= IAU definition of planet =

The definition of planet set in Prague , Czech Republic in August 2006 by the International Astronomical Union ( IAU ) states that , in the Solar System , a planet is a celestial body which :
is in orbit around the Sun ,
has sufficient mass to assume hydrostatic equilibrium ( a nearly round shape ) , and
has " cleared the neighborhood " around its orbit .
A non @-@ satellite body fulfilling only the first two of these criteria is classified as a " dwarf planet " . According to the IAU , " planets and dwarf planets are two distinct classes of objects " . A non @-@ satellite body fulfilling only the first criterion is termed a " small Solar System body " ( SSSB ) . Initial drafts planned to include dwarf planets as a subcategory of planets , but because this could potentially have led to the addition of several dozens of planets into the Solar System , this draft was eventually dropped . The definition was a controversial one and has drawn both support and criticism from different astronomers , but has remained in use .
According to this definition , there are eight known planets in the Solar System . The definition distinguishes planets from smaller bodies and is not useful outside the Solar System , where smaller bodies cannot be found yet . Extrasolar planets , or exoplanets , are covered separately under a complementary 2003 draft guideline for the definition of planets , which distinguishes them from dwarf stars , which are larger .

= = Reasons for the debate = =

Before the discoveries of the early 21st century , astronomers had no real need for a formal definition for planets . With the discovery of Pluto in 1930 , astronomers considered the Solar System to have nine planets , along with thousands of smaller bodies such as asteroids and comets . Pluto was thought to be larger than Mercury .
In 1978 , the discovery of Pluto 's moon Charon radically changed this picture . By measuring Charon 's orbital period , astronomers could accurately calculate Pluto 's mass for the first time , which they found to be much smaller than expected . Pluto 's mass was roughly one twenty @-@ fifth of Mercury 's , making it by far the smallest planet , smaller even than the Earth 's Moon , although it was still over ten times as massive as the largest asteroid , Ceres .
In the 1990s , astronomers began finding other objects at least as far away as Pluto , now known as Kuiper Belt objects , or KBOs . Many of these shared some of Pluto 's key orbital characteristics and are now called plutinos . Pluto came to be seen as the largest member of a new class of objects , and some astronomers stopped referring to Pluto as a planet . Pluto 's eccentric and inclined orbit , while very unusual for a planet in the Solar System , fits in well with the other KBOs . New York City 's newly renovated Hayden Planetarium did not include Pluto in its exhibit of the planets when it reopened as the Rose Center for Earth and Space in 2000 .
Starting in 2000 , with the discovery of at least three bodies ( Quaoar , Sedna , and Eris ) all comparable to Pluto in terms of size and orbit , it became clear that either they all had to be called planets or Pluto would have to be reclassified . Astronomers also knew that more objects as large as Pluto would be discovered , and the number of planets would start growing quickly . They were also concerned about the classification of planets in other planetary systems . In 2006 , the matter came to a head with the first measurement of the size of 2003 UB313 . That measurement had showed Eris ( as it was mistakenly believed to be until the ' New Horizons ' mission to Pluto ) to appear to be slightly larger than Pluto , and so was thought to be equally deserving of the status of ' planet ' at the time .

= = = Historical parallel = = =

The process of new discoveries spurring a contentious refinement of Pluto 's categorization echoed a debate in the 19th century that began with the discovery of Ceres on January 1 , 1801 . Astronomers immediately declared the tiny object to be the " missing planet " between Mars and

Jupiter . Within four years , however , the discovery of two more objects with comparable sizes and orbits had cast doubt on this new thinking . By 1851 , the number of " planets " had grown to 23 , and it was clear that hundreds more would eventually be discovered . Astronomers began cataloguing them separately and began calling them " asteroids " instead of " planets " .

= = History of the definition = =

Because new planets are discovered infrequently , the IAU did not have any machinery for their definition and naming . After the discovery of Sedna , it set up a 19 @-@ member committee in 2005 , with the British astronomer Iwan Williams in the chair , to consider the definition of a planet . It proposed three definitions that could be adopted :

Cultural
a planet is a planet if enough people say it is ;
Structural
a planet is large enough to form a sphere ;
Dynamical
the object is large enough to cause all other objects to eventually leave its orbit .

