The History of the Twentieth Century
Episode 264
"What Is a Planet?"
Transcript

[music: Fanfare]

The bet was that someone would find a new planet by December 31, 2004. The winner of the bet would receive five bottles of champagne, to be drunk in celebration of new planetary frontiers or in mourning for the sad limitations of our solar system.

We sat for a few minutes, staring up at the telescope, thinking about planets.

"We've got one problem. We'll never know if someone wins this bet," I said.

"What?" she asked. "How could we not know whether or not someone finds a planet? Surely the entire world will hear about it. It'll be pretty obvious."

"Well, okay," I said, "then I have one question for you: What is a planet?"

Mike Brown. *How I Killed Pluto and Why It Had It Coming.*

Welcome to *The History of the Twentieth Century.*

[music: Opening Theme]

Episode 264. What Is A Planet?

Before the invention of the telescope, the stars in the night sky could only be observed by the naked eye. How many stars are visible to an unaided human eye? That's a question without a clear answer. Human eyes vary in their acuity, and viewing conditions are never ideal. Still, we can say there are somewhere between five and ten thousand stars in total across the night sky that are visible to the unaided human eye under ideal conditions; never all at once, of course. On a given night, and given reasonably good viewing conditions, the average human might be able to see as many as two to three thousand.

Even in ancient times, it was well known across the world that the vast majority of these stars were fixed in position, relative to each other. They appeared in the same configuration every

night. But there were exactly seven objects that did not. These seven moved across the firmament of stars independently, each in its own way.

Ancient Greek astronomers distinguished these seven objects by naming them *asteres planetai,* wandering stars, from which we get the English word *planet.* These were distinguished from the *asters aplaneis,* the unmoving, or fixed, stars.

Of these seven objects, the sun and the moon are clearly unique. They are different from the other planets, from the stars, and from each other. The remaining five objects, however—Mercury, Venus, Mars, Jupiter, and Saturn—looked very much like stars. They were brighter than most stars. Venus and Jupiter were sometimes brighter than any of the fixed stars, but only sometimes. An untrained observer might easily mistake any of these five objects for ordinary stars.

Nicolaus Copernicus—did I mention he was Polish?—Copernicus developed his heliocentric model of the solar system, published in 1543, which was eventually accepted as a more accurate depiction of the solar system. In the heliocentric model, the sun and moon are no longer planets, though they remain unique objects, and the Earth now becomes a planet. You could say, the definition of planet has changed. It now means an object that orbits the sun.

In 1610, the Italian astronomer Galileo Galilei, using a telescope, discovered the four largest moons of Jupiter. He called them planets at first, but it became conventional to refer to objects that orbited other planets as moons or satellites rather than as planets, by analogy to Earth's moon.

In 1781, the German-born British astronomer Sir William Herschel, discovered a new planet. This discovery was a lucky accident. Herschel thought he'd found a comet at first, but as he and other astronomers gathered information about its movement, it became clear that it revolved around the sun in a nearly circular orbit more distant than any previously known planet, which suggested it was a planet as well. Knowing its distance and observing the size of its disk in a telescope allows for calculation of its size, and the new planet proved to be much larger than the Earth, though not so large as Jupiter or Saturn. Still, given its orbit and its size, astronomers accepted it as a planet. Why not? There was no reason to dispute that classification.

Herschel named the new planet *Georgium Sidus*, which is Latin and means something like "George's Planet." This was intended in honor of the British King George III, but astronomers in other countries were reluctant to accept that name. The German astronomer Johann Elert Bode suggested the name Uranus, apparently because in ancient mythology, Saturn was the father of Jupiter and Uranus the father of Saturn. The suggestion had a certain logic to it, and it became generally accepted, although the British Nautical Almanac Office persisted in calling the planet *Georgium Sidus* for another sixty years before finally giving in.

I'll also remind you in passing that the element uranium was discovered in 1789, just a few years later. Its discoverer, the German chemist Martin Klaproth, named it in honor of the discovery of the planet.

