Identity Crisis:

The evolution of the classification of our planets

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Look to the heavens and count the stars[1]

Humans are innately programed to organize and classify things. Throughout history, people, regardless of class or age have classified things (Taylor, 2004, p. 298). Early nomads had to have a way to know which berries were edible and which were poisonous. Retail shops organize merchandise. Aristotle said humans put things into categories based on commonalities (Taylor, 2004, p. 298); however, modern day thinkers include differences as well (Basri & Brown, 2006, p.195; Weintraub, 2007, p. 1). This categorization is the basis of human learning. The classification of objects is to find patterns that help us understand how things work (Tyson, 2009, p. 73). The planets are our way of organizing the universe beyond ourselves to better understand it (Brown, 2010, p. 187).

To classify things, we must first determine the boundaries of each category. After the category is defined, the object is compared to the category to see if it meets all the criteria (Weintraub, 2007, p.3). Sometimes things don't quite fit into a category. This problem is the exact problem astronomers have with the planets. At first they didn't have the categories properly defined. Throughout the years, human knowledge has been ever changing and the categories are becoming better defined. They don't have categories that properly define what a planet is or is not.

This paper will follow the path of planet classification and the intellectual discovery throughout history. The beginning of this path was in Ancient Greece. It is important to remember that just because an object is moved from one category for another does not mean that the object actually changed. It only means that our ideas about the object have changed. To the ancient Greeks, the sun was a planet. When the Sun was moved from the planet category to the category of star, it didn't suddenly change. It had

[1] Genesis 15:5 (All scriptures are New King James, unless otherwise noted)

been a star the entire time; humans just didn't know enough about it to put it in its appropriate category (Weintraub, 2007, p. 3). The end of this path will not be the end by any means, but rather present day.

In the beginning was the word[2]…. And the word was "wanderer"

Astronomy is one of the oldest sciences and it was very important to the ancient civilizations. They needed to know when the seasons would change in order to know when the best time to plant and harvest crops would be. They studied the positions of the stars and the sun to accomplish this (Weintraub, 2007, p.8). It wasn't long before they noticed that some of the stars actually moved. These ancient civilizations didn't have a good understanding about why this was happening, but they did acknowledge that these moving stars were different. They put them in a separate category called "wandering star" or "plantoi" in Greek (Boyle, 2010, p.13-14; Brown, 2010, p 18). To the ancients, anything in the sky that they could see, that moved was a planet (Basri & Brown, 2006, p 194). Their planetary system included Mars, Venus, Jupiter, Mercury, Saturn, the Sun and the Moon (Brown, 2010, p 19; Weintraub, 2007, p.16). At that time, they still considered the Earth to be at the center of the universe, it was not a planet.

Greek astronomers began to use math in their studies around 300 B.C.E. These ancient thinkers were highly skilled observers and extremely careful with their ideas. The most influential of these were Aristotle, Aristarchus, Eratosthenes, Hipparchus and Ptolemy (Weintraub, 2007, p.10). Some of their accomplishments included the idea that the earth revolves around the sun (but this wouldn't catch on for a few thousand years), and correctly measuring the circumference of the Earth using only shadows (Weintraub, 2007, p. 14-31).

[2] John 1:1

That they may have life[3]… on all planets!

For nearly fifteen hundred years, the solar system contained seven planets and the categorization of the planet did not change. Planets were still seen as wandering stars. These ideas flourished with the rise of Christianity in the early first century. The church leaders liked the fact that the heavens were perfect and that the Earth was the center of everything (Weintraub, 2007, p. 31). Weintraub alludes to the idea that Christianity actually hindered the growth in the field of astronomy (2007, p.32) while Stark argues Christianity actually jumpstarted the reformation of Western knowledge (2005). Not much else in the field of astronomy changed during this time. Scholars provided powerful philosophical, physical, and theological reason why there should only be seven planets; and the seven planet scheme viewed as the word of God, since seven was a holy number (Weintraub, 2007, p. 35).