Another committee , chaired by a historian of astronomy , Owen Gingerich , a historian and astronomer emeritus at Harvard University who led the committee which generated the original definition , and consisting of five planetary scientists and the science writer Dava Sobel , was set up to make a firm proposal .

= = First draft proposal = =

The IAU published the original definition proposal on August 16 , 2006 . Its form followed loosely the second of three options proposed by the original committee . It stated that :

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 .

This definition would have led to three celestial bodies being recognized as planets :

Ceres , which had been considered a planet at the time of its discovery , but was subsequently treated as an asteroid
Charon , a moon of Pluto ; the Pluto @-@ Charon system would have been considered a double planet
Eris , a body in the scattered disk of the outer Solar System

A further twelve bodies , pending refinements of knowledge regarding their physical properties , were possible candidates to join the list under this definition . Some objects in this second list were more likely eventually to be adopted as ' planets ' than others . Despite what had been claimed in the media , the proposal did not necessarily leave the Solar System with only twelve planets . Mike Brown , the discoverer of Sedna and Eris , has said that at least 53 known bodies in the Solar System probably fit the definition , and that a complete survey would probably reveal more than 200 .

The definition would have considered a pair of objects to be a double planet system if each component independently satisfied the planetary criteria and the common center of gravity of the system ( known as the barycenter ) was located outside of both bodies . Pluto and Charon would have been the only known double planet in the Solar System . Other planetary satellites ( like Earth and its moon ) might be in hydrostatic equilibrium , but would still not have been defined as a component of a double planet , since the barycenter of the system lies within the more massive celestial body ( the Earth ) .

The term " minor planet " would have been abandoned , replaced by the categories " small Solar System body " ( SSSB ) and a new classification of " pluton " . The former would have described those objects underneath the " spherical " threshold . The latter would have been applied to those planets with highly inclined orbits , large eccentricities and an orbital period of more than 200 earth

years ( that is , those orbiting beyond Neptune ) . Pluto would have been the prototype for this class . The term " dwarf planet " would have been available to describe all planets smaller than the eight " classical planets " in orbit around the Sun , though would not have been an official IAU classification . The IAU did not make recommendations in the draft resolution on what separated a planet from a brown dwarf . A vote on the proposal was scheduled for August 24 , 2006 .

Such a redefinition of the term " planet " could also have led to changes in classification for the trans @-@ Neptunian objects Haumea , Makemake , Sedna , Orcus , Quaoar , Varuna , 2002 TX300 , Ixion , 2002 AW197 , and the asteroids Vesta , Pallas , and Hygiea .

On 18 August the Division of Planetary Sciences of the American Astronomical Society endorsed the draft proposal .

According to an IAU draft resolution , the roundness condition generally results in the need for a mass of at least 5 × 1020 kg , or diameter of at least 800 km . However , Mike Brown claims that these numbers are only right for rocky bodies like asteroids , and that icy bodies like Kuiper Belt objects reach hydrostatic equilibrium at much smaller sizes , probably somewhere between 200 and 400 km in diameter . It all depends on the rigidity of the material that makes up the body , which is in turn strongly influenced by its internal temperature . Assuming that Methone 's shape reflects the balance between the tidal force exerted by Saturn and the moon 's gravity , its tiny 3 km diameter suggests Methone is composed of icy fluff .

= = = Advantages = = =

The proposed definition found support among many astronomers as it used the presence of a physical qualitative factor ( the object being round ) as its defining feature . Most other potential definitions depended on a limiting quantity ( e.g. , a minimum size or maximum orbital inclination ) tailored for the Solar System . According to members of the IAU committee this definition did not use human @-@ made limits but instead deferred to " nature " in deciding whether or not an object was a planet .

It also had the advantage of measuring an observable quality . Suggested criteria involving the nature of formation would have been more likely to see accepted planets later declassified as scientific understanding improved .