Johann Elert Bode is important in the history of planetary astronomy for more than the mere fact of his providing the name for a new planet. At the time Uranus was discovered, Bode was puzzling over a number sequence first discovered by a fellow German astronomer named Johann Daniel Titius 25 years earlier. This number sequence, now known as the Titius-Bode Law, is generated from a mathematical formula. I won't trouble you with the formula, but the sequence of numbers it produces is interesting because the numbers correspond closely to the distances of the various planets from the Sun.

The Titius-Bode Law was nothing more than a mathematical curiosity until Uranus was discovered. The news of the new planet made Bode sit up and take notice, because its orbit was just at the place where the Titius-Bode Law predicted the next planet out from Saturn ought to be. Huh.

There was one other significant fact about the Titius-Bode Law: it suggested that a planet was missing. Specifically, the sequence predicts a planet in orbit between Mars and Jupiter, where no planet was known to be. In the year 1800, with the discovery of Uranus offering apparent confirmation that the Titius-Bode Law was something real, and not just an interesting coincidence, a Hungarian astronomer named Franz Xaver von Zach decided to organize a search for the missing planet.

Zach chose 24 of the best observational astronomers in Europe. He divided the ecliptic, the region of the sky that is in the plane of the solar system, into 24 sections of 15 degrees each, then wrote to his 24 chosen astronomers, assigning each of them one of these regions and asking them to search that region for evidence of an undiscovered planet.

One of Zach's chosen 24 was a Sicilian astronomer, also mathematician and priest, named Giuseppe Piazzi. Ten years earlier, King Ferdinand of the Two Sicilies had tapped Piazzi to take charge of a new astronomical observatory the King had built in Palermo. Piazzi was in 1800 overseeing the compilation of a new star catalog at the Palermo observatory, so he was a good choice to participate in this project.

As fate would have it, by the time Zach's proposal reached Palermo, Piazzi had already discovered the object they were looking for. It was first observed in fact on New Year's Day, 1801, the first day of the 19th century. Piazzi tracked its movement for a few weeks, then announced his discovery. He believed at first it was a comet, but, in his words, "its movement is so slow and rather uniform, it has occurred to me several times that it might be something better than a comet."

It was something better than a comet. It was a whole new planet, a planet that filled in the gap between Mars and Jupiter. Piazzi named his discovery *Ceres Ferdinandea,* with the second name meant to honor his patron, King Ferdinand. Once again, this was unacceptable to astronomers of other nationalities, and so the new planet came to be known simply as Ceres, after the Roman goddess of agriculture. It is from her name that we get the English word cereal, as in grain. Two years later, in 1803, a newly discovered chemical element would be named cerium, after this new planet.

But by that time, a second planet had been discovered, orbiting at a similar distance from the Sun. Its discoverer had been looking for Ceres and had stumbled upon this new planet by accident. It was named Pallas, an alternative name for Athena, the Greek goddess of wisdom.

Two more planets were discovered in 1804 and 1807. These were named Juno and Vesta after two other Roman goddesses. The older planets had all been named after gods, except for Venus, so perhaps astronomers were thinking it was time to give the goddesses their due.

Funny thing about these four new planets, though. None of them was big enough to be visible as anything more than a point of light, even in a telescope. This meant they couldn't be very big, certainly much smaller than any of the other planets. None was bright enough to be visible to the unaided eye, except for Vesta, the brightest of the four, which is barely bright enough to be seen, if you know where and when to look.

The first estimates of the size of Ceres ranged from a diameter of 260 kilometers to 2,600 kilometers, which is certainly a lot of uncertainty, but even at the upper end, Ceres would be only a fraction of the size of Earth's moon. Some people began calling these four objects "minor planets." Sir William Herschel, who was still around at this time, proposed the word *asteroid,* derived from Greek and meaning "similar to a star."

For the next 38 years, it was generally accepted that there were eleven planets: seven major planets and four minor planets. Then in 1845, a fifth minor planet was discovered. The following year, 1846, saw the discovery of another new major planet. A very major planet.

