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Pluto's Classification

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Lurking billions of miles away from the sun, a desolate, frigid world silently waited to be discovered. After observing that both Uranus and Neptune mysteriously wobbled on their paths around the sun, astronomers hypothesized that a planet, nicknamed "Planet X," was responsible for tugging these two celestial bodies out of their typical orbits. In 1930, Clyde Tombaugh excitedly exclaimed that he had finally found Planet X spinning in the deep, icy outer limits of the solar system. Later, this barren body was named Pluto. As telescopes improved, astronomers discovered many more celestial objects quietly orbiting the sun beyond Neptune. Soon, confusion arose over which of these Trans-Neptunian Objects were categorized as official planets. To clear up the uncertainty, the International Astronomical Union (IAU), the universally recognized, governing astronomical organization to which all professional astronomers worldwide adhere, developed official definitions for both planets and dwarf planets (IAU 1). Each of these definitions consists of three criteria. While two of the criteria are identical for planets and dwarf planets, the IAU declares that planets clear the neighborhood around their orbits, but dwarf planets do not clean their orbital zones of celestial debris (Definition 1). In addition to creating definitions for planets and dwarf planets, the IAU also recategorized Pluto as a dwarf planet, stripping the celestial body of planetary status (Maran 2). The public was dismayed by this decision like a child whose ice cream cone fell on the ground. Today, astronomers still debate whether Pluto should be categorized as a planet or as a dwarf planet. Because astronomers can mathematically calculate that Pluto's neighborhood is scattered with celestial debris such as comets and asteroids, Pluto should be categorized as a dwarf planet.

After William Hershel discovered Uranus in 1781 (Cleere 1), astronomers observed that the planet had many irregularities in its orbit. Instead of having a smooth orbit like all of the other known planets at the time, Uranus's orbit mysteriously wobbled. Puzzled by these orbital deviations, astronomers thoroughly studied the irregularities. Until Uranus was discovered, all of the known planets in the solar system could accurately be predicted using Newton's laws of gravitation (O'Connor 1). At first, Uranus also perfectly followed these rigorous equations; however, overtime the planet slowly began to stray farther and farther from its predicted location (O'Connor 1). Carefully observing Uranus's orbital deviations, John Adams hypothesized that another planet was pulling on Uranus causing the planet to wobble (Cleere 1). Also, Urbain Le Verrier separately published a paper explaining that a massive planet must be responsible for Uranus's orbital irregularities. In addition, Le Verrier's essay predicted the position for this mysterious planet (O'Connor 3). Surprisingly, both Adams's and Le Vierre's papers contained nearly identical positions for the planet even though neither of the men knew of the other (O'Connor 3). After diligently searching the dark distant skies, Johann Galle discovered Neptune in 1846 adding an eighth planet to the solar system (Cleere 1). Later, astronomers observed that Neptune also had an irregular orbital pattern similar to Uranus's heliocentric path. Thus, Neptune did not solve the puzzle for the mysterious force pulling Uranus out of its typical orbital path. Astronomers nicknamed the celestial body responsible for pulling both Neptune and Uranus out of their orbits "Planet X" or "Planet Nine" (Maran 113). Mathematical calculations at the time indicated that Planet X lay beyond Neptune in the far ends of the solar system and had a mass approximately ten times the mass of earth. Like a match lighting up a firework, these calculations sparked interest in astronomers worldwide. Driven by the desire to finally fulfill the quest of discovering Planet Nine, astronomers such as William Pickering and Percival Lowell rapidly searched the deep night sky in hopes to discover the peculiar celestial object.

During the early 1900s, astronomers worldwide eagerly searched for Planet X. Deeply obsessed with planet hunting fever, Percival Lowell repeatedly calculated the deviations in Uranus's and Neptune's orbits and computed what he believed to be Planet X's routinal path around the sun. In addition, Lowell funded many searches for Planet Nine and opened his own observatory, Lowell Observatory, in Flagstaff, Arizona (Maran 11). Unfortunately, he died in 1916 before fulfilling his dream of discovering Planet X. However, Lowell's death did not soften the deafening scream to find the mysterious celestial object. After Lowell's death, Vestro Sipher became the director of the observatory. Sipher added new telescopes and hired astronomers, including Clyde Tombaugh, to continue the quest for Planet X. Tombaugh scanned and photographed the night sky. Then, he studied these photographs during the day with a blink comparator (Maran 121). After months of repeating this process, Tombaugh finally spotted a minuscule speck of light among billions of sparkling stars sluggishly yet consistently moving in the remote background of the outer solar system. Excitedly, he checked his calculations and photographs, which confirmed that he had found "Planet X" ending the search. As the news that a ninth planet in the solar system had finally been found rippled throughout the world, Clyde Tombaugh quickly grew famous as the first American to discover a planet in the solar system.

