

LOSING IT IN PRAGUE:



The INSIDE STORY of

How many planets are there in our solar system?
It depends what you mean by the word “planet.”

By Owen Gingerich

When rumors began to spread that I would chair a committee for the International Astronomical Union (IAU) to recommend how to define the word “planet,” I promptly received a visitor with an emotional request.

“Don’t demote Pluto,” he pleaded. “Little children love Pluto. They’ll be heartbroken if you tell them Pluto isn’t a planet.”

The next day another caller came by. “Pluto would never have been considered a planet if astronomers had realized, when it was discovered in 1930, that it’s smaller and less massive than the Moon,” he said. “Don’t make the same scientific mistake again.”

I quickly realized that our committee would be treading through a minefield of contrary opinions held by passion-

ate stakeholders. Little did I suspect how that passion would play out!

COUNTING PLANETS

I knew that the roster of planets had changed numerous times over the ages. In antiquity the “wanderers” were seven — a mystic number! — comprising the Sun and Moon as well as the naked-eye planets: Mercury, Venus, Mars, Jupiter, and Saturn. In the heliocentric system of Nicolaus Copernicus there were only six planets, with the Sun and Moon off the list but with the Earth now accorded a new status.

When Galileo turned his new spy-glass (not yet named the telescope) to Jupiter in 1610, he found four small bodies in orbit around it. He asked his patron, Cosimo de Medici, for permission to name these objects the “Cosmian Planets.” But Johannes Kep-

ler promptly invented the word “satellites” to encompass the new bodies, so they became moons instead.

Not until 1781 did the roster of solar-system planets expand. That’s when William Herschel’s systematic sweep of the heavens turned up what he supposed to be a comet but turned out to be a new planet. After several decades of contention, everyone agreed to call it Uranus.

In 1801 yet another non-cometary body ascended to the ranks, when Giuseppe Piazzi added Ceres, the first of the objects found orbiting in the anomalously empty zone between Mars and Jupiter. Herschel sniffed that he would call them “asteroids” since they were too small to show anything but starlike points of light; clearly he didn’t think they deserved the same rank as his planet, which was resolv-



PLUTO'S DEMOTION

IAU illustration by Martin Kornmesser

able into a distinct aquamarine disk. But his son John was more generous, and in writing the 1833 forerunner to his *Outlines of Astronomy*, the greatest astronomy text of the 19th century, the younger Herschel listed 11 planets in order from the Sun: Mercury, Venus, Earth, Mars, Vesta, Juno, Ceres, Pallas, Jupiter, Saturn, and Uranus. The discovery of Neptune in 1846 made it an even dozen.

By the middle of the 19th century, though, it was becoming clear that the asteroids were much too small and numerous to be regarded as proper planets. In 1853 the *Monthly Notices of the Royal Astronomical Society* published a roster of 23 asteroidal objects under the title “minor planets.” That term eventually was incorporated into the name of the IAU’s Minor Planet Center, which keeps

track of the hundreds of thousands of such bodies now known.

When Pluto was discovered, astronomers assumed that it had a mass comparable to Earth’s. Only gradually, in the ensuing decades, did celestial mechanics come to realize that this was a gross overestimate; Pluto’s bulk is actually less than 1% of Earth’s. Meanwhile its other peculiarities had also become apparent: Pluto’s orbit is cocked 17° from the ecliptic plane in which the other planets travel, and its eccentric path occasionally carries it closer to the Sun than Neptune.

Clearly Pluto is very unlike its inner neighbors, the gas giants Uranus and Neptune, so much so that when the refurbished Hayden Planetarium in New York City unveiled its spiral planet walk, Pluto was deliberately excluded. Pluto partisans were scandalized, the planetarium basked in the ensuing publicity, and the *New York Times* editorialized that Pluto’s dethronement was a good idea because otherwise schoolchildren would soon have a list of planets too long to memorize.