Additionally , the definition kept Pluto as a planet . Pluto 's planetary status was and is fondly thought of by many , and the general public could have been alienated from professional astronomers ; there was considerable uproar when the media last suggested , in 1999 , that Pluto might be demoted , which was a misunderstanding of a proposal to catalog all trans @-@ Neptunian objects uniformly .

= = = Criticism of first draft proposal = = =

The proposed redefinition was criticised as ambiguous : Astronomer Phil Plait and NCSE writer Nick Matzke both wrote about why they thought the redefinition was not , in general , a good one . It defined a planet as orbiting a star , which would have meant that any planet ejected from its star system or formed outside of one ( a rogue planet ) could not have been called a planet , even if it fit all other definitions . A similar situation already applied to the term ' moon ' , such bodies ceasing to be moons on being ejected from planetary orbit ; this usage had widespread acceptance . Similarly , the redefinition did not differentiate between planets and brown dwarf stars . Any attempt to clarify this differentiation was to be left until a later date .

There had also been criticism of the proposed definition of double planet : at present the Moon is defined as a satellite of the Earth , but over time the Earth @-@ Moon barycenter will drift outwards ( see tidal acceleration ) and could eventually become situated outside of both bodies . This development would then upgrade the Moon to planetary status at that time , according to the redefinition . The time taken for this to occur , however , would be billions of years , long after many astronomers expect the Sun to expand into a red giant and destroy both Earth and Moon .

In an 18 August 2006 Science Friday interview , Mike Brown expressed doubt that a scientific

definition was even necessary . He stated , " The analogy that I always like to use is the word " continent " . You know , the word " continent " has no scientific definition ... they 're just cultural definitions , and I think the geologists are wise to leave that one alone and not try to redefine things so that the word " continent " has a big , strict definition . "

On 18 August , Owen Gingerich said that correspondence he had received had been evenly divided for and against the proposal .

= = Alternative proposal = =

According to Alan Boss of the Carnegie Institution of Washington , a subgroup of the IAU met on August 18 , 2006 and held a straw poll on the draft proposal : only 18 were in favour of it , with over 50 against . The 50 in opposition preferred an alternative proposal drawn up by Uruguayan astronomer Julio Ángel Fernández .

Under this proposal , Pluto would have been demoted to a dwarf planet .

= = Revised draft proposal = =

On 22 August the draft proposal was rewritten with two changes from the previous draft . The first was a generalisation of the name of the new class of planets ( previously the draft resolution had explicitly opted for the term ' pluton ' ) , with a decision on the name to be used postponed . Many geologists had been critical of the choice of name for Pluto @-@ like planets , being concerned about the term pluton which has been used for years within the geological community to represent a form of magmatic intrusion ; such formations are fairly common balls of rock . Confusion was thought undesirable due to the status of planetology as a field closely allied to geology . Further concerns surrounded use of the word pluton as in major languages such as French and Spanish , Pluto is itself called Pluton , potentially adding to confusion .

The second change was a redrawing of the planetary definition in the case of a double planet system . There had been a concern that , in extreme cases where a double body had its secondary component in a highly eccentric orbit , there could have been a drift of the barycenter in and out of the primary body , leading to a shift in the classification of the secondary body between satellite and planet depending on where the system was in its orbit . Thus the definition was reformulated so as to consider a double planet system in existence if its barycenter lay outside both bodies for a majority of the system 's orbital period .

Later on August 22 , two open meetings were held which ended in an abrupt about @-@ face on the basic planetary definition . The position of astronomer Julio Ángel Fernández gained the upper hand among the members attending and was described as unlikely to lose its hold by August 24 . This position would result in only eight major planets , with Pluto ranking as a " dwarf planet " . The discussion at the first meeting was heated and lively , with IAU members in vocal disagreement with one another over such issues as the relative merits of static and dynamic physics ; the main sticking point was whether or not to include a body 's orbital characteristics among the definition criteria . In an indicative vote , members heavily defeated the proposals on Pluto @-@ like objects and double planet systems , and were evenly divided on the question of hydrostatic equilibrium . The debate was said to be " still open " , with private meetings being held ahead of a vote scheduled for the following day .

