When Is a Planet Not a Planet? The Story of Pluto*

INTRODUCTION

My very eager mother just served us nine pizzas

A very silly sentence, yet schoolchildren have memorized it for years, because it helps them remember the planets in our solar system. The first letter of every word stands for a planet, in the order of how close it is to the Sun. **M**y **v**ery **e**ager **m**other **j**ust **s**erved **u**s **n**ine **p**izzas.

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto

Mercury is the planet closest to the Sun, and tiny Pluto is the farthest away. That is, until recently.

Pluto is still there, of course. Along with the planets, asteroids, comets, meteors, and bits of space rock and ice, Pluto is part of our solar system. Pluto and all those other objects orbit, or travel around, the Sun. However, on August 24, 2006, the International Astronomical Union (IAU), a group of individual astronomers and astronomical societies from around the world, made an announcement. They declared that Pluto was not a planet. Suddenly, "My very eager mother just served us nine pizzas" didn't work anymore, because now there are only eight major planets orbiting the Sun. Perhaps someone will create a new sentence to help us remember their names and order.

While names are important, they are not the only things to know about the planets (or about our solar system). Learning how planets form, where they are located, and what they are like is the kind of activity that makes science exciting, useful, and even fun.

THE WANDERERS

From the beginning of time, people have paid attention to objects in the night sky. Our ancient ancestors studied the Moon. They watched it grow from a tiny crescent-shaped sliver to a round ball of light, then slip back to a tiny sliver again. As they watched it, they began to mark off time. One full cycle of the Moon became one month. They noticed other things moving in the night sky---stars, comets, meteors, planets---which filled them with wonder and amazement.

Around 1000 B.C., through careful observation of the night sky, the early Greeks noticed that some of the objects in the night sky were brighter than others. They noticed that these objects moved from east to west, across a background of stars that seemed to stay still. What were these things? The Greeks called them *planetes*---which, in their language, means "wanderers." Our word "planet" comes from that Greek word.

Why did the planets wander? In the ancient world, some people thought the planets were gods, walking across the heavens. (Note: All of the planets, as well as the days of the week, have names derived from the Greek and Roman gods.) Others, however, wanted a more scientific answer. Ptolemy (Tole-uh-me) was a Greek astronomer who lived from A.D. 100 to 179. He was one of the first to

describe how planets "wander." Ptolemy said planets moved in an orbit, a curved path that one object travels along as it revolves around another. Ptolemy believed that the Earth was at the center of our universe, so he claimed that the planets, the stars, the Sun, and the Moon all orbited around the Earth. For the next 1,400 years, people believed Ptolemy's *geocentric* theory of the solar system ("geo" is Greek for earth).

Later, other astronomers observing the heavens began to make observations and mathematical calculations that suggested Ptolemy's theory was incorrect. One such sky gazer was Polish astronomer Nicolaus Copernicus. Based on careful measurement and observation, Copernicus concluded that it was the Sun, not the Earth, that was at the center of our solar system. He said that all of the planets---including Earth---orbited the Sun. Copernicus's *heliocentric* theory (*"Helios"* is Greek for Sun) contradicted ancient understandings of the solar system, and many people, most especially a group of Christians who followed the teachings of Martin Luther (the Lutherans), did not accept Copernicus's explanation. It was, in short, a revolutionary idea. In fact, Copernicus's theory would eventually be so important to understanding the solar system, that it is often referred to as "the Copernican Revolution"---a turning point in a more scientific understanding of the world.

Still, Copernicus's ideas would not be embraced during his lifetime. However, the work of Italian astronomer, Galileo Galilei, would build on and support Copernicus's observations. Galileo, as he was known, lived from 1564 to 1642. Working with a telescope that he invented, Galileo discovered that Jupiter has moons orbiting it, just as our Moon orbits Earth. He also discovered that the Milky Way is not a smear of white in the night sky, but is made up of individual stars---billions of them! Galileo, making more precise measurements and observations with the assistance of his telescope, agreed with and confirmed Copernicus's heliocentric theory. However, many people were still not ready for new ideas. In fact, most people at the time (mid-16th and early 17th centuries) thought Galileo's theories went against the stories in the Bible that seemed to put Earth at the center of the universe. In those days in Catholic countries like Italy, the church made the laws, and the church punished people who broke its laws. Galileo was put under house arrest, where he remained for the rest of his life. Others who agreed with him were punished, and some were even burned at the stake. Galileo's life was spared on one condition: he had to publicly renounce his theories. In other words, he had to deny what he saw with his own eyes and knew to be true.

