006.

**Classification**

Dispassionately put, the status of Pluto and the Edgeworth-Kuiper Belt objects is a question of classification: of moving an object from one class to another with new knowledge in the case of the former, or of classifying newly discovered objects in the case of the latter. Classification is an important part of science, and has a long and distinguished history, especially in biology. As Linnaeus stated in his Systema Naturae (1735), "The first step in wisdom is to know the things themselves. This notion consists in having a true idea of the objects; objects are distinguished and known by classifying them methodically and giving them appropriate names. Therefore, classification and name-giving will be the foundation of our science." And as Stephen J. Gould has said more recently in connection with biology, "Taxonomies are reflections of human thought; they express our most fundamental concepts about the objects of our universe. Each taxonomy is a theory about the creatures [for astronomy, the objects] that it classifies." Indeed, this is why Pluto has raised so much emotion.

Classification in biology has been proceeding apace for almost three centuries since Linnaeus, and some of biology's most distinguished thinkers, including recently deceased Harvard Professor Ernst Mayr, have discussed its importance and its intricacies. Controversies abound at many taxonomic levels, including the top level of "Kindgom" or "Domain". But no biologist seriously questions the value of classification. Therefore the IAU was following the best tradition of science, not only in classifying Pluto, but also in changing classifications based on new knowledge. Creating a new class of objects, or moving objects to another class, is not unusual either in biology or astronomy. Historically astronomers have often had to reclassify objects with the growth of knowledge. There was the curious case of Chiron, discovered in 1979, thought at that time to be a comet or an asteroid. It is now classified as both, an intermediate object called a Centaur. In the case of quasars, originally called 'quasi-stellar objects,' the objects were moved from the realm of the stars to the realm of the galaxies when they were found to exist at the cores of active galaxies. Similarly, recently the reverse happened: the sources of short period gamma ray bursts were shown to be galactic rather than extragalactic, in other words, in the realm of the stars rather than the realm of the galaxies. And if we step back beyond astronomy, we see the same thing happening, historically and presently, in biology.

**The universe is what it is, not what we want it to be, and science must always be open to correcting its mistakes.**

Moreover, historically, the Pluto situation has occurred before in the solar system. Two centuries ago, in 1806, William Herschel's discovery of the 7th planet, Uranus, was exactly 25 years in the past. But astronomers were rejoicing in the discovery of 3 new planets in the last three years, Ceres in 1801, Pallas in 1802 and Juno in 1804. And Vesta was about to be discovered in 1807. So in 1806, astronomers thought there were 11 planets. Astronomer James Hilton has shown how for almost 50 years the Nautical Almanacs listed 12 planets, including Vesta. Then, 39 years after those 4 new planets had been discovered, came a problem: in 1847 three new one were found, and by the end of 1851 there were 15. Only by the mid-19th century, 'once their numbers grew too large to fit the existing scheme of classification,' were 'minor planets' or 'asteroids' accepted as a class of their own. We now face a similar problem: if Pluto is a planet, then immediately so are a dozen or more objects, and by the end of the decade the solar system will have 50 or more planets. We will be adding several planets per year to the solar system. What will the school kids say about that? Or we can reclassify Pluto as the IAU has done. Textbooks had to change in the 18th and 19th centuries with the discoveries of Uranus and Neptune. Surely we should not be less flexible now, though for sentimental reasons subtracting a planet seems to be more traumatic than adding.

Many will admit this much, but dislike the details of the definition. Definition is part of classification, and some members of the IAU's Planet Definition Committee have complained that the definition as adopted in Prague is not optimal. They may well be correct, since the crucial provision that a real planet must have "cleared the neighborhood around its orbit" is subject to interpretation and not readily understood by the public. But though the definition may be tweaked, I do not think it will, or should, change the result. It is the result of compromise between the planetary scientists (who agreed on the "roundness" criterion), and the dynamical astronomers (who insisted on the "clearing" criterion that tipped Pluto toward dwarf planet status). In his essay "The Eight Planets", Mike Brown, the discoverer of UB313, argues why the new classification should be accepted. The Pluto debate has starkly illustrated what those of us who have worked in the field have always known: astronomers can be passionate, irrational, and wrong. But in the end, consensus leads to progress.

Taking the longer view of history, we need to recognize that Pluto and the Edgeworth-Kuiper Belt objects are just the most recent episodes of problems of interpretation and classification that have taken place throughout the history of astronomy, the history of biology, and the history of science in general, wherever objects need to be classified, wherever 'natural history' is undertaken. As I pointed out in a lecture to the American Astronomical Society earlier this year proposing an overall classification system for astronomical objects, when one looks at history the lesson above all is that decisions about Pluto and other problematic objects should be based on a set of principles of classification, uniform and consistent across the field of astronomy, rather than on ad hoc personal feelings. An object needs to be classified, or reclassified, as new information comes in. In the case of Pluto we've waited 76 years, and had we known in 1930 what we now know about Pluto, it likely would never have been designated a planet. We need to use history to apply a consistent set of classification principles, but we should not invoke history because of a nostalgic attachment to any particular person or object. To use the title of historian of science Paul Farber's book, the best classification will reflect "the order of nature," and nature has made Pluto different from the other planets in our solar system, but similar to the Edgeworth-Kuiper belt objects. The universe is what it is, not what we want it to be, and science must always be open to correcting its mistakes.

**Exploration and Worldview**

NASA's position is that it will, of course, use the new guidelines established by the International Astronomical Union. The agency has said that it will continue pursuing exploration of the most scientifically interesting objects in the solar system, regardless of how they are categorized. That, of course, is only proper, but it should not demean the importance of classification to science. Exploration implies that objects will be reclassified based on new discoveries. The New Horizons spacecraft will undoubtedly yield mountains of information about Pluto and, by extension, about the new class of dwarf planets. If, however, the New Horizons spacecraft discovers that Pluto is actually Darth Vader's Death Star (unlikely, but Saturn's Mimas has a certain resemblance!), then it would have to be reclassified. I doubt this will happen. The classification problems of astronomy will not go away: refined knowledge about what constitutes a planet will undoubtedly be useful in classifying the more than 170 planets now known to exist beyond our solar system, and the thousands that are sure to be discovered when the Kepler spacecraft launches in 2008.


The venue for the IAU General Assembly in Prague, where the decision was made to reclassify Pluto. Image by Steven Dick.

Finally, the cultural reaction to the downgrading of Pluto has been extraordinary. Who would have thought so many people cared about Pluto? Some seem to be worried that their world view will now have to be changed from the one they acquired based on their textbooks. But surely the definition of textbooks (as opposed to the Bible, for example) is that they change with new knowledge. Over the last three quarters of a century, our astronomical world view has changed in much more profound ways than reclassifying Pluto, in terms of cosmic evolution, the possibilities of extraterrestrial life, the size of the universe, and our place in it. If people take that new knowledge as seriously as they have Pluto, and consider changing their worldviews accordingly, there will be an uproar worthy of real debate.

Further Reading

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***Steven J. Dick***
***NASA Chief Historian***

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