At the second meeting of the day , following ' secret ' negotiations , a compromise began to emerge after the Executive Committee moved explicitly to exclude consideration of extra @-@ solar planets and to bring into the definition a criterion concerning the dominance of a body in its neighbourhood .

= = Final draft proposal = =

The final , third draft definition proposed on 24 August was :

= = = Plenary session debate = = =

Voting on the definition took place at the Assembly plenary session during the afternoon . Following a reversion to the previous rules on 15 August , as a planetary definition is a primarily scientific matter , every individual member of the Union attending the Assembly was eligible to vote .

The IAU Executive Committee presented four Resolutions to the Assembly , each concerning a different aspect of the debate over the definition . Minor amendments were made on the floor for the purposes of clarification .

Resolution 5A constituted the definition itself as stated above . There was much discussion among members about the appropriateness of using the expression " cleared the neighbourhood " instead of the earlier reference to " dominant body " , and about the implications of the definition for satellites . The Resolution was ultimately approved by a near @-@ unanimous vote .

Resolution 5B sought to amend the above definition by the insertion of the word classical before the word planet in paragraph ( 1 ) and footnote [ 1 ] . This represented a choice between having a set of three distinct categories of body ( planet , " dwarf planet " and SSSB ) and the opening of an umbrella of ' planets ' over the first two such categories . The Resolution proposed the latter option ; it was defeated convincingly , with only 91 members voting in its favour .

Resolution 6A proposed a statement concerning Pluto : " Pluto is a dwarf planet by the above definition and is recognized as the prototype of a new category of trans @-@ Neptunian objects . " After a little quibbling over the grammar involved and questions of exactly what constituted a " trans @-@ Neptunian object " , the Resolution was approved by a vote of 237 ? 157 , with 30 abstentions . A new category of dwarf planet was thus established . It would be named " plutoid " and more narrowly defined by the IAU Executive Committee on 11 June 2008 .

Resolution 6B sought to insert an additional sentence at the end of the statement in 6A : " This category is to be called ' plutonian objects ' . " There was no debate on the question , and in the vote the proposed name was defeated by 186 ? 183 ; a proposal to conduct a re @-@ vote was rejected . An IAU process will be put in motion to determine the name for the new category .

On a literal reading of the Resolution , " dwarf planets " are by implication of paragraph ( 1 ) excluded from the status of ' planet ' . Use of the word planet in their title may , however , cause some ambiguity .

= = Final definition = =

The final definition , as passed on 24 August 2006 under the Resolution 5A of the 26th General Assembly is :

The IAU further resolves :

The IAU also resolved that " planets and dwarf planets are two distinct classes of objects " , meaning that dwarf planets , despite their name , would not be considered planets .

= = Criticism = =

= = = Substance = = =

The wording of the final draft of the definition has continued to be criticized . Notably , Alan Stern , the lead scientist on NASA 's robotic mission to Pluto , has contended that Earth , Mars , Jupiter , and Neptune have not fully cleared their orbital zones , just like Pluto . Earth orbits with 10 @,@ 000 near @-@ Earth asteroids . Jupiter , meanwhile , is accompanied by 100 @,@ 000 Trojan asteroids on its orbital path . Stern has asserted : " If Neptune had cleared its zone , Pluto wouldn 't be there . "

Some astronomers counter this opinion by saying that , far from not having cleared their orbits , the major planets completely control the orbits of the other bodies within their orbital zone . Although Jupiter does coexist with a large number of small bodies in its orbit ( the Trojan asteroids ) , these bodies only exist in Jupiter 's orbit because they are in the sway of the planet 's huge gravity . Earth

accretes or ejects near @-@ Earth asteroids on million @-@ year time scales , thereby clearing its orbit . Similarly , Pluto may cross the orbit of Neptune , but Neptune long ago locked Pluto and its attendant Kuiper belt objects , called plutinos , into a 3 : 2 resonance ( i.e. , they orbit the Sun twice for every three Neptune orbits ) . Since the orbits of these objects are entirely dictated by Neptune 's gravity , Neptune is therefore gravitationally dominant .