Around the world, people excitedly brainstormed names for the celestial body Tombaugh had discovered. Eventually, an eleven-year old girl living in England, Venetia Burney, suggested the name "Pluto," the name of the Roman god of the underworld to her grandfather (Maran 125). Agreeing with his granddaughter's suggestion, he passed it on to the International Astronomical Union. Because Pluto fit with the theme of naming planets in the solar system after Roman gods and the first two letters were the initials of Perceval Lowell, astronomers finally settled on Burney's suggestion after sifting through thousands of names (Maran 3). About fifty years later, astronomers discovered that Pluto had five moons accompanying the isolated icy world (Maran 162). Since Pluto is the name of the god of the underworld, its moons, Charon, Hydra, Nix, Kerberos, and Styx, were also named after Roman characters affiliated with the underworld. Because Pluto rests a staggering 3.6 billion miles from the sun, little was known about this distant land until 2015 when the first spacecraft, New Horizons, visited and photographed the barren world (Maran 9). After nine long years of flying through space, this spacecraft revealed the hostility of Pluto. For example, the average surface temperature is a chilling -400 degrees Fahrenheit. New Horizons' stunning photographs of Pluto revealed towering mountains, red methane snowfall, and an enormous heart-shaped ice plain (Bagenal 2). In addition, NASA's mission showed that Pluto and Charon always face each other similar to earth and its moon (Nagy 5). Billions of miles from the sun, Pluto discovered by Tombaugh proved to be an isolated, icy world.

After New Horizons visited Pluto in 2015, astronomers learned that Pluto did not have sufficient mass to deviate the orbits of Uranus and Neptune. Thus, the hunt for Planet X continues today. Surprisingly, they also noticed that Pluto had orbital irregularities similar to Uranus and Neptune. Since Pluto's discovery, many other dwarf planets such as Sedna, Eris, Ceres, and Biden have been found lurking in the outer limits of the solar system. For example, four years ago, Scott Sheppard spotted 2015 TG387, another celestial body isolated in the inky edges of the solar system (New 1). This celestial body, nicknamed "the Goblin," also wobbles on its orbit around the sun (Sheppard 1). This dwarf planet "has an orbit that is consistent with it being influenced by an unseen Super-Earth-sized Planet X on the solar systems' very distant fringes" (Discovered 2). Last year, Scott Sheppard and David Tholen discovered 2018 VG18 resting 120 AU from the sun (MPEC 2). However, astronomers have not yet determined if 2018 VG18, also called "Farout," has orbital deviations similar to the other distant objects in the solar system because of its staggering distance and slow speed (Discovered 2). To test if Planet X could deviate the orbits of these distant celestial bodies, two astronomers completed computer simulations to study the effects a massive planet would have on the Goblin's heliocentric path (While 1). They observed that the Goblin was gravitationally shepherded by Planet X. In other words, Planet X did not allow the Goblin to come near its orbit resulting in the Goblin having many orbital deviations (While 3). "This gravitational shepherding could explain why the most distant objects in the solar system have similar orbits" (While 3). Although all of the distant bodies in the solar system have similar deviated orbits and simulations have suggested that a massive celestial object is responsible for the orbital irregularities, this evidence does not prove that Planet X exists but instead supports this theory. As more clues are found pointing toward Planet X, astronomers are still searching the distant night skies in hopes of discovering this mysterious celestial body.

After finding Pluto, astronomers debated on whether this celestial object should be categorized as a planet or a dwarf planet. When Pluto was first discovered in 1930, astronomers firmly believed that this world was the ninth planet in the solar system. However, sixty-two years later, astronomers began to question Pluto's planetary status after other celestial bodies were discovered beyond Neptune. For example, in 2003 David Rabinowitz discovered another faint speck of light, which appeared to be a planet, in the outer limits of the solar system (Pluto and the 2). This world seemed to be even larger than Pluto. Soon, confusion sprang up because no one knew which of these Trans-Neptunian Objects were officially categorized as planets. Also, astronomers discovered a zone called the Kuiper Belt located beyond the orbit of Neptune in which thousands of small, planetary-like objects, including comets and asteroids, orbit the sun. Pluto was the first Kuiper Belt Object found. After Tombaugh's discovery, other objects that are comparable to Pluto's mass and size have been found in the Kuiper Belt, verifying that the outer solar system is more complex than previously thought. Astronomers began to wonder what truly distinguishes a planet from all other categories of celestial bodies. While certain criteria for planets did exist, these criteria were loose, general, and varied from one astronomer to another. Soon, confusion spread globally over how many planets were in the solar system. Oftentimes, astronomers argued whether Pluto or other Kuiper Belt Objects were categorized as planets. To solve the growing issue of whether or not Pluto was a planet, the International Astronomical Union (IAU) met in Prague, Czech Republic, to officially define what constitutes both planets and dwarf planets.