Back in episode 54, I told you the story of the French mathematician Urbain Le Verrier, who took an interest in analyzing the motions of the planets mathematically, according to the laws of gravitation developed by Sir Isaac Newton. Le Verrier noticed a problem in the orbit of Uranus, which, according to his calculations, had once been moving a little too fast, and later a little too slowly. This suggested to Le Verrier that there was an unknown large planet farther out than Uranus that was influencing its orbit. The unknown planet was found at just the place where Le Verrier had predicted, in 1846. I guess I should mention that an English mathematician and astronomer named John Couch Adams had come to the same conclusions independently at about the same time, and is generally regarded as a co-discoverer. The new planet was named Neptune, in keeping with the custom of naming new planets after Greco-Roman deities.

Neptune was much farther from the sun than Uranus, but was comparable in size, meaning it was bigger than any other planet apart from Jupiter or Saturn. And its orbit was *not* where the Titius-Bode Law would predict the next planet out from Uranus to be, so that was it for the Titius-Bode Law. In our time, it is regarded more as a curious coincidence than anything else, although the possibility exists that the Titius-Bode number sequence represents some as-yet-undiscovered law of solar system formation. We can't say for certain until we examine a few more solar systems.

Over the next fifty years, the dam broke, as far as asteroid discoveries went. By 1860, there were more than sixty known asteroids, by 1880 over 200, and at the dawn of the twentieth century, the list was at 463, with an additional 17 discovered in the year 1901 alone. That's about one discovery every three weeks.

Well, that was just about enough of that. Over the period from 1850 to 1900, astronomers gradually stopped referring to the objects between Mars and Jupiter as planets, but Herschel's suggestion caught on and most people now call them asteroids, and they are regarded not as planets but as a separate category of object within our solar system.

But the discovery of Neptune was important, beyond the obvious reasons, because Le Verrier had deduced the existence of the planet and accurately calculated its position based on irregularities in the movement of Uranus. The power of math, people! I told this story in episode 54. I also told you how afterward Le Verrier and others turned their attention to irregularities in the orbit of Mercury, which some suggested were caused by a hypothetical planet closer to the sun. Le Verrier even named this hypothetical planet. He called it Vulcan.

A number of astronomers, amateurs and professionals, claimed to have sighted the planet Vulcan, but none of those sightings could be confirmed. Albert Einstein solved the mystery when he published his general theory of relativity in 1915, episode 114. Relativity gave us a more complete understanding of gravity, and it turned out that the anomalies in Mercury's orbit disappeared when you corrected your math for relativistic effects, eliminating the need to conjure up a planet.

But there remained a question about possible planets beyond Neptune, farther out in the solar system. Some astronomers, checking Le Verrier's work, came to the conclusion that Neptune alone was not enough to account for the anomalies in the orbit of Uranus, and that there remained one or more planets that orbited even farther from the sun.

One of the astronomers who picked up on this idea was the American Percival Lowell, a wealthy Bostonian I also told you about in episode 54. Lowell spent the first decade of the twentieth century claiming to have discovered evidence of intelligent life on Mars in the form of canals. By 1910, Lowell was forced to concede he'd been wrong about that, but by then, his reputation in the field had taken quite a beating. He turned his attention to the question of possible undiscovered planets beyond Neptune and did his own mathematical analysis of the orbit of Uranus, from which he deduced the existence of a new planet, which he called Planet X. He

calculated it would have a mass about seven times that of the Earth, or about half that of Neptune, and that it would orbit the sun at a distance of about 43 astronomical units.

Lowell spent years photographing the night sky in the region where his calculations predicted Planet X would appear, then painstakingly examining the photographic plates with a magnifying glass. Lowell expected that Planet X would be large enough to appear as a disc rather than a point of light on his plates, but nothing of the kind ever appeared.

Percival Lowell died suddenly in 1916 of a stroke at the age of 61. He had apparently been in good health until the end, and there was speculation that disappointment over the failure of his effort to discover Planet X had contributed to his death.

Lowell had founded the Lowell Observatory in Flagstaff, Arizona in 1893. His will included a substantial bequest to the Observatory, but this was contested by his widow, Constance. After years of litigation, the issues were resolved; the Lowell Observatory got its bequest and resumed the search for Planet X after purchasing a new telescope more suitable to the task.