It wasn't until the late 1500's when scholars began to challenge Aristotle's hegemony (Weintraub, 2007, p. 36). Copernicus read Aristarchus's ideas that the earth was not the center of universe. This was the beginning of a revolution that would not actually take place for two hundred more years (Bartusiak, 2004, p.51-52; Brown, 2010, p 20; Weintraub, 2007, p.42). The Earth as the center of the universe was one of the central pillars of Christianity. Imagine everyone's surprise when Copernicus asserted, with scientific evidence, that the Sun was the center, and that it was not even a planet (Weintraub, 2007, p. 36). He postulated that the earth was no different than any other planet (Weintraub, 2007, p. 44). His ideas didn't catch on in the scientific world; these claims were just too outrageous. There were scriptures to back up a geocentric universe, and there was no way the Bible could be wrong or that they had misinterpreted it (Weintraub, 2007, p.47-48).

[3] John 10:10

Tycho Brahe was one of the few who agreed with Copernicus; he came up with a part geo- and part heliocentric model of the solar system. In his system the sun and the moon orbit earth, while the other planets orbited the sun (Weintraub, 2007, p. 52-54.) This model somewhat appeased the church, however, many scientists still didn't like it. Everything the ancients knew about the planets had been thrown out for this new awareness of our solar system. If the earth was a planet, then the ancient definition of a planet no longer made sense. The Sun couldn't be a planet either since it didn't move (Weintraub, 2007, p. 57-58).

In the late 1500's, Johannes Kepler developed three laws of planetary motion. One of which said that planets must orbit the sun in an elliptical pattern (Weintraub, 2007, p. 54-55). The second two laws deal with math and measuring both the speed and distance of the planets. These ideas and formulas would be the basis of later discovering new planets. It was to these laws and ideas that Kepler devoted his life to. He proved the most fundamental Aristotelian concepts to be incorrect (Weintraub, 2007, p. 56).

Kepler's new definition of a planet was "an object that orbits our Sun and obeys the three laws" (Weintraub, 2007, p.58). According to Kepler, there were only six planets: Mercury, Venus, Earth, Mars, Jupiter, and Saturn. The moon was excluded as a planet because it orbited Earth and not the Sun (Weintraub, 2007, p.65); moons were called secondary planets (Boyle, 2010, p. 16). Kepler's definitions and criteria came at the same time as the first refracting telescope. Before he had his ideas published, Galileo announced his discovery of four new planets orbiting Jupiter (Brown, 2010, p 18-19; Weintraub, 2007, 62-64). Strangely enough, it was these four moons that caused Galileo to stop and think. If something could orbit a planet, why couldn't the planets orbit the sun? The church put Galileo under house arrest and forced him to recant the ideas about the heliocentric nature of the universe (Weintraub, 2007, p.62).

Although the church put a damper on Galileo's voice, his ideas still prospered. By the mid 1650's the idea of a heliocentric universe was accepted worldwide wide. However, these same astronomers still agreed upon the eleven planet scheme with some planets orbiting other planets (Weintraub, 2007, p.66). Kepler's ideas had been thrown onto a back burner for the time being.

As technology improved, more and more objects were being discovered. Christiaan Huygens discovered a moon and the rings of Saturn in 1684. By the end of that year, 4 more of Saturn's moon had been discovered. All were called planets and thus bringing the total number of planets to 16 (Weintraub, 2007, p.66). Even though only six of these planets obeyed Kepler's formal laws, scientists were not as quick to dismiss satellites as planets as Kepler (who had died by this time) was. They still held on to their old categories (Weintraub, 2007, p.67).

Huygens read one of Kepler's books. In this book Kepler was also that life existed on all planets (objects orbiting stars) (Weintraub, 2007, p.65). He began to study the moon and proved it was incompatible with life due to its lack of atmosphere and water. He also made the assertion that all secondary planets were like our moon and unsuitable for life (Weintraub, 2007, p.69). From this assertion, the idea that secondary planets (satellites) were not planets gained popularity. And it was on the basis of life that the new definition of the category of "planet" was formed (Weintraub, 2007, p. 69). If an object could not have life, it was not a planet. The six planets in (Mercury, Venus, Earth, Mars, Jupiter, and Saturn) were all considered to be capable of bearing life in 1758. As more and more satellites were discovered they were slowly moved from the category of "secondary planets" to that of "moons."