Fortunately, brave scientists continued to study the heavens anyway. At the same time Galileo was working in Italy, Johannes Kepler (1571-1630) was working with a telescope in Germany. Kepler studied the sky through his telescope, and astronomy changed again. He became the first person to discover that the planets move in an elliptical, or oval, orbit around the Sun, not a circular one, as Copernicus and Galileo had thought. He also discovered that planets do not move at a steady speed. Instead, they move faster the closer their orbits take them to the Sun. Another of Kepler's important discoveries was that the time required for a planet to complete its orbit depends on its distance from the Sun. For example, Mercury, the planet closest to the Sun, completes its orbit around the Sun in 88 days. It takes Earth 365 days, or one year, to complete its orbit, while distant Pluto takes 248 Earth *years* to do the same thing. Kepler helped people understand *how* the planets move around the Sun, but no one

understood *why* they moved. About forty years after Kepler died, an English mathematician named Isaac Newton answered that question.

Few scientists try to solve a problem or answer a question from scratch. Instead, they build upon the work that scientists before them have done. Isaac Newton (1643-1727) understood Kepler's work, and it helped him to make his own discoveries. Newton had been using a telescope to study the planets and their movements. One day, he watched an apple fall from a tree and began to think about the force that pulled it down. Since apples fall from the top branches of the tree as well as from those near the bottom, Newton realized that the force that pulled them down---gravity---reached all the way to the top of the apple tree. And if it reached the top of the tree, Newton began to wonder….could gravity reach all the way to Moon? Using mathematics and observations made with his telescope, Isaac Newton hypothesized that the planets, stars, moons, asteroids, and comets---all the objects in the universe---have gravity, and that it is gravity that holds them in their orbits.

Kepler's laws had explained *how* the planets move. Now Newton's laws explained *why* they moved. Kepler's and Newton's discoveries formed the foundations for the study of physics. Physics is the science of how matter (anything that takes up space in the universe, whether it is solid, liquid, or gas) is affected by energy (the force that makes anything move, or work).

In science, when someone discovers a fact, or an event, that repeats itself over and over again, the discovery becomes a scientific law---something future scientists can rely upon to be true. Kepler's and Newton's discoveries are part of the law of physics, and so far, these laws have never been broken. They are considered as true today as they were when the men discovered them. Scientists still use them as they conduct their investigations and gather new and exciting information about our universe.

Today, scientists do their work in much the same way that Kepler and Newton did. They begin with *observation*---carefully watching how something works. After some time of observation, they develop a *hypothesis*, which is a scientifically based educated guess about how or why something works the way that it does. Hypotheses are based on lots of scientific research, and thus, make predictions about what is expected to happen. For example, a researcher could have a hypothesis that a particular germ causes a disease. Or an expectation that a new planet can be found in a certain area of the night sky. A hypothesis is just an idea or an educated guess, until it is tested.

Scientists test their hypotheses over and over again. If the results don't disprove the hypothesis, they ask other scientists to test their hypotheses also. And if those tests produce identical results, the hypothesis becomes a *theory*. Scientists then begin to count on the theory being true. However, scientific theories---and even laws---can change if new information is discovered.

Until 1781, everyone operated on the theory that Mercury, Venus, Earth, Mars, Jupiter, and Saturn were the only planets in our solar system (that is, there were only six planets). Then in 1781, an English astronomer named William Herschel (1738-1822) discovered another planet, Uranus. Twenty years later, in 1801, an Italian priest and astronomer, Giuseppe Piazzi (1746-1826), was looking through his telescope. He saw a bright object---something new and different—traveling from east to west. It was large, about one-third the size of our Moon. Piazzi shared his discovery with other astronomers, and

they determined Piazzi had found another new planet. It was named Ceres. But the following year, astronomers found an object similar to Ceres in the same orbit. Then they found another. And another. The astronomers were puzzled. Could there be *that* many new planets? William Herschel suggested they give these small objects a new name: "asteroids." More and more asteroids were found. They were whizzing around in space, orbiting the Sun, just like Ceres. Astronomers named this region of space the Asteroid Belt.

