Defining Planets

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The artist's rendition shows "Sedna" in relation to other bodies in the solar system, including Earth and its Moon; Pluto; and Quaoar, a planetoid beyond Pluto that was the largest known object beyond Pluto. Image courtesy: NASA/JPL-Caltech

In 2005, Michael Brown of the California Institute of Technology and his team discovered a large body in the outer solar system. It was not the first distant object that had been found in the Kuiper Belt -- the region is composed of hundreds of icy objects. But it was the largest known Kuiper Belt object, just beating out Pluto in terms of size, and so their discovery was heralded as "the tenth planet."

Scientists think eventually we will discover many planet-sized globes in

that distant region of space, and that brings to the forefront questions about what defines a planet. Recent discoveries of many unusual extrasolar planets in other solar systems also have put the definition of "planet" up to scrutiny. This planetary debate was put to a vote at a meeting of the International Astronomical Union in 2006, and scientists there chose to reclassify Pluto and other large Kuiper Belt objects as "dwarf planets."

In part two of this five-part lecture presented at NASA's Jet Propulsion Laboratory, Brown talked about the discovery of Pluto in 1930, and how scientists today find other distant objects in the Kuiper Belt.

"People were looking for a planet in the outer solar system back in 1930, and they were expecting to find something big. They had done some calculations and found that Neptune, as it moved around in its orbit, was being tugged by something massive out there. We now know that that's not true, Neptune was just moving around the way it's supposed to. But at the time the data weren't very good and people thought it was being tugged along a little funny, and so they were looking for another planet.

The trick to finding objects in the outer solar system came from Clyde Tombaugh, who had been hired by the Lowell Observatory to find this new planet. Clyde Tombaugh took a picture of the sky one night, came back the next night to take another picture, and looked to see if any bright spots had moved. He spent more than a decade doing this. He would take these photographic plates, a big piece of glass with photographic emulsion painted on it, and he would make two or three photos. He had a machine where he could put in two photos, and blink back and forth between them with a set of binoculars. That's exactly what we do now with a computer, but he had to do it by hand.

He only found one thing that moved. It's a tiny, tiny thing, and it's not even a particularly bright star. When you look at the discovery images

and realize how small it is and what a small area of the sky he looked at, you realize what an amazing job it was that he found this, regardless of whether we call Pluto a planet or not. Finding it back in 1930 was simply an incredible piece of astronomical work. But even when Clyde Tombaugh found it, he thought it wasn't big enough to be the Planet X people were looking for.

Pluto is so small it's one of the reasons we don't consider it a planet these days. It's not nearly as big as any of the other planets. It also has a very funny orbit. The four giant planets - Jupiter, Saturn, Uranus, and Neptune -- all have nice circular orbits going around the sun, all in one disk. You throw Pluto in there, and it suddenly ruins the entire pattern. Pluto has this crazy orbit that dips inside of the orbit of Neptune, and then it goes further out. Pluto is tilted about 20 degrees with respect to the planets. So it never fit the pattern of the other planets.

At the time, there was a debate about what to call this thing. There weren't that many options. Can you call it an asteroid? People knew about asteroids at this point, but the asteroids were all in this little band between Mars and Jupiter. A comet? Comets are known to have orbits that loop way out and then come back in, so it kind of looks like a comet, but comets are defined by the fact that they have tails -- the gas expanding out from it. So it clearly didn't fit the bill of comet. So by default, "planet" was really the only thing it could be.

Clyde Tombaugh kept looking, because he wanted to find Planet X. He ended up looking at a huge swath of sky. He looked over the whole ecliptic -- the line where the planets are located - and he looked a good bit south and a good bit north of that, and found no other objects in the outer solar system except for Pluto.

In the end I think he was disappointed that Planet X was not there.

In the 65 years after this discovery though, astronomers had started to relook at the outer solar system to see what else might be there, to see what was missed in the 1930s and 40s with the antiquated technology.