In 1992 another trans-Neptunian object was discovered, and then an-

Above: If the International Astronomical Union (IAU) had adopted the definition of “planet” proposed by the committee led by author Owen Gingerich, our solar system would now have 12 planets, including the asteroid Ceres, the double planet Pluto-Charon, and the large Kuiper Belt object 2003 UB₃₁₃. After much wrangling, however, astronomers settled on a more restrictive definition that gives us eight planets; demotes Ceres, Pluto, and 2003 UB₃₁₃ to “dwarf planets”; and leaves Charon as Pluto’s largest satellite. Sizes, but not separations, are drawn to scale.

The IAU's planet-definition committee of astronomers, science historians, and writers gathers for a group photo during its meeting in Paris this past summer. Clockwise from upper left: Andre Brahic (University of Paris), Iwan Williams (Queen Mary University, London), Junichi Watanabe (National Astronomical Observatory of Japan), Richard Binzel (Massachusetts Institute of Technology), Owen Gingerich (Harvard-Smithsonian Center for Astrophysics), Dava Sobel (author of *Longitude*, *The Planets*, and *Galileo's Daughter*), and Catherine Cesarsky (European Southern Observatory).



IAU

other. We now know of thousands of small icy bodies in a zone called the Kuiper Belt. At least 100 of them, like Pluto, take 248 years to orbit the Sun, 1.5 times longer than Neptune's 165-year period. Gravitationally locked into a 3:2 resonance with Neptune, they were dubbed "plutinos."

The discovery in 2003 of Sedna, an object almost as big as Pluto, and then in the same year an even larger world temporarily designated 2003 UB₃₁₃ (*S&T*: October 2005, page 28), brought about a bureaucratic crisis. If 2003 UB₃₁₃ were deemed a planet, the responsibility for naming it would fall to the IAU's working group for planetary-system nomenclature, which has been particularly active in naming satellites. Otherwise the object's discoverers would propose a name to the Minor Planet Center, which would then forward it for approval to a different IAU committee, the one for small-body nomenclature.

PERPLEXED IN PARIS

With all this as background, a diverse international group of seven met face to face on the last day of June to consider the planet question. We assembled in a conference room at the Paris Observatory, once part of Louis XIV's stables.

Where to begin? We knew that the status of Pluto was the elephant in the parlor. Some committee members were serious plutophiles prepared to defend the ninth planet and to expand the planetary census to include all comparable Kuiper Belt objects. "What's wrong with kids learning the names of 50 planets?" asked one participant. "After all, they can learn 50 states and 50 state capitals." Others may have aimed to thumb their noses at astrologers by throwing Pluto out. And surely some thought a scientific error shouldn't be perpetuated.

Most important, everyone was convinced that scientific progress had opened up new vistas that couldn't have entered

into the decisions of prior centuries. It was the growth of scientific knowledge that had forced a new look at the meaning of "planet" for the 21st century, and thus we should give that new knowledge paramount consideration in our discussion.

I had compiled a source book of reference articles, some historical and others scientific. After reading this material, we looked at lists of the traditional planets, trans-Neptunian objects, and asteroids ordered by size. We pondered whether there were any scientifically justifiable breaks in their size distributions. Could we simply confer planetary status on bodies greater than a particular diameter? If so, would such a boundary exclude Pluto or include it along with some of its Kuiper Belt cousins?

As we struggled with these questions, we also examined the results of a previ-

PLANET?



S&T: RICHARD TRESCH FIENBERG

Using two lumps of modeling clay, planetary scientist Richard Binzel (MIT) demonstrates an easy way to teach kids the essential difference between planets, which are round, and small solar-system bodies, which are not. Alas, it's not that simple, because the IAU has defined a class of "dwarf planets" that are round and orbit the Sun but are not really planets.

COMMITTEE

ous 19-person IAU panel that had failed to reach a strong consensus after nearly two years of trying to define the word "planet." When we finally broke for dinner, we weren't confident that we could find a path through the labyrinth any more successfully than this earlier committee.

When we reconvened the next morning, several admitted they had spent a night of fitful sleep, wondering if we could frame a definition that we could all agree on and defend from both scientific and cultural viewpoints. And then, during the day, our diverse opinions coalesced into a miraculous unanimity.