Then in 1846, a German astronomer named Johann Gottfried Galle (GOL-lee) (1812-1910) discovered Neptune. Now there were nine planets in the solar system. After much more study and consideration, however, astronomers began to change their minds about Ceres. Though it was much larger than other bodies traveling in the Asteroid Belt, Ceres wasn't traveling by itself, in its own orbit, as each of the planets did. Ceres was traveling with asteroids. Also, compared to the other planets, Ceres was very small. Astronomers finally decided that Ceres was an asteroid---one of the largest, but still an asteroid. So Ceres was demoted from planetary status and the solar system returned to eight planets.

Percival Lowell (1855-1916) was a successful American businessman, travel writer, and diplomat. He was not a professional astronomer, though he loved to study astronomy. In 1894, using his own money, he established the Lowell Observatory in Flagstaff, Arizona.

Lowell was fascinated with Mars, but he had another abiding interest. He hoped to find a ninth planet---one he called Planet X. As he studied the recently discovered Neptune, he noticed that the planet wobbled as it orbited. Using Newton's and Kepler's laws, Lowell decided that Neptune might be wobbling because the gravity of another, unseen, planet was tugging on it. He used the laws of physics to help pinpoint where this mysterious new Planet X might be found. Sadly, when Lowell died in 1916, he had still not found it. But in 1929, astronomers at the Lowell Observatory decided to look for Planet X again. A young astronomer, Clyde Tombaugh (1906-1997), used Percival Lowell's calculations to search the night skies. On February 18, 1930, he found what he was looking for---the smallest and farthest planet, Pluto. But, in time, as this planetary newcomer was more closely studied, problems with Pluto became apparent.

There are two groups of planets in our solar system. The planets closest to the Sun---Mercury, Venus, Earth, and Mars---have a solid surface made of a mix of rocks, dirt, and minerals. The planets farthest away from the Sun---Jupiter, Saturn, Uranus, and Neptune---don't have a solid surface. They are made up mostly of gas, with a rocky core. Scientists have a theory about why some planets are terrestrial, or made of rocks and dirt, and why some are composed primarily of gas.

Most scientists believe that our solar system is about 4.5 billion years old and that it all began as a space cloud, called a nebula. The nebula was made up of bits of space dust, rocks, ice, and gas. After 100,000 years or so, a tiny star, not yet ready to give light, began to form in the center of the nebula. The star was our Sun. Millions of years passed, and the Sun grew big enough that high temperatures and extreme pressure caused hydrogen at the center of the Sun to begin to fuse into helium and release energy as light---sunshine!

Meanwhile, the nebula continued to orbit the new Sun until it formed a large flat ring around it. Scientists call this ring a "protoplanetary disk." The disk, or ring, was hottest where it was closest to the Sun, and coolest at its outer edge. As the disk swirled around the Sun, the Sun's gravity went to work. It pulled and tugged at the bits of rock, dust, ice, and gas until they came together in clumps of material we now call the planets.

The planets that were closest to the Sun didn't keep much of their gas. The Sun's heat blasted it away, leaving behind a solid sphere of matter, with only a little gas. Those spheres became the terrestrial planets---Mercury, Venus, Earth, and Mars. But on the outer edges of the disk, far away from the Sun's heat, it was much cooler. The clumps or rock and dirt there still had their thick layers of gas; they didn't burn away. The planets farthest from the Sun became the gas giants, Jupiter, Saturn, Uranus, and Neptune.

Because astronomers still believed this theory about how our planets formed, they had a problem with Pluto. When it was first discovered in 1930, astronomers assumed Pluto was made of ice and gas because of its great distance from the sun. However, by 1987, Pluto had moved into a position that only occurs twice in its 248-year orbit and scientific instruments had improved. Astronomers were able to study Pluto and the light that reflected off it. Their instruments told them that Pluto was dense and must have a rocky core. That new information raised questions. If the planets closest to the Sun were mostly made of gas, why was Pluto---the most distant planet of all---made of rock?