And, as of today, we now know that Pluto is not alone. Pluto is a member of what we call the Kuiper Belt. We now know of more than a thousand objects in this region out beyond Neptune. Astronomers have found these Kuiper Belt objects using the same technique as Clyde Tomball - take a picture, come back a couple hours later and take another picture, and look for things that move.

Pluto was just the tip of the iceberg. There are many thousands of objects out there, some of them approaching or even exceeding the size of Pluto. And Pluto is just a typical member of this Kuiper Belt. Pluto's orbit takes it from the inner edge of the Kuiper Belt to the outer edge of the Kuiper Belt.

To find these thousand objects in the Kuiper Belt, astronomers have done something that looks a little strange. Astronomers, in the first ten years looking for objects in the outer solar system, looked well beyond the ecliptic.

I gave this talk to a third grade class, and one of the students raised his hand and asked, "How come astronomers are stupid now?" That's a really hard question to answer, because the reasons are vast. But the reason that astronomers covered so little sky in the first ten years is not because they're stupid, but because as technology improved, telescopes got bigger, detectors got bigger, everything got bigger except for our ability to cover large swaths of sky at once.

And the reason is simple and its something that most people don't think about when they consider the advances in astronomy - Clyde Tombaugh used photographic plates -- a piece of glass with photographic emulsion

painted on the back of it -- and the plates were big, so you could cover big areas of sky at once.

These days all astronomers use much smaller digital CCD cameras. The camera we have at Palomar Observatory is about 5 years old, and it has 170 megapixels. When everybody only had 2 megapixels in their digital cameras, that sounded really impressive. Still, we can cover a huge area of sky compared to what we had before. If you hold your hands out and make a circle, that's about how much sky we get at once.

The other key component is a telescope to put the camera on. The telescope that this camera goes on is one of the smaller telescopes at Palomar Observatory, but it has a wide field of view. It also has a microwave link, so we can run this telescope entirely robotically. And this means that my wife still talks to me, because night in and night out, I don't have to go down to the telescope. I can actually have a life. In the morning, the data get transferred from the telescope to my computer at the Cal Tech campus, so I don't have to lose too much sleep.

After five years, we've finally done a survey of the sky that covers more sky than Clyde Tombaugh did. That shows you what an amazing job he did with the technology he had back then. We have a few spots missing. We can't see the southern hemisphere, of course.

We've been looking to dig tunnels. We generally avoid the swath of sky that's the Milky Way galaxy, because it's the galactic plane. When you're looking for Kuiper Belt objects, if you have all those stars in your background, it's generally impossible to find anything. We still have some patches to do for the northern winter sky - January and February. Anyone who remembers how cloudy it was last January, or the January before, or the January before, won't be surprised that we haven't got much data.

We take a picture of the sky, come back to the same spot an hour and a half later and take a picture, and come back one more time and take a picture an hour and a half later. The data come down to the computer in Pasadena, and the computer looks for anything that moves.

If it's not moving, it's a star and the computer throws it out. If it thinks it sees something moving, it flags it and gives it to me to look at in the morning. Every morning I probably look at 100 little postage stamp-sized photos that the computer flagged. It takes me about 15 minutes every day to go through all of that.

The postage stamp is actually about the size of a hair, held at arms length. It's a tiny part of the sky where the computer has picked out something it thinks is moving over the course of the night. Now, if you take pictures of the night sky, you see a lot of things that move. And you can tell a lot about them just from how fast they move. The further away something is, the slower it moves, and the closer it is, the faster it moves. We found about 80 objects in the outer solar system by doing this.

The fastest thing we see are airplanes. Palomar is in the path of the San Diego airport. Airplanes are also really big, so they ruin the entire field and we have to start all over again. We see satellites in orbit around the Earth - they move very quickly. Moving out further, we see many asteroids.

Asteroids are in a region between Mars and Jupiter, and it's a tiny area of the sky that's relatively close by. We're interested in near-Earth asteroids -- in fact, we're collaborating with the group at JPL who look for near-Earth asteroids. So if ever we take pictures of objects that are about to smash into us and kill us, don't worry, we send the data to the right place. It might be a day or two late, but we do send it."