As it turns out, there are two fundamentally different ways to define planets. One is to treat the planets as a dynamically interacting ensemble with bodies that perturb each other gravitationally. This approach is what led to Pluto originally being considered as massive as the Earth — to account for the perturbations on Neptune and Uranus that were supposedly the basis of Percival Lowell's prediction of a trans-Neptunian planet. But as the decades rolled by, astronomers realized that apparent irregularities in the motions of the outer planets were attributable to an erroneous mass assigned to Neptune. Pluto, discovered by coincidence roughly where Lowell said it should be, is actually an irrelevant lightweight compared to the main family of planets.

At the same time that dynamicists were coming to appreciate the small mass of Pluto, the Space Age began, producing fabulous postcards from other worlds. A whole new breed of planetary geologists — let's call them structuralists — began to take a deep interest in the physical nature of these bodies. Together these groups, with rather different interests and approaches, have led us to understand that the Sun's attendants comprise a very

complex mélange of objects ranging from Jupiter down to rocks, snowballs, pebbles, and dust. Even the line between asteroids and comets has become blurry as several objects have been found that display structural and dynamical characteristics of both.

Our task as a committee was to sort all this out, choosing a group of objects distinctive enough that an overwhelming majority of astronomers and the public would accept them as “planets.” We needed a physically defensible discriminator, not an arbitrarily chosen dividing line.

PLANETS IN THE ROUND

As we considered the problem afresh that Saturday morning, we realized that one suitable boundary was roundness, the distinction between tomatoes and potatoes. A celestial object is round when it is massive enough for its gravity to overpower the mechanical strength of its internal structure and pull it into a ball. Physicists refer to this state as *hydrostatic equilibrium*.

In an astronomy textbook that I once adopted, Saturn was depicted floating in a bathtub, a vivid way to show that its average density is less than that of water. But one day a guest lecturer pointed out that it is physically impossible to build a bathtub big enough to hold Saturn — the tub’s own gravity would collapse it into a ball of porcelain and steel. That’s hydrostatic equilibrium! It applies to rocky bodies with masses exceeding about 0.1% of Earth’s mass and diameters about 800 kilometers (500 miles) or larger, and to icy ones about half that size.

A scientific definition of “planet” based on roundness includes a substantial number of Pluto’s cousins, the dirty ice balls beyond Neptune. These objects, like Pluto itself, tend to have eccentric orbits noticeably inclined to the ecliptic plane, and they are all much smaller than the Moon. These are planets, yes, but of a distinct category from the other eight.

At this point a suggestion I had pro-

posed the previous afternoon became increasingly attractive: why not call these objects “plutons”? Here is a short, two-syllable word very similar to “planet,” and one that preserves Pluto’s role as the prototype of the newly defined class. In this way it could act like the name “cepheid” in referring to its prototype among variable stars, Delta Cephei. Soon there was unanimous enthusiasm in the committee that “pluton” allowed both a historical and cultural nod to Pluto, while at the same time removed it from the pantheon of “classical” planets.

We were close, but our work was not quite done. Besides dotting the i’s and crossing the t’s of possible IAU resolutions to be voted on at the late-August General Assembly in Prague, Czech Republic, there was still the fact that our proposed definition also included the original minor planet, Ceres. Recent pictures from space verify that it meets the roundness criterion.

We had already added a period requirement for plutons: 200 years or more to circumnavigate the Sun, the same number that divides long-period and short-period comets. So Ceres was clearly not a pluton, but then again, it hardly qualified as a classical planet even though it had functioned in that role for several decades in the 19th century. So for now we suggested that it be categorized as a lonely “dwarf planet” plying its orbit among the rocky lumps of the asteroid belt between Mars and Jupiter.

PROBLEMS IN PRAGUE

In the weeks between our Parisian conference and the gathering in Prague, the IAU Executive Committee enthusiastically endorsed our proposed resolution. But its members also worried about an effective strategy to guide it through a possibly quite contentious forum. In particular, they feared that if astronomers learned of our group’s recommendations from incomplete or garbled accounts in the press, they would be predisposed to vote against it. For this reason, IAU officials decided to keep the proposal under wraps until the

day after the General Assembly’s inaugural ceremony on August 15th.