But the astronomers at the Observatory were less than enthusiastic about this project. It was slow, tedious work, and they had their own research they wanted to conduct. Also, not to put too fine a point on it, the deceased Mr. Lowell had been a great patron of the Observatory, but he had also been a bit of a crank, not taken seriously by real astronomers since that whole Martian canal episode. Who would want to spend years of their life chasing down another of Percival Lowell's wild speculations?

[music: *eDream*]

Clyde William Tombaugh was born on February 4, 1906, in Streator, Illinois. His father was a farmer. The family moved to a farm near Burdett, Kansas during Clyde's childhood, but Clyde was not cut out to be a farmer. He wanted to go to college, but the 1920s were a very bad time for farm families, and there was no money for such a thing, and so he was stuck on the farm. It's an old and familiar story. You'll find it in many times and many places, even a long, long time ago in a galaxy far, far away.

Clyde was interested in astronomy, and motivated enough to build his own telescopes, grinding the lenses and mirrors himself. He made sketches of his observations of Mars and Jupiter and sent them on to the Lowell Observatory in 1928. The good news was, the director of the Observatory was sufficiently impressed to offer Clyde a position at the Observatory, and Clyde was off to Arizona like a shot.

The bad news was, he was going to get stuck with the job no one else wanted: the search for Planet X.

Actually, it was a good job for someone like Clyde Tombaugh. He had no formal training in astronomy and was just 22 years old, but he had barrels of energy and enthusiasm for the work.

The work consisted of photographing the night sky in the region of the ecliptic. Clyde would take photographs of the same region of the sky a few days apart, then compare them using a device called a blink comparator, invented in 1904. You put two photographs in this device and look through the eyepiece. A lever allows you to switch rapidly from one photograph to the other. If your photographs are aligned properly, the stars will be in the same place in both photographs, and will not appear to move as you switch from the one photograph to the other. But, any object that did move between the times the photographs were taken will appear to bounce back and forth as you flip the lever, easily catching your eye and giving itself away as something other than a star. Each of these pairs of plates might include the images of as many as 100,000 stars, and it could take Clyde as long as a week to thoroughly examine each pair. While this was a tedious process, the blink comparator made the job much easier and faster than it would have been otherwise.

Tombaugh began his new job in January of 1929. In October, he discovered four new objects, which proved to be asteroids. The US stock market crashed that same month, and by 1930, the Great Depression was taking hold in the United States. Fortunately for Clyde, the Observatory had the resources to keep him on.

On February 18, 1930, a little over a year after beginning his work at the observatory, Clyde was using the blink comparator when he identified a tiny spot of white that moved a little bit between one photograph and the other. The two images had been taken a few days apart in January. He spent 45 minutes going back and forth between the two images until he was sure enough of what he was seeing to call his supervisor.

The Observatory monitored the object for a few weeks to confirm the discovery, before announcing it on March 13. The news made headlines around the world. The barely 24-year-old Clyde Tombaugh had discovered a ninth planet, and at just about the location Percival Lowell had predicted. Naturally, the question arose of what to name it. Lowell Observatory received hundreds of letters from across the world with suggestions. Even Constance Lowell weighed in. She thought Percival to be a good name, or if not, what about Constance? It has a nice ring to it, don't you think?

The winning suggestion came from an 11-year-old girl in Oxford, England named Venetia Burney. She suggested Pluto, after the Greek god of the underworld. For an object so lonely and cold and remote, it seemed fitting. Also, the first two letters of the name Pluto are the initials of Percival Lowell, which clinched the deal. The following year, 1931, animator Walt Disney gave his signature cartoon character Mickey Mouse a dog named Pluto the Pup, and it seems likely the name was inspired by the news of Pluto's discovery, although Disney never said so, so we can't be 100% certain. I can tell you that the character of Goofy was introduced in 1932, which led to generations of debate over the question, "If Pluto is a dog, then what is Goofy?" but that's another episode.

Clyde Tombaugh continued his work at Lowell Observatory for a couple more years, searching the rest of the ecliptic just in case there was another planet out there somewhere. He didn't find any, though he did discover two comets and a large number of asteroids and variable stars, which also give themselves away on a blink comparator. Afterward, he went to the University of Kansas, where he earned a bachelor's and a master's in astronomy. Later in life, he taught astronomy at New Mexico State University until his retirement in 1973.