It was never a question that comets were not planets. They did meet Kepler's Laws, but the ancient Greeks categorized them differently than planets, so they must be different

(Weintraub, 2007, p.71). The criteria for a planet still was not clearly defined, but scientists thought they had a pretty good handle the category of "not a planet" (Cook, 2006; Weintraub, 2007, p.81).

Let the heavens be glad, and let the earth rejoice[4]…. We've found some planets!

As technology continued to improve, new telescope designs were being built, and man starting discovering new planets. William Herschel discovered Uranus in 1781. At first he wasn't sure of his discovery. He was trained in studying stars, not planets. The discovery of Uranus was a cause for celebration. It was the first new planet since ancient times (Weintraub, 2007, p.107). It inspired scientists all over to launch a search for new planets.

Just after this discovery, a planet was any object that both obeyed Kepler's three laws and the Titius-Bode Rule (Weintraub, 2007, p.94). The Titius-Bode Rule is the idea that the spacing of the planets follows a certain pattern. Kepler first noticed it, but he couldn't get his calculations quite right. Johann Titius and Johann Bode later were able to discover the exact spacing calculations (Weintraub, 2007, p. 82-84).

There was a gap where they thought a planet should be located. It was right between Mars and Jupiter. Armed with the information from the Titius-Bode Rule, astronomers finally began looking in this gap (Weintraub, 2007, p.94-5). In 1801, a scientist compiling a catalog of stars noticed something moving and night after night he watched it. Giuseppe Piazzi thought what he had discovered was a comet (Weintraub, 2007, p.97). After discussing this with Johann Bode and William Hershel, Piazzi finally accepted what he had just found was indeed the missing planet in between Mars and Jupiter (Basri & Brown, 2006, p. 194; Tyson, 2009, p. 29;

[4] Psalms 96:11

Weintraub, 2007, p.99). They named this new planet Ceres; it was the smallest planet in the solar system.

Just a few months later, another object very similar in size and location to Ceres was discovered. It was named Pallas (Weintraub, 2007, p.100-101). These two new twin planets were so close that they actually crossed orbits. This was astonishing to astronomers, however, it was soon decided that Pallas was a comet. Piazzi argued, saying that it both followed Kepler's Laws and fit perfectly in the Titius-Bode Rule and that it was obviously not a comet. Herschel decided to make a new category for Pallas and Ceres. Since he didn't have very good telescopes, he thought they both were very similar to stars; he called them "asteroids," meaning, "star-like" in Greek (Boyle, 2010, p.19-20; Tyson, 2009, p. 71; Weintraub, 2007, p.101). *(See Appendix A for more sub categories of the planets, along with definitions.)*

Like every change that has happened in the astronomy world thus far, not everyone accepted it. Some scientists still said our solar system had nine planets (Weintraub, 2007, p.102). A few years later, Juno and Vesta, followed by Astraea were all discovered in this same area as Ceres and Pallas (Boyle, 2010, p.17-19; Weintraub, 2007, p.102-103). According to many scientists, there were now thirteen planets.

Now what shall we do?[5] We've got a problem.

Meanwhile, another astronomer, John Couch Adams, had been studying Uranus. He noticed a small discrepancy in its orbit (Tyson, 2009, p. 22; Weintraub, 2007, p. 108). Isaac Newton had only a few years before, introduced the laws of gravity. With this knowledge, Adams calculated the position and size of an additional planet past Uranus. He didn't have

[5] Acts 2:37

access to a telescope, so he made his findings public; no one with a telescope believed him and consequently, it took three months before it was finally discovered; Johann Gottfried Galle found Neptune exactly where Adams' calculations said it would be on the very first time he looked (Weintraub, 2007, p.112-114).