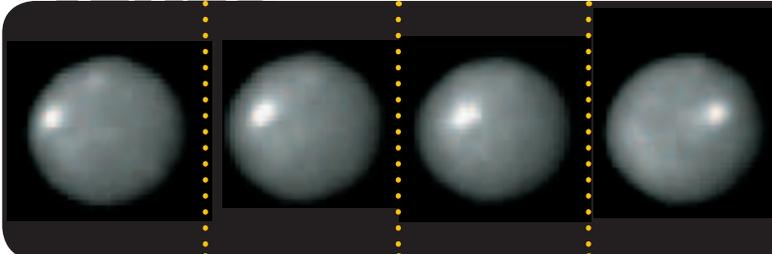
Reporters had already gotten wind that the IAU would consider a planet-definition proposal, so the press room in Prague’s conference center was a beehive of activity even before the opening session. In preparing a press release, the experts were convinced that the public would want the answers to two questions: is Pluto still a planet, and how many planets are there? Our committee had never actually counted the number, knowing full well that a few more plutons would be added before the year was out, but I was unable to persuade the writers of the press release simply to say, “eight classical planets, Ceres, and a growing number of plutons.”

So the official press release announced that if the proposed resolution passed, Pluto would still be a planet, and, based on a technical footnote, there would be 12 planets in all. In addition to the traditional nine, the list would include Ceres; soon-to-be-renamed 2003 UB₃₁₃; and Pluto’s largest companion, Charon, because the center of mass of the Pluto-Charon system lies in free space between the two bodies, making them in effect a “double planet.”

It didn’t take long before we knew we’d made a strategic error. A few skeptics said, “Ceres and Charon, huh?” and, dwelling on these two anomalies, complained that the whole thing was too complicated, especially for children. The press, eager to promote controversy, soon found astronomers who agreed with the criticism.

There was more trouble to come. A meeting of the IAU’s planetary systems science division on August 18th was fractious and raucous, with objections on many fronts. Several dynamicists said they felt ignored by our largely structuralist approach to the problem. They put forward a counter-resolution that added a defining condition, making a planet not only round but also “the dominant object in its local population zone.” In a stroke, they believed, this somewhat vague requirement neatly eliminated Ceres, Pluto, and the other icy balls beyond

CERES



Only a small fraction of the solid bodies in our solar system are massive enough for their self-gravity to overcome internal structural forces and pull their bulk into a ball. The asteroid Ceres, 930 kilometers (580 miles) in diameter, is one such object, as revealed in these images from the Hubble Space Telescope. Ceres almost became a planet at the IAU General Assembly in Prague. But because the rocky body is too diminutive to clear out the smaller chunks orbiting the Sun in the asteroid belt, astronomers decided to call it a “dwarf planet” instead.

NASA / ESA / J. PARKER (SWRI) / P. THOMAS (CORNELL UNIV.) / L. MCFADDEN (UNIV. OF MARYLAND)

■ inside story of pluto's demotion

Neptune, leaving only eight planets.

In a straw poll neither our original resolution nor the dynamicists' alternative garnered a majority. There was universal agreement on only one point: after Italian astronomer Andrea Milani noted that *Pluton* is the name for Pluto in the romance languages, attendees overwhelmingly rejected using the name "pluton" to describe the class of modest-size round objects in the Kuiper Belt. (Our committee had been aware of a possible problem here, but since the two French-speaking members had raised no objections, we thought we were on solid ground. We were wrong.)

Later that afternoon a quorum of the planet-definition committee caucused with IAU president Ron Ekers and other officers to see if our definition could be simplified to address some of the objections and to give a more prominent place to the term "dwarf planets," which the planetary scientists seemed to favor. Ekers proposed breaking the resolution into parts in the hope that each part could individually muster a majority. The resulting resolution thus had two principal components:

(1) A planet is a celestial body that (a) has sufficient mass for its self-gravity to overcome rigid-body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (b) is in orbit around a star, and is neither a star nor a satellite of a planet.

(2) In our solar system we distinguish between the eight "classical planets," as the dominant objects in their local population, and "dwarf planets," which are not.