Once Pluto was discovered, reviews of old astronomical photographs revealed that it had in fact been photographed sixteen times by other astronomers as long ago as 1909, ironically including two photographs made for Percival Lowell in 1915, as part of his search for Planet X. In every case, Lowell and other astronomers had overlooked Pluto, taking it for a star.

Tombaugh's discovery was big news, but it immediately presented new problems. For one thing, Pluto was very, very small; so small that it appeared as no more than a point of light in the best telescopes of the time, which was how Lowell and those other astronomers had mistaken it for a star. Remember that Percival Lowell had believed that Planet X would be large enough to show as a disk, so what's that about?

For that reason, and also because Pluto is so distant from other objects in the solar system, it was impossible for astronomers to get a clear fix on how big it was. They did know how bright it was, and you could estimate from that, provided you know Pluto's albedo, which is a measure of how reflective an object is. In our solar system, the planet with the lowest albedo—that is to say, the darkest planet—is Mercury, with an albedo of .07, meaning it reflects just 7% of the light that falls on it, a number comparable to the albedo of asphalt.

If Pluto were as dark as Mercury, or asphalt, then it might be as large as the Earth, and that was the conclusion most astronomers of the time accepted. Remember that Pluto had been discovered by his supposed gravitational influence on Uranus, so it would have to be pretty big, right?

Well, but Percival Lowell had predicted Planet X would have seven times the mass of the Earth. There was no way Pluto was that big, was there? I'm old enough to remember once reading an astronomy textbook that suggested Pluto was covered with a smooth layer of ice, and what astronomers were seeing in their telescopes was actually the reflection of the sun on that mirror-smooth surface. Maybe Pluto was big, but all we were seeing was that reflection.

No, I don't buy it either. From the early days following Pluto's discovery, many astronomers, perhaps most, concluded Pluto could not possibly be the Planet X Percival Lowell had predicted, and that it was just a coincidence that Pluto had turned up at about the place Lowell had expected to find Planet X.

In 1949, after twenty years of planning and construction, a new telescope, the Hale Telescope at Mt. Palomar Observatory in California, began operation. The Hale Telescope has a mirror diameter of 200 inches, or 500 centimeters, which was double the diameter of any other

telescope in the world in 1949, and represented a major leap forward in observational astronomy. Soon after it began service, the Dutch-American astronomer Gerard Kuiper used it to observe Pluto. Even the Hale Telescope could not discern a disc, which further limited how big Pluto could be. It was certainly no larger than Mars, and probably smaller.

When I was a kid growing up in the 1960s, the textbook figure for the diameter of Pluto was 3600 miles, or about 5800 kilometers, and that was about all the information the textbook would offer for Pluto. Even so, this made Pluto only the second-smallest planet, still a little bigger than Mercury.

Pluto has a more eccentric orbit than any other planets; in fact, its orbit brings it closer to the sun than Neptune for part of a Plutonian year. Pluto's orbit brought it closer to the sun from 1979 through 1999, and now it is farther away again.

Pluto's small size and eccentric orbit led to suggestions that it might be an escaped moon, perhaps from Neptune. But the math doesn't work out. Pluto's orbit appears to cross Neptune's in a two-dimensional display of the solar system, but a three-dimensional display will quickly show you that the two planets never get near each other, so there goes that idea.

In 1976, astronomers managed to get a spectroscopic reading of light from Pluto and determined that the surface of the planet was covered with frozen methane. This is not surprising, given Pluto's great distance from the sun, but it's significant because methane as a pretty high albedo, meaning Pluto was even smaller than previously thought; no more than 1% of the mass of the Earth.

During the 1970s and 1980s, NASA, the National Aeronautics and Space Administration, launched Voyager 2, a probe that took advantage of a rare configuration of the outer planets to allow it to fly past Jupiter, Saturn, Uranus, and Neptune. Alas, plans for a Voyager spacecraft to fly by Pluto were scrapped, leaving it the only planet in the solar system never to have been visited by a human spacecraft.