Neptune's discovery stirred several changes. The first of which was with the Titius-Bode rule. Neptune wasn't in the place the Titius-Bode rule had predicted. It was over 750 million miles closer than it was supposed to be (Weintraub, 2007, p. 116-7). The Titius-Bode rule was one of the criteria for a planet. Obviously Neptune was a planet; it just didn't meet the definition. It was time, once again, for a reformation of the criteria for the planet category (Weintraub, 2007, p.118). This was perhaps the first instance since the time of Aristotle that scientists did not have a good definition of a planet and they began to consider that maybe a planet was something the would know when they saw it (Weintraub, 2007, p.118).

The second change that Neptune's discovery sparked was to push the five smaller planets back into the "asteroid" category (Weintraub, 2007, p.103). Along with the acceptance of thisclassification came new technology and the discovery of hundreds more AsteroidsWeintraub, 2007, p.104). They called this new area filled with asteroids, the asteroid belt. Some scientists suggested that all these asteroids did account for the missing planet of the Titius-bode law, and that the planet had some how broken up into thousands of pieces (Weintraub, 2007, p.104). Today there are more than 200,000 objects classified as asteroids (Boyle, 2010, p.21). Due to these higher quality telescopes available, they are also called "minor planets" because scientists can now tell they are very much like planets, and less likes stars as originally thought. *(See Appendix B for a graph of the history of the planet count and Appendix C for a timeline.)*

The third change Neptune's discovery ignited was the idea that a planet could be discovered by math by someone who had never looked into a telescope. Many scientists such as Urbain le Verrier began to study Neptune's orbit for anomalies in which to help him detect the next planet (Weintraub, 2007, p 122-123). Many astronomers had tried to predict this "Planet X" and each calculation was very different from each other, both in size and location. None of the predictions resulted in a discovery (Weintraub, 2007, p 130). With of all of these seemingly random calculations, Jean Gaillot (and later Standish) decided to re-examine the orbits of both Uranus and Neptune. He concluded that any anomalies find in Neptune's orbit were caused by Uranus and not Planet X (Standish, 1993; Tyson, 2009, p. 28; Weintraub, 2007, p 131). Most scientists accepted this.

While most of the scientists had turned their attention to Neptune, Edmond Lescarbault had turned his attention to the inner most planet: Mercury. Like Uranus, Mercury had a seemingly odd irregularity with its orbit. In 1859, he announced the sighting of a very small body between the Sun and Mercury. He called it Vulcan (Weintraub, 2007, p 124). Although no one else ever saw Vulcan, the calculations proved, like they did with the existence of Neptune, that something was toying with the orbit. Many researchers accepted Vulcan into the planet category sight unseen (Weintraub, 2007, p125). After ten years of watching, Vulcan had still never been spotted, and the existence was never actually proven. The occasional sky watcher thought they had caught a glimpse of this elusive planet, but since it is so near the sun, it's very hard to spot, and was eventually it was no longer regarded as a planet.

There's a new name written in the heavens[6]… and it's Pluto!

[6] Revelation 2:17

Percival Lowell and William Pickering were two astronomers that had never accepted the idea of no Planet X. They actually predicted it, along with eight other planets past the orbit of Neptune, but both died before ever discovering any of other planets (Weintraub, 2007, 133). Lowell's nephew soon hired a young astronomer named Clyde Tombaugh to work in the observatory. It was Tombaugh's job to examine thousands of images of the night sky, comparing them for a new planet in the form of a spot that moved between two or more images. In 1930, Tombaugh finally saw something worth noting. It was later named Pluto (Weintraub, 2007, p136-138). Since it was quite a bit smaller than Lowell had predicted, some scientists were skeptical, but the instant popularity of this small, odd planet was far too great for these skeptics (Boyle, 2010, p.11; Weintraub, 2007, p 139). It was the first planet discovered in America, so of course, Americans love it. When the time came to name this newly discovered planet, it was an 11 year old girl who suggested "Pluto" and as a result, made the planet a favorite among children (Boyle, 2010, p.49).