In the meantime our resolution received the endorsement of the Division for Planetary Sciences of the American Astronomical Society, the world's largest group of planetary scientists. And in presenting the revised resolution to a union-wide open meeting on August 22nd, I read from an endorsement from the National Sharing the Sky Foundation, which said, "This definition looks to the future [and] is very important to the public perception of astronomy, especially to children trying to make sense of their environment. We strongly encourage its approval." Yet the dynamicists persisted in their vehement objections to a definition of "planet" that did not give a prominent role to orbits and the dynamical evolution of the solar system.

Once again our committee and the IAU officers convened, this time including two representatives from the opposition: Milani and Uruguayan astronomer Gonzalo Tancredi. They insisted that for dynamics to be in the second tier of the definition was not good enough. But as Ekers pointed out, whereas our revised definition was a clear compromise, to include a primarily dynamical criterion for planethood represented a 180° turnaround from what our committee had proposed. In our resolution Pluto remained a planet, though of a special category, whereas in the counter-proposal Pluto was no longer a planet of any kind.

I suggested revising the wording again to acknowledge that some planets are

heavyweights and perturb their neighbors, while others are lightweights and do not, but the critics would have none of this. Even Ceres can influence the Earth, they argued, moving it by a few meters. Consequently, under the tutelage of the IAU Resolutions Committee, another draft containing the vague and ambiguous words "dominant object in its local population zone" was hurriedly prepared for an ad hoc continuation of the day's earlier open forum. At the same time, the resolution was explicitly restricted to our own solar system, because the particular dynamical evolution of the Sun's family would not necessarily apply to planetary systems around other stars.

In this second session the revised text appeared to meet with general approval. But again the concession to Pluto's historic past, that is, the naming of a special class of trans-Neptunian objects to honor Pluto as the prototype, was rejected. Finally, at the end of a long queue at the microphone, I made an appeal to name the class "plutonians" rather than "plutons," a suggestion we got from Donald Lubowich (Hofstra University, New York).

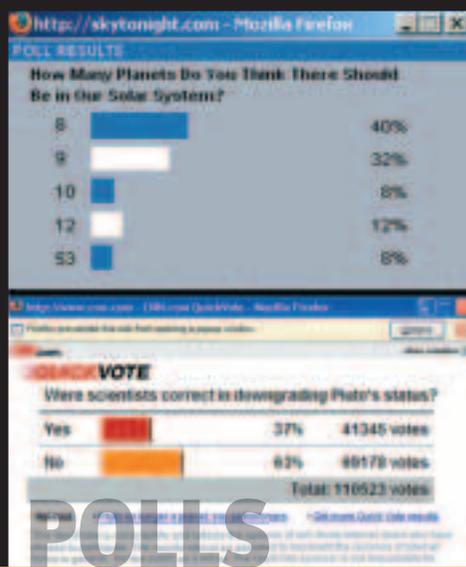
As I was leaving the hall, my mobile phone rang. It was Dennis Overbye, a former *Sky & Telescope* staffer and now a leading science writer for the *New York Times*. "It looks like Pluto's status as a planet is doomed," I told him.

That night I tossed and turned thinking of the problems that remained in the draft. I gradually realized that the addition of a single word would solve a glaring semantic problem. By placing the word "classical" before the word "planet" in the definition,



IAU members eligible to vote receive yellow cards as they file into the assembly hall, then hold the cards high to cast their vote for or against a resolution. This was the scene in Prague on August 24th when astronomers voted to limit the solar system to eight "planets" and demote Pluto to the status of "dwarf planet," a category that will surely grow as deep surveys turn up more large, round objects in the Kuiper Belt beyond Neptune.

IAU / LARS HOLM-NIELSEN



Amateur astronomers and the general public were not happy after the IAU vote, if you can believe these unscientific tallies from two Web sites.

there would be two categories of planets: classical planets and dwarf planets. The last version of the text I'd seen defined both "planet" and "dwarf planet," but in such a way that a "dwarf planet" was not a planet. This, in my opinion, was a linguistic absurdity and brought to mind Humpty Dumpty scornfully telling Alice, "When I use a word, it means just what I choose it to mean — neither more nor less." True, astronomers have been living for 1½ centuries with "minor planets" that aren't considered planets, but that's a term hardly ever used by nonspecialists, and here was our chance to set everything right for both astronomers *and* the public.