There were other questions as well. Pluto's orbit is different from the orbits of the planets. Think of an orbit as a lane on a racetrack. Just as runners have their own lanes on the track, each planet has its own orbit around the Sun. For the runners, all the lanes together make up the racetrack. For the planets, all their orbits, taken together, make up the "orbital plane." Just as runners don't run outside their individual lanes, planets don't travel around the Sun outside their individual orbits. Except for Pluto. Pluto crosses Neptune's orbit. The shape of Pluto's orbit is different, too. The larger planets travel around the Sun in an oval-shaped orbit. Pluto's orbit is more of a stretched-out oblong. The other planets' orbits are level with the Sun. Pluto's is tilted. Comets' orbits are often tilted, so astronomers wondered, Could Pluto be a comet?

And of course there is Pluto's size. Astronomers knew Pluto was tiny when it was discovered in 1930. But because it was so far away, it was hard to see the planet clearly. Pluto appeared as a tiny dot of light in the night sky. Then telescopes improved. In 1976, American astronomer James Christy discovered that the tiny dot everyone thought was Pluto was really two objects: Pluto had a moon---Charon. Once astronomers discovered that Charon was separate from Pluto, they realized that Pluto was even smaller than they had originally thought. Pluto is only 1.440 miles in diameter. (Charon's diameter is 790 miles.) They began to ask, Is Pluto too small to be a planet? And since they had found Charon, they wondered, Were there more objects out there the size of Pluto? Were *they* planets, too?

FINDING PLANETS

In 1992, astronomers made an amazing discovery: 9.3 billion miles away from our sun is another region of space, shaped like a disk. Astronomers believe it contains approximately 70,000 icy objects, including

Pluto. This area of space was named the Kuiper Belt, after the Dutch-American astronomer Gerard Kuiper (KI-per) who lived from 1905 to 1973. In 1951, more than forty years before its discovery, Kuiper actually predicted that a region like this might exist.

Michael Brown, Chad Trujillo, and David Rabinowitz are planetary astronomers who study Kuiper Belt Objects, or KBOs. People often call these men "the Planet Finders." Together, they hunt for planets at the outer edges of our solar system using the Samuel Oschin Telescope at the Palomar Observatory in Pasadena, California. The Oschin telescope is a wide-field telescope, which means it views broad regions of the sky at once. When paired with a camera at the observatory, it can take pictures of these large areas. In the past, astronomers had to spend their evenings peering through telescopes in order to study the night sky. Thanks to advanced technology, things have changed. Computers control the Oschin telescope and its camera, and as Mike Brown has said, "I can actually have a wife and a life."

While Mike and the other astronomers are having their "life" in the evenings, the cameras in the telescope at the Palomar Observatory are at work. They take three photographs over three hours of the part of the night sky the scientists want to study. Any object moving across the background of billions of stars and galaxies will be captured in pictures. The pictures are then sent from the telescope's cameras to a bank of ten computers at the California Institute of Technology. Next, the computers decide which objects appear to be moving and therefore might be a planet. Usually, the computers select about 100 objects; when the astronomers arrive at work each morning, the pictures are ready for them to view.

Based on his research and observations, Mike Brown hypothesized that there was yet another planet lurking out in the distant solar system, so he developed, wrote, and programmed the computers to analyze the regions of the Kuiper Belt where he predicted it would be most likely to find a planet. Mike Brown says most of the objects he looks at on his computer screen are not planets. Many are caused by some kind of flaw in the telescope's camera. But every once in a while, an astronomer will get very lucky and something new and exciting will appear. That's how Mike and his team discovered 2003UB313, or Xena (zee-nah), as it was nicknamed, on October 21, 2003. Mike says, "The very first time I saw Xena on my screen, I thought that there was something wrong. It was too big and too bright. Then I did a calculation of how big it was and how far away it was. Xena is the most distant object ever seen in orbit around the Sun." Pluto is 3.6 billion miles away, but Xena is 10 billion miles away and is *approximately 400 miles bigger in diameter than Pluto*. It takes Xena more than twice as long as Pluto to orbit the Sun.

Xena was always a nickname. On September 13, 2006, the newly discovered celestial body officially became Eris (AIR-is), for the Greek goddess of strife and discord. It seems an appropriate name, since there was a lot of strife and discord surrounding Eris. Was it a planet or not?