In 2006, the IAU General Assembly debated the characteristics of a planet (Pluto and the 2). Finally, the IAU announced three criteria, which officially define a planet. This union declared that a particular celestial body must comply with all three of these criteria to be classified as a planet. The assembly stated that a planet in the solar system 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, and (c) has cleared the neighborhood around its orbit" (Definition 1). The first of these three criteria is that the celestial body must orbit the sun. An orbit is "a regular, repeating path that one object takes around another object" (Rutledge 1). For example, the earth continually circles around the sun on the same path. This orbit constitutes one earth year. Additionally, comets and asteroids orbit the sun. However, not all celestial bodies in the solar system have heliocentric orbits. For instance, the earth's moon rotates around the earth instead of the sun. Since the moon completes a geocentric orbit as an alternative to a heliocentric path, the moon is categorized as a satellite of the earth, not a planet. According to the IAU General Assembly in 2006, the first criterion in determining whether a celestial body is classified as a planet in the solar system is that the body must orbit the sun.

The second criterion that the IAU proclaimed to distinguish a planet in the solar system from all other celestial bodies is that the object must withhold a hydrostatic equilibrium (Definition 1). In other words, all planets must have a spherical or nearly round shape. Celestial bodies of various sizes can obtain a hydrostatic equilibrium. For example, Mercury, the closest planet from the sun, has a diameter of 4,879 kilometers (North 159). The fifth planet from the sun, Jupiter, has approximately a 143,000-kilometer diameter (Lang 299). Even though Mercury's diameter is nearly thirty times smaller than Jupiter's diameter, both of these celestial bodies have a nearly spherical shape. Therefore, they meet the IAU's second criterion for planetary status. According to the IAU, all celestial bodies must assume hydrostatic equilibriums to be categorized as planets in the solar system.

The third criterion that a celestial body must follow to be categorized as a planet is that the body must clear its orbital zone (Definition 1). In other words, all planets have cleaned the area around their orbits of debris. While this criterion does not place an exact number on the mass a celestial body must have to be classified as a planet, in order to follow the third criterion, the body must have sufficient mass to push small objects out of its orbital zone. For example, Mercury has enough mass to clear its neighborhood from outside debris even though its diameter is almost thirty times smaller than Jupiter's diameter. Thus, Mercury is categorized as a planet. Comets and asteroids, which consistently orbit the sun like planets, are not large enough to clean their path from debris. Therefore, comets and asteroids are not classified as planets. The IAU defines planets in the solar system as celestial objects, which orbit the sun, have a nearly round shape, and have cleaned their orbital paths from debris (Definition 1).

In addition to defining a planet in the 2006 General Assembly, the IAU also debated on what constitutes dwarf planets in the solar system. After the assembly, the IAU announced that a dwarf planet is a celestial body that orbits the sun, assumes a hydrostatic equilibrium, and does not clear its orbital zone (Definition 1). In order to be classified as a dwarf planet, the celestial body must meet all three of these criteria. Like planets, dwarf planets in the solar system must also orbit the sun. For example, Ceres, classified as a dwarf planet by the IAU in 2006, also steadily circles the sun. Similar to a planet, a dwarf planet has sufficient mass to obtain a nearly round shape (Definition 1). While the first two criteria are the same for both planets and dwarf planets, the third criterion distinguishes these two categories of celestial objects. The IAU's third distinction of a dwarf planet is that the celestial body's neighborhood has not been cleared of debris (Definition 1). In other words, a dwarf planet's orbit is scattered with asteroids, meteoroids, and other celestial debris. Unlike planets, dwarf planets do not have enough mass to be gravitationally dominant, resulting in an orbit intercepted by debris. Thus, dwarf planets have less mass than planets. While both planets and dwarf planets orbit the sun and obtain hydrostatic equilibriums, celestial debris scatters only a dwarf planet's orbital zone (Definition 1).