In 1978, an astronomer named James Christy, studying photographic images of Pluto, detected a small bulge on the edge of the planet that appeared and disappeared at regular intervals. The bulge turned out to be a satellite of Pluto, which Christy named Charon, after the ferryman of the dead in Greek mythology, an appropriate name for an associate of Pluto.

A mythologically appropriate name, but Christy also had in mind an indirect tribute to his wife Charlene, known as "Char" to her friends. Although most people pronounce Charon as I just did, the classical Greek pronunciation, James Christy prefers to pronounce it Charon, and some astronomers follow his lead.

Either way, the discovery of an object in orbit around Pluto was significant, because it made it possible for the first time to pinpoint Pluto's mass, and the number was a shocker. Pluto was even smaller than previously believed—only about one five-hundredth the mass of the Earth.

This finding absolutely clinched it: Pluto was not the Planet X Percival Lowell had been looking for. The discovery of Pluto was indeed just a fortunate coincidence. But it also raised an intriguing possibility: perhaps Planet X was still out there somewhere. The 1970s and 1980s saw a revival of interest in Planet X as several astronomers went back to the old data on the orbit of Uranus or else looked at new data from the orbits of comets and made new calculations of the size and location of potential Planet Xs. Coincidentally, now that there were nine planets, the label "Planet X" took on a new significance, since you could read it as a Roman numeral: "Planet Ten."

But these new calculations were received with much skepticism by other astronomers, and searches of the sky turned up nothing. In 1992, analysis of data from Voyager 2's flyby of Neptune showed that Neptune was 0.5% less massive than previously believed. That doesn't sound like much, but it's equivalent to the mass of Mars. When astronomers took another look at that old data on supposed discrepancies in the orbit of Uranus, the data Percival Lowell had relied upon in making his calculations regarding Planet X, and corrected the mass of Neptune, the discrepancy went away. The strongest evidence for the existence of another planet had just evaporated.

Also in the year 1992, the now 86-year-old Clyde Tombaugh received a phone call from a scientist at the Jet Propulsion Laboratory requesting permission to visit "his" planet. Tombaugh reportedly replied that "he was welcome to it."

You mean, "my world and welcome to it?"

Also also in the year 1992, American astronomers David Jewitt and Jane Luu discovered a small object, just over 100 km in diameter, with an orbit well outside that of Neptune, making it just the third object discovered that far out. It would eventually be named Albion, but not until 2018. Until then, it was known by the provisional designation 1992 QB_1. Over the remaining eight years of the twentieth century, more than three dozen more small objects were found in this distant region of the solar system. At first, astronomers dubbed them with the informal name cubewanos, after 1992 QB_1, the first discovered.

It soon became clear that the region beyond Neptune's orbit is home to a large number of small objects, something like the asteroid belt between Mars and Jupiter. Today, this region of the solar system is called the Kuiper Belt, after Gerard Kuiper. The objects found there are divided into several categories, but overall you can just call them Kuiper Belt Objects or Trans-Neptunian Objects.

Clyde Tombaugh passed away in 1997, at the age of 90. In the year 2000, NASA put together a team under Alan Stern to work up a proposal for a mission to Pluto, the only planet in the solar system never visited by a human spacecraft. The mission met resistance from the Bush Administration, but had strong support from the scientific community and was approved in 2002. The spacecraft, named *New Horizons,* was launched in 2006, on a course that would fly by Pluto in 2015. In addition to its scientific instruments, *New Horizons* also carried a portion of the ashes that represent the mortal remains of Clyde Tombaugh.

But during this same period, additional Trans-Neptunian Objects continued to be discovered. As I record this podcast, the number known is approaching 3,000. Long before that milestone, though, the notable abundance of Trans-Neptunian Objects raised questions about Pluto. When Pluto was first discovered, it was believed to be much larger, and was thought to be a unique object in its part of the solar system. Now astronomers knew neither of those things was true. Pluto was looking less like a planet and more like an analogue to Ceres, by which I mean merely the first and largest to be discovered in a previously unknown class of objects. Asteroids then, cubewanos now.