Some aspects of the definition are as yet difficult to apply outside the Solar System . Techniques for identifying extrasolar objects generally cannot determine whether an object has " cleared its orbit " , except indirectly via an orbit @-@ clearing criterion . The wording of the 2006 definition is heliocentric in its use of the word Sun instead of star or stars , and is thus not applicable to the numerous objects which have been identified in orbit around other stars . A separate " working " definition for extrasolar planets was , however , recommended by a working group of the IAU in 2003 and includes the criterion : " The minimum mass / size required for an extrasolar object to be considered a planet should be the same as that used in the Solar System . "

= = = Process = = =

The final vote has come under much criticism because of the relatively small percentage of the 9000 @-@ strong membership who participated . Besides the fact that most members do not attend the General Assemblies , this lack was also due to the timing of the vote : the final vote was taken on the last day of the 10 @-@ day event , after many participants had left or were preparing to leave . The claim is that only 424 astronomers were present for the vote , which is less than 5 % of the entire community of astronomers . However , sampling 400 representative members out of a population of 9 @,@ 000 statistically yields a result with good accuracy ( confidence interval better than 5 % ) . There is also the issue of the many astronomers who were unable or who chose not to make the trip to Prague and , thus , cast no vote . Astronomer Marla Geha has clarified that not all members of the Union were needed to vote on the classification issue : only those whose work is directly related to planetary studies .

= = Impact = =

The decision generated cultural and societal implications , affecting the " industry of astronomical artifacts and toys . " Most educational books that included the definition were printed after 2006 . The decision was important enough to prompt the editors of the 2007 edition of the World Book Encyclopedia to hold off printing until a final result had been reached . The new designation also has repercussions in the astrological world and finds mixed receptions , with differences of opinion as to whether to make any changes to astrological practice as a result of the redefinition .

= = = Popular culture = = =

The impact of the revised definition , particularly the change in the status of Pluto , has been reflected in popular culture . A number of musical contributions have commemorated the change :

" Planet X " ( 1996 ) , song by Christine Lavin . A good @-@ natured protest against suggestions that Pluto is not a planet .

" Pluto " ( 1998 ) , song by 2 Skinnee J 's . An impassioned defense of Pluto 's status as a planet .

Thing a Week , August 25 , 2006 podcast by Jonathan Coulton . Featured a song " I 'm Your Moon " , from Charon 's point of view , about Pluto being reclassified as a dwarf planet .

" Bring Back Pluto " ( 2007 ) , song by Aesop Rock on the album None Shall Pass . Hip @-@ hop song supporting Pluto 's status as the 9th planet in the Solar System .

" Pluto " ( 2009 ) , song by Robbie Fulks , part of his release " 50 @-@ vc . Doberman . " About Pluto 's reclassification , remembered as a 9th planet from the times of the singer 's youth , and re @-@ presents Pluto as an unforgotten monarch of the Kuiper Belt .

" Ode to Pluto " is the final track on Terra Lumina 's self @-@ titled debut album , mentioning the change of classification .

= = = Plutoed = = =

The verb to pluto ( preterite and past participle : plutoed ) was coined in the aftermath of the 2006 IAU decision . In January 2007 , the American Dialect Society chose plutoed as its 2006 Word of the Year , defining to pluto as " to demote or devalue someone or something , as happened to the former planet Pluto when the General Assembly of the International Astronomical Union decided Pluto no longer met its definition of a planet . "

Society president Cleveland Evans stated the reason for the organization 's selection of plutoed : " Our members believe the great emotional reaction of the public to the demotion of Pluto shows the importance of Pluto as a name . We may no longer believe in the Roman god Pluto , but we still have a sense of connection with the former planet " .

= = New dwarf planet subclass = =

On June 11 , 2008 , the IAU announced that the subcategory of dwarf planets with trans @-@ Neptunian orbits would be known as " plutoids " . In an accompanying press release , the IAU said that :

This subcategory includes Pluto , Haumea , Makemake and Eris .