Science and technology had grown by leaps and bounds in the decades before Pluto's discovery, but even with the most powerful telescopes, Pluto was just a speck. It couldn't be seen very well, and therefore couldn't actually be confirmed to be a planet, but since Lowell had predicted a planet in the exact location of Pluto (Boyle, 2010, p.3, 43-45, 64-65; Weintraub, 2007, p183), the small planet slipped into the planet category without much resistance. Many scientists and astronomers agree that if Pluto had been discovered today, it would not be called a planet at all, but a minor planet and that Pluto's planetary status was simply an accident (Boyle, 2010, p.3; Weintraub, 2007, p 217). We have much better telescopes and know much more about the outer solar system than we did in 1930.

Today Pluto, the small planet, remains a favorite planet. It is still the only planet that has not been explored by spacecraft. It is the smallest and by far, the hardest to get to. Pluto has always been sort of an oddity (Boyle, 2010, p.7). It is much smaller than even the smallest planet. Its rotation is so distinctive that the sun rises in the south and sets in the north (Boyle, 2010, p.7). Unlike the other planets with a round orbit, its orbit is an oval shaped. So much so that at the closest to the sun it is inside Neptune's orbit, and at it's farthest it's 1.8 million miles farther away (Boyle, 2010, p.7). Charon, Pluto's moon is also very similar in size to Pluto. The two actually orbit each other around a point in space between the two (Weintraub, 2007, p.176). This is unlike any other planet in our solar system.

A time to search[7]… for more planets

When Pluto was discovered, most scientists stopped looking for new planets (Cook, 2006). There were a few scientists who clung onto the idea of yet another Planet X, but many seemed satisfied with our nine planet system.

Technology continued to rapidly progress. By this time many of the telescopes were computer operated and took pictures of the night sky. Astronomers would look at these pictures during the day. Several small asteroid-like comets were discovered in the 1970’s by Jan Oort and Gerard Kuiper, but no additional planets had been observed. Over fifty years after the discovery of the ninth planet, David Jewitt of the University of Hawaii, decided to keep searching for a planet past Pluto (Weintraub, 2007, p 158). He and Jane Luu wanted to prove to the world that the universe was still worth investigating.

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7 Ecclesiastes 3:6

After 5 years, they still had nothing to show for their search (Cook, 2006). Finally, in 1992, they saw a small something. It was given the official name of "1992 QB1" and labeled as an asteroid (Cook, 2006). It was small, but it was the first discovery in the outer solar system in over sixty years; within a year, Jewitt and Luu had discovered six more objects. The two astronomers concluded that they had finally found the asteroid belt Kuiper had predicted; and Pluto was located in the midst of it (Cook, 2006; Weintraub, 2007, p 158) .Jewitt and Luu's discovery did indeed prove that our outer solar system was still worth investigating. Astronomers all around the world turned their telescopes that direction once again. By 2002, almost 5000 minor planets, or asteroids, had been cataloged by the Minor Planet Center (Weintraub, 2007, p161).

At the end of the 20^{th} century, most scientists agreed that the criteria for being a planet included a primary orbit around a star, large enough mass to be spherical, and not so large to generate nuclear fusion (Weintraub, 2007, p185). However, there was no official definition, and many other objects in our solar system seemed to fit that definition including at least 15 known asteroids (Weintraub, 2007, p202), but no on tried to argue that there were 24 planets in our solar system. There had to be some underlying criteria that everyone was using to exclude the asteroids.

Another drop in the bucket [8]

In 2003, a very large KBO was discovered by Michael Brown. This object was thought to be larger than Pluto (Boyle, 2010, p.8-9). Brown said that if Pluto was a planet, then this object must also be a planet (Weintraub, 2007, p 163). This object was later given the official name of

[8] Isaiah 40:15

Eris (Boyle, 2010, p.9). It was with this discovery that Brown finally started making people think. Astronomers and scientists all over the world started analyzing what they knew about Pluto and planets. Many thought Pluto was still a planet despite the recent discoveries of the Kuiper Belt and of Eris. Others thought that none of them were planets. However, it was then that everyone realized they didn't have a formal definition of a planet.