After creating definitions for planets and dwarf planets in the solar system, the IAU demoted Pluto, originally classified as a planet, to a dwarf planet in the 2006 General Assembly "by a vote of 237 to 157" (Maran 200). Although Pluto was simply reclassified, this decision stirred up commotion worldwide (Maran 2). For example, "the reaction to the idea of demoting Pluto was so strong that in February 1999, the IAU General Secretary Johannes Anderson issued a press release denying that Pluto was being demoted" (Dick 19). Dismayed by Pluto's new status as a dwarf planet, some astronomers are still debating this issue today. Those, who argue that Pluto is worthy of a planetary status, demand that the IAU hold an assembly to reclassify Pluto as a planet. Many astronomers, who faithfully believe that Pluto is a planet, are still trying to disprove the IAU on the decision that the union concluded over a decade ago. While some believe that Pluto should be classified as a planet, Pluto should be categorized as a dwarf planet because this celestial object complies with all of the IAU's three criteria of a dwarf planet in the solar system: Pluto orbits around the sun, has a nearly spherical shape, and has not cleared its neighborhood from celestial debris.

The first reason Pluto should be categorized as a dwarf planet is that Pluto follows the IAU's first criterion of a dwarf planet in the solar system. According to the IAU, all dwarf planets must regularly orbit the sun (Definition 1). Zipping around the sun at approximately 10,623 miles per hour, Pluto steadily completes one heliocentric revolution every 247.6 earth years (Tholen 127). While Pluto does not spin around the sun at an unusual speed, this celestial body has a highly inclined orbit. Typical inclinations of planets are only a few degrees. For example, the inclination of Venus is 3.4 degrees while the inclination of Saturn is 2.5 degrees (Garlick 58). However, Pluto's inclination is slightly more than 17.2 degrees implying that the celestial object's orbit is greatly tilted with respect to the ecliptic and the planes of the other planets (Schmude 110). Also, unlike the eight planets, Pluto completes a highly eccentric orbit. All of the planetary orbits are somewhat elliptical similar to a flattened circle. The degree of the flattening is called eccentricity. Most eccentricities are small. While a perfect circle has an eccentricity of zero, the eccentricity of Mars is 0.093, and Mercury's eccentricity is 0.163 (Delsate 1). However, the eccentricity of Pluto is 0.249 implying that its distance to the sun varies greatly from 29.5 AU to 49.4 AU (Maran 139). At its perihelion, Pluto rests closer to the sun than Neptune, and the ice on its surface begins to sublime (Cruikshank 334). In addition to having a higher orbital eccentricity than the planets in the solar system, Pluto's orbit falls in a different plane than the planets due to a 17.16-degree inclination angle. However, the IAU disregards the eccentricity and inclination of an orbit when categorizing a celestial object. Even though Pluto's revolution around the sun is both highly eccentric and inclined, Pluto still orbits around the sun meeting the IAU's first criterion for a dwarf planet in the solar system that the celestial body must complete a heliocentric orbit.

Another reason that Pluto should be classified as a dwarf planet is that Pluto also falls under the IAU's second criterion for dwarf planets in the solar system. In addition to having a heliocentric orbit, the IAU declares that a celestial body must obtain a hydrostatic equilibrium (Definition 1). To assume a hydrostatic equilibrium, the celestial body must have enough mass. Also, “the threshold for roundness depends on the interior composition of the body and temperature-dependent material strength” (Margot 6). While these two characteristics play an important role in obtaining a hydrostatic equilibrium, this data is much more difficult to gather as it cannot be observed using a telescope from earth (Margot 6). Thus, the most easily obtainable and widely used quality to determine the shape of a celestial body is the object’s mass. In 2008, Tancredi and Favre proved that celestial objects, which have a diameter of at least 800 kilometers, always assumed a hydrostatic equilibrium (Margot 6). Therefore, celestial objects must have a minimum diameter of 800 kilometers to sustain a nearly round shape. Pluto’s diameter is approximately 2,300 kilometers (Pluto and Eris 1). Since Pluto’s diameter exceeds that which Tancredi and Favre concluded to be the minimal dimensions to obtain a hydrostatic equilibrium, Pluto has a nearly spherical shape. Because Pluto has sufficient mass to assume a hydrostatic equilibrium, Pluto complies with the IAU’s second requirement for a dwarf planet in the solar system.