But culturally speaking, the two situations are quite different. The discovery of Ceres attracted little public notice. In 1801, not many people outside the field gave much thought to objects in the night sky that were too dim to be visible to lay people. The discovery of Pluto, on the other hand, coincided with the rise of modern technology and of science fiction. Pluto's unique position as the most distant planet—cold, remote, and mysterious, on the threshold of interstellar space—made it a popular location for science fiction speculation, either as a jumping off point for humans headed for the stars, as in Joe Haldeman's 1974 novel *The Forever War,* or as a convenient location for aliens to observe humanity undetected, as in Robert A. Heinlein's 1958 novel *Have Space Suit, Will Travel,* or simply as an exotic location, as in Larry Niven's 1968 short story, "Wait It Out." I name these three stories in particular, only because they were the first to come to my mind when I wrote this episode. I am sure there are many other examples.

The upshot is, that by the early 21st century, millions of people on Earth had visited Pluto in their imaginations and had a romantic, even sentimental attachment to the place. The thought that Pluto might actually be just a hunk of solar system debris, one piece among thousands, was an uncomfortable one, even for some professional astronomers. And beyond them, there were tens of millions of members of the general public with their own ideas about Pluto.

On the other hand, although many Trans-Neptunian Objects were turning up, none of them was as big as Pluto, so that provided some cover for putting off these unpleasant thoughts and continuing to treat Pluto as if it were something different, something special, and not just another Trans-Neptunian Object.

Enter astronomer Mike Brown, born in 1965. At the same time NASA was putting together the *New Horizons* mission, Brown and his team were cataloging and studying Trans-Neptunian

Objects. One in particular stood out. This object was farther from the sun than any previously discovered. It also had a moon, which made it a simple matter for Brown and his team to determine its mass. It turned out that the new object had a mass 27% greater than that of Pluto. And it had its own moon.

In some sense, this was Planet X, the long-sought-after tenth planet. Brown and his team nicknamed the object Xena, a nod to the designation X and also to the US television series *Xena: Warrior Princess,* which ran from 1995 to 2001. They called its moon Gabrielle, after Xena's companion on the show.

Once the discovery of this object was announced in 2003, known provisionally as 2003 UB_{313}, astronomers were forced to confront the inconsistency in the status of Pluto. If Pluto was a planet, then Xena was a planet too, and Mike Brown had to be credited as the only living person to have discovered a planet. On the other hand, if the astronomical community refused to recognize Xena as a planet, then it would be impossible to justify retaining that designation for Pluto.

The controversy came to a head at the 2006 meeting of the General Assembly of the International Astronomical Union, or IAU, where, amidst far more controversy than normally happens at these meetings, the Assembly adopted an official definition of *planet.* This was a unique act. There are no similarly approved definitions of say, star or galaxy or nebula. But it was necessary. The IAU voted a three-pronged definition of planet: the object has to orbit the sun, it has to be in hydrostatic equilibrium—in other words, it has to have pulled itself into a spherical shape—and it has to have "cleared the neighborhood" in which it orbits. An object that fits the first two parts of the definition, but not the third, was designated a dwarf planet.

Pluto was thus demoted, if you want to call it that, from planet to dwarf planet. The latter category also includes Ceres, though no other asteroid, and also Charon and possibly a number of other Trans-Neptunian Objects. As was the case with asteroids, Trans-Neptunian Objects are now regarded not as planets, but as a separate category of object in the solar system.

The new definition of planet is certainly awkward. It's really more of a capsule argument for why Pluto isn't a planet than anything else, but it seems like the right idea. Mike Brown agrees with it, as do most astronomers, although there are some who still oppose the decision, even in our time. Someday a more elegant definition may arise, but the point of this distinction is to reserve the word *planet* for large and important objects, objects that are easy to detect and are major influences on the movement of other objects in the solar system, which really does come closer to what most people mean by the word *planet,* as opposed to a definition that would embrace potentially thousands of remote and virtually undetectable objects in the Kuiper Belt.