Neil Tyson director at the Hayden Planetarium hosted a debate to help him figure out what kind of changes he could make to the planetarium (Tyson, 2009, p 69). He brought together several of the world's leading astronomers including Jane Luu and Alan Stern to talk about Pluto's status as a planet. As the debate progressed, Tyson gaged from the audience's reactions that they agreed with the decision the scientists came to: that Pluto didn't need to retain any official planetary status (Tyson, 2009, p. 75). Still, nothing was official; the only thing that Tyson could do was change his own museum's display. Members of the audience included a few textbook writers who began changing textbooks on astronomy to exclude Pluto from the official planet category and instead included it under the category of other planetary bodies. There were reporters from the audience that wrote newspaper and magazine articles discussing the issue (Tyson, 2009, p. 81). The public outrage was only just beginning as they wrote angry letters to Tyson because he "demoted Pluto."

Tyson's debate didn't make anything official, so who could officially change the definition of a planet? The International Astronomical Union (IAU) was the organization that stepped in. It was established in 1919 as the world governing body dealing with astronomical nomenclature and definitions (Boyle, 2010, p. 4; Cook, 2006). However, the IAU is still not the official authority on the planets. They only name objects and surface features such as mountain ranges on Mars (Grinspoon, 2009, p. 20). Since the previous definition of a planet was thrown out long before the IAU's creation, they didn't have a previous definition to work from (Boyle, 2010, p.112; Basri & Brown, 2006, p.194). They had never met to discuss the definition of a planet because the definition was not important to "astronomical research, but it's vital to the public perception of astronomy, especially for children trying to make sense of their environment" (Levy, 2006, p. 110).

What is a planet? It sounded pretty simple to both the public and to the scientists. Everyone agreed that the classification scheme used was outdated and needed to change (Tyson, 2009, p. 100). No one knew how to bring about this change, so the first place they looked was to the dictionary. However, the dictionary definition of a planet and related terms just didn't work for either scientific purposes or for classification purposes. It was "essentially worthless" (Weintraub, 2007, p.5). Scientists began proposing many ides for the new criteria for a planet such as the presence of an atmosphere, life, water, a moon, a solid surface, even a magnetic field (Stern & Levison, 2000, p 2; Weintraub, 2007, p. 203-204). In the end, all of these ideas fell flat. However, most astronomers agreed that the new definition should be "succinct and easily understood by the public, yet precise enough to be acceptable to scientists" (Basri & Brown, 2006, p. 195). The word "planet" has been around for several millennia and scientists needed to be careful not to change it too drastically (Basri & Brown, 2006, p. 195). The decisions astronomers are making today will affect the scientists of tomorrow. Roger Pelland, a third grade science teacher said, "Why not let the children have a role in the decision? After all, it is they who will have to live with the definition of "planet" (Levy, 2010, p. 18). Tyson agrees with Pelland and enjoys getting letters from children, regardless of their viewpoints. He reads and responds to each on individually to encourage the future scientists.

Before Pluto was discovered, there were two main subcategories of a planet: terrestrial planets and gas giants (Stern & Levison, 2000, p. 1). The idea of a new definition for planets sparked new ideas about a possible third category: icy planets (Boyle, 2010, p. 197). With the addition of a third sub category, Pluto could remain a planet, while still being in a different class than the other planets. For the time being, there were no new categories, so Pluto remained a planet for lack of better nomenclature (Tyson, 2009, p. 82).