Because scientists always check and recheck their work, Mike Brown and his team of astronomers didn't announce their discovery of Eris until January 5, 2005, after they had had a chance to verify their information. When they revealed their discovery, many people thought the solar system had gained its

tenth planet. But others disagreed. Soon an argument was raging among astronomers all over the world. And the argument came down to one question. What, exactly, is a planet?

It seems surprising, but until August 24, 2006, science had never had a definition for the word "planet." Dictionaries had definitions, of course, but most said something similar to "A large celestial body that circles around the Sun or another star." For a scientist, that definition had problems. For one thing, what is meant by "large body"? Jupiter, the largest planet in our solar system is 88,700 miles in diameter, and it is a planet. Pluto is only 1,440 miles in diameter and---at the time---it was a planet, too. The question "What is a plant?" needed an answer, and the International Astronomical Union (IAU) decided to create not one definition but three.

The IAU developed three classes of objects that orbit the Sun: planets, dwarf planets, and small solar-system bodies. The IAU decided that a celestial body is a planet if it:

1. Orbits the Sun
2. Is round or nearly round, because its gravity has pulled it into shape
3. Is big enough and has enough gravity to "clear the neighborhood" around its orbit

The first two qualifications for planethood, orbiting the sun and a round shape, are easy to understand. The concept of "clearing the neighborhood" is a little more difficult. It might help to think of planets as the schoolyard bullies of the solar system. In order to clear the neighborhood, a planet has to be big enough, and have enough gravity, to get rid of any celestial objects in its way. A large planet might clear its orbit by using its gravity to pull other, smaller, objects toward it and destroy them, the way asteroids are destroyed when they hit Earth. Or, a planet might clear its orbit by attracting smaller objects toward it, then turning them into moons that remain in orbit around the planet. Sometimes a planet will simply push a smaller body into a completely different orbit and get rid of it that way. But no matter how it does the clearing, according the IAU definition, a planet must travel in its orbit by itself.

The second category of planets, called "dwarf planets," have the following characteristics. They must:

1. Orbit the Sun
2. Be round
3. Not be a moon or satellite of any other planet

By this definition, Pluto is a dwarf planet. And although Charon, its former moon, is still locked in an orbit with Pluto, it is a dwarf planet, too. Now they are known as a double-planet system. Ceres is a dwarf planet, also, and Mike Brown's discovery, Eris, is one as well. They are dwarf planets because they orbit the Sun, they are round, and they are not moons of another planet---but they're too small to have enough gravity to clear their neighborhood. Pluto, Charon, Ceres, and Eris are all Kuiper Belt Objects (KBOs)---orbiting far out in space with other objects in the Kuiper Belt. Everything else---asteroids, comets, meteors---are now members of a third class of objects that orbit the Sun and are called "small solar-system bodies."

Some astronomers think the definition of a planet will change again in the future. Others think the current definition is a good one and will last. Science is exciting because it continually changes as new information is discovered. A long time ago, we thought there were six planets. Then we thought there were eight. For a while, with Ceres, there were nine. Then it was back to eight. Then, with Pluto, the number jumped up to nine again. And now it's back to eight. And that is just in *our* solar system!

We know our Sun is not the only star that has planets in orbit around it. New planets are forming around other stars, making new solar systems. There are more than 200 billion stars in the Milky Way galaxy alone. And there are billions of galaxies, full of stars, in the universe. As we study those planets and the stars they orbit, we ask questions. Are there other planets like Earth somewhere in the universe? Does life exist on them? We ask questions as we study the planets in our own solar system, too. Does life exist on one of them, or even on one of their moons? Did life ever exist on any of them? Is Earth the only planet with life? Are we alone in the universe?

In January 2006, NASA launched the New Horizons mission to Pluto. If all goes well, the New Horizons spacecraft will reach Pluto and Charon sometime in the summer of 2015. Then, instruments aboard the spaceship will begin to get a close look at these distant worlds. As the information beams back to Earth, scientists here will study it, trying to learn more about the origins of our solar system and what lies at its outer edges. Pluto still has a story tell. There are questions that need answers, and the answers will come through science. New information is just waiting to be discovered.

*This text has been adapted from, *When Is a Planet Not a Planet?: The Story of Pluto* by Elaine Scott (2007)