Unfortunately I was heading to the airport with a plane ticket arranged many weeks earlier before I realized what a cliffhanger the upcoming vote would prove to be. I sent an e-mail proposing that in the definition to be voted on at the closing assembly on August 24th, the word "classical" should be added before "planet," thus defining two different sorts of planets, the eight dominating classical planets and the dwarf planets. This would make Ceres, Pluto, 2003 UB₃₁₃, and other modest-size round objects planets, albeit lightweights in a system of heavyweights. I also reiterated my objection that the phrasing the dynamicists had suggested to define a planet would be immensely confusing.

DENOUEMENT

Two days later I tuned in to the webcast of the IAU General Assembly's closing session. I was gratified to see that members were given a chance to add the word "classical" to the definition of "planet," but



JAY W. PASAGHOFF / SCIENCE FACTORION

Jocelyn Bell Burnell, the codiscoverer of pulsars and a member of the IAU Resolutions Committee, demonstrates how the umbrella term "planets" could encompass "classical planets" like Neptune (represented by a balloon) and "dwarf planets" like Ceres and Pluto (represented by a cereal box and a Disney toy). But the IAU chose instead to define only "planets" and "dwarf planets," with the latter not considered planets at all.

DOGGONE

saddened when this was rejected by a substantial margin. I was then horrified to see that the words "dominant object in its local population zone" had been replaced by the equally ambiguous and scientifically questionable phrase "cleared the neighborhood around its orbit." And I was disappointed when the category name "plutonians" narrowly lost in what was essentially a tie vote.

At that point Catherine Cesarsky gave an eloquent and passionate plea for the relevance of cultural sensitivity to the public understanding and support of astronomy, but it was too late. The voting members, a tiny minority of the 2,700 astronomers who had passed through the conference center's doors during the preceding 10 days, declined the opportunity to reconsider any of what they'd just decided. Perhaps they just wanted to be done with it and go home.

As I write this, the backlash has already begun. Mark V. Sykes (Planetary Science Institute) points out, "The problem with this definition is that it is too simple and

leads to nutty consequences." Indeed, a Scottish newspaper has already carried the headline "Pluto Row Could Lead to Neptune Losing Planet Status," since the giant Neptune has not yet cleared the dwarf Pluto from its neighborhood. What other silliness awaits?

Our solar system is a wondrously interesting place, far more complex than Percival Lowell could ever have dreamt when he predicted the existence of a major planet beyond Neptune. Our telescopes and spacecraft have opened up fascinating new vistas that will be the heritage of today's schoolchildren. While the nearly 10,000 members of the IAU will be heavily involved in exploring this rich diversity, it's a shame that a few hundred stumbled in trying to keep it simple. *

Because OWEN GINGERICH is both an astrophysicist and a historian of science, he was a logical choice to chair the IAU's planet-definition committee. He is a professor emeritus at the Harvard-Smithsonian Center for Astrophysics.

PLANETARY PARTICULARS

Here is the complete text, including footnotes, of "Definition of a 'Planet' in the Solar System," adopted at the International Astronomical Union (IAU) General Assembly in Prague, Czech Republic, on August 24th.

Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particu-

lar, to the designation "planets." The word "planet" originally described "wanderers" that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.

The IAU therefore resolves that "planets" and other bodies in our solar system be defined into three distinct categories in the following way:

(1) A "planet"¹ 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) shape², and (c) has cleared the neighborhood around its orbit.

(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 neighborhood around its orbit, and (d) is not a satellite.

(3) All other objects³ except satellites orbiting the Sun shall be referred to collectively as "small solar-system bodies."

The IAU further resolves that Pluto is a "dwarf planet" by the above definition and is recognized as the prototype of a new category of trans-Neptunian objects.

¹The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. ²An IAU process will be established to assign borderline objects into either dwarf planet and other categories. ³These currently include most of the solar-system asteroids, most trans-Neptunian objects, comets, and other small bodies.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.