Nevertheless, the decision prompted considerable backlash among the general public, as you no doubt already know. There were many people who were reluctant to give up the special place Pluto held in popular culture and in their imaginations. In Illinois, the state of Clyde Tombaugh's

birth, the state Senate passed a resolution condemning the change as “unfair.” In New Mexico, the state where Tombaugh taught astronomy for many years, the state House of Representatives passed a resolution declaring that Pluto would be considered a planet when in the sky over New Mexico.

That having been settled, there remained the question of a name for Xena. I for one would have been happy to keep the name Xena, but Mike Brown suggested a more formal name, which was adopted by the IAU. Brown felt that since Xena had just missed being designated a planet, it should have a name drawn from Greco-Roman mythology, like the eight true planets. The difficulty with that idea is that most of those names have already been used, to name asteroids, for the most part. Brown and his team did an extensive search for the name of a Greek or Roman deity that hadn’t already been taken and came up with Eris, the Greek goddess of discord. It seemed an appropriate choice for an object whose discovery had prompted so much controversy.

As for Eris’ moon, Brown chose Dysnomia, one of Eris’ daughters. Dysnomia was the goddess of lawlessness, which is what the word *dysnomia* means in Greek. It’s an appropriate name for a moon of Eris; you might also take it as a sly reference to *Xena: Warrior Princess* and Lucy Lawless, the actor who portrayed the title character in the TV show, although Brown says he hadn’t thought of that when he chose the name. Let’s call it a happy coincidence.

What Brown did intend in the choice of name was a tribute to his wife, Diane, known to her friends as Di. You can read the name Dysnomia as incorporating his wife’s nickname in the same way that Charon, or Charon, incorporates Charlene Christy’s name. In a similar manner, Mike Brown prefers the pronunciation Dysnomia.

In the aftermath of the IAU decision, Mike Brown became a personal target for those unhappy with the new definition of planet, and he has been dubbed “the man who killed Pluto.” Brown chose to embrace that identity, as demonstrated in the title of his memoir, *How I Killed Pluto, and Why It Had It Coming,* published in 2010, which I quoted from at the top of the episode.

Among the scientists who resist the new definition of planet is Alan Stern and others of his *New Horizons* team. They oversaw a spacecraft that was meant to visit the only unvisited planet in the solar system, only to have their spaceship’s destination demoted before it ever got there. *New Horizons* flew past Pluto and Charon on July 14, 2015, returning some gorgeous pictures and a large amount of data, which is still being analyzed as I record this episode.

Photographs of Pluto revealed that its most prominent surface feature is a large, smooth, bright plain of nitrogen ice. The *New Horizons* team suggested the name Tombaugh Regio for this region, in honor of Clyde Tombaugh, and this suggestion was adopted. The feature is seen by many as heart shaped, although some people prefer to see in it the profile of Walt Disney’s cartoon creation, Pluto the Pup.

We'll have to stop there for today. I thank you for listening. This is a special bonus episode that is my Christmas gift to you, my listeners. I hope you've enjoyed it, and whether you celebrate this day or not, I hope you have a great one. I'll return on Sunday with the final episode in our current East Asia series, "Foreign Commentary Changes Nothing."

Oh, and before I go, just one more thing. At this moment in the history of astronomy, it seems exceedingly unlikely that any real planet nine—an object big enough to be worthy of the name—might still exist anywhere in our solar system. Our instruments today are very good and they have been used to survey the sky repeatedly.

But in 2014, a group of astronomers noted some commonalities in the orbits of some Trans-Neptunian Objects, anomalies that might be traced to the gravitational influence of a large object far, far away from our sun, but nevertheless in orbit around it.

Mike Brown was skeptical at first. He teamed up with a colleague at Caltech, Konstantin Batygin, to do a mathematical analysis and came away persuaded that the evidence supports the existence of an undiscovered object about six times the mass of the Earth, orbiting 400 times farther away from the sun than the Earth, or ten times farther away than Pluto.

No such object has been discovered, as of when I release this episode, but to the best of my knowledge, Mike Brown remains confident of his analysis, and last I heard, he was offering to take bets on its existence, while Konstantin Batygin is predicting the planet will be discovered before the end of this decade.

[music: Closing Theme]