The third reason that Pluto should be categorized as a dwarf planet is that Pluto follows the IAU’s third criterion of a dwarf planet in the solar system. While the first and second requirements are identical for both planets and dwarf planets, the IAU’s third criterion distinguishes these two groups of celestial bodies. The IAU states that although planets clean their orbital zone of celestial debris, a dwarf planet’s neighborhood is scattered with debris (Definition 1). Even though this criterion may seem straightforward, “it must be emphasized at outset that a planet can never completely clear its orbital zone because gravitational and radiative forces continually perturb the orbits of asteroids and comets into planet-crossing orbits" (Margot 1). Thus, neither planets nor dwarf planets have completely cleaned their orbits from every comet and asteroid. However, dwarf planets have significantly more debris lingering in their neighborhoods than planets. Because planets are gravitationally dominant, only an occasional stray asteroid or comet crosses their orbits. The following expression is used to determine if a celestial body's neighborhood has been cleared of debris: $\Pi = \frac{M_{body}}{M_{clear}}$ (Margot 2). In this expression, M_{body} represents the mass of the celestial object, and M_{clear} stands for the mass that a body must have in order to clear its neighborhood of debris. M_{clear} is given by the expression: $\left(\frac{M_*}{M_\Theta}\right)^{5/8}\left(\frac{t_*}{1.1\ x\ 10^5\ years}\right)^{-3/4}\left(\frac{\alpha_p}{1\ AU}\right)^{9/8}$, which can be used to calculate the minimal orbital clearing mass (Margot 6). In order for a celestial object to clean the neighborhood around its orbit, Π, the planet discriminant, must be greater than or equal to one. Using the above expressions and the data for Pluto, astronomers calculated that Pluto has a discriminant of 2.8×10^{-2} (Margot 2). Since this discriminant is less than one, Pluto's neighborhood is not cleared from celestial debris. Therefore, Pluto fails to meet the IAU's third requirement for a planet that the neighborhood around the body's orbit must be cleared. Hence, Pluto should be classified as a dwarf planet since this celestial body meets the IAU's third requirement for a dwarf planet in the solar system that the celestial object's neighborhood is not cleared of debris.

After discovering Neptune by studying the deviations in Uranus's heliocentric path, astronomers surprisingly found that Neptune has a wobbly orbit similar to Uranus's orbital path. Thus, they concluded that another planet, nicknamed "Planet X", must be responsible for forcing both Neptune and Uranus out of their typical orbits. In 1930, Clyde Tombaugh discovered a faint speck of light among the velvety, star-sprinkled background of deep space. This faint speck of light, named Pluto, was thought to be the missing Planet X. However, mathematical calculations later proved that Pluto's mass was not sufficient to affect the orbits of Uranus and Neptune. When first discovered, Pluto was immediately deemed the ninth planet in the solar system. Subsequently, dozens of other Trans-Neptunian Objects such as Ceres and Eris were found resting in the outer limits of the solar system as well resulting in global confusion over which of these celestial objects were planets. To solve this problem, the International Astronomical Union held a general assembly in Prague in 2006. During the assembly, the union created an official definition for planets in the solar system that "a planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium, and (c) has cleared the neighborhood around its orbit" (Definition 1). Also, the IAU universally defined a dwarf planet as a celestial body that has a heliocentric orbit and has a nearly round shape. While planets successfully clean their neighborhoods of debris, a dwarf planet does not clear its orbital zone (Definition 1). In this assembly, the IAU demoted Pluto from a planet to a dwarf planet upsetting the public. Thirteen years later, astronomers still debate whether Pluto should be categorized as a planet or a dwarf planet. Pluto should be classified as a dwarf planet because this body has a heliocentric orbit, has a nearly round shape, and has not cleared its orbital zone of celestial debris. Thus, Pluto complies with all of the IAU's three criteria for a dwarf planet in the solar system. While Pluto satisfies the requirements for dwarf planets, Pluto does not meet the third criterion of a planet as celestial debris intercepts its neighborhood. Those, who argue that Pluto should be categorized as a planet, claim the IAU's third criterion of a planet, that the celestial object's neighborhood has been cleared of debris, is ambiguous. They argue that neither planets nor dwarf planets can completely sweep up every piece of celestial debris from their orbital zone. While planets still have an occasional comet or asteroid lingering in their neighborhoods, dwarf planets have significantly more debris intercepting their heliocentric path. This criterion can be calculated using the expression $\Pi = \frac{M_{body}}{M_{clear}}$ (Maran 2). If Π is less than one, then the object has failed to clean its neighborhood from debris. If Π is greater than one, then the celestial body has succeeded in clearing its orbital path. The Π of Pluto, 2.8×10^{-2}, is less than one (Margot 2). Therefore, Pluto does not meet the IAU's third criterion of a planet but instead fulfills the IAU's third requirement for a dwarf planet. Because this frozen, barren world lurking over four billion miles from the sun follows all of the IAU's criteria of dwarf planets in the solar system by orbiting the sun, sustaining a nearly round shape, and having a neighborhood scattered with celestial debris, Pluto should be classified as a dwarf planet.

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