The IAU brought together a small committee of astronomers and scientists to formally define a planet in early 2006. What they came up with was that a planet must "be able to clear out the neighborhood of its orbit and be the biggest thing in its orbital space" (Boyle, 2010, p.9). No where did they clarify what the "neighborhood" was or how big the "orbital space" was. It was very arbitrary and brought ample obloquy to the world of science. They also said this would exclude Pluto from the planetary ranks. The public was outraged and astronomers were split on the idea. People from all over, including children wrote thousands upon thousands of articles, blog posts, emails, letters, poems, and even song lyrics about their beloved Pluto (Boyle, 2010, p. 6). Cook speculated that if it had been Neptune that had been demoted no one would care; it was simply because Pluto was a favorite among the people that they were upset (2006). The IAU knew this definition would not work. They decided to have a formal discussion at the General Assembly later that year.

Pouring salt into the wound[9]

The 26th General Assembly of the IAU met in Prague, Czech Republic. Scientists rewrote the previously proposed definitions and removed the major problems. They defined the

[9] Proverbs 25:20 (Good News Translation)

differences between the eight classical planets and the numerous dwarf planets; they also made it clear that the definition only pertained to our own solar system (Boyle, 2010, p. 123). During this meeting, the participants began acting more like children than adults. “They argued, quite often belligerently, from their own narrow perspectives, unable (or unwilling) to see the situation from anybody else’s point of view” (Feinberg, 2006, p.8). The arguments grew very political. There were people who wanted to keep Pluto a planet to preserve history, while others wanted Pluto demoted to preserve accuracy and unity of classification (Boyle, 2010, 115). The resulting definition read like it came from bureaucrats, not scientists (Feinberg, 2006, p. 8). Nevertheless, the scientists were relatively pleased with their definition. They were happy the debate was finally over. Since the definition wasn’t vitally important to astronomy, many of the scientists who disagreed with it, including Owen Gingerich, kept quiet (Boyle, 2010, p.133). After the IAU announced their results to the public, everything fell apart (Gingerich, 2006, p. 139). *(See Appendix D for the full definition.)*

This new, hastily written definition caused more problems than it solved (Grinspoon, 2009, p.20). The entire point of having a definition is for clear communication and no one was communicating correctly with this vague definition; even professional astronomers were confused (Boyle, 2010, p. 173; Feinberg, 2006, p.8). Scientists everywhere, including Stern said the definition was “linguistically flawed” (Boyle, 2010, p. 20; Levy, 2006, p. 111), others declared it was “partially redundant,” (Beatty, 2008, p. 34), “scientifically questionable” at best and far too narrow in scope (Feinberg, 2006, p.8). It was “so atrocious that many planetary scientists didn’t want anything to do with it” (Beatty, 2008, p.34). “An overly narrow classification system is asking to be rendered obsolete by future additions to the planetary list,” (Boyle, 2010, p. 199). Grinspoon said it best, “It doesn’t have to be a perfect definition, just one that makes sense, however, if the IAU adopts a clearly flawed definition, nobody is under any obligation to accept it" (2009, p. 20).

While scientists were most frustrated with the definition for the way it was worded, the public was concerned with their favorite planet no longer being considered as a planet. Many people assumed that since there were eight classical planets that dwarf planets don't count as planets, but the IAU never actually said that. They intended that both classical and dwarf were subcategories of the larger group of "planet" (Grinspoon, 2009, p.20).

As sort of a bandage for the situation, Levy and Stern suggested sending a spacecraft to Pluto to see what the photos looked like. The additional information would be beneficial in once again reclassifying the small planet and others like it (Cook, 2006; Tyson, 2009, p. 75). The New Horizons spacecraft will reach Pluto in 2015, after nearly ten years of travelling (Cook, 2006). Once again, Pluto will likely be the center for discussion at the IAU General Assembly.

In the meantime, scientists continue to use this definition for classical planets and dwarf planets for new discoveries. Since 2006, the number of dwarf planets has grown to five confirmed and four unconfirmed dwarf planets. They hope to learn more about these objects in 2015 when New Horizons gets there (Brown, 2010, p. 182).

There have even been some recent predictions about yet another asteroid belt or larger planets past the farthest reaches of our known solar system. A Japanese astronomer has noticed a few irregularities in the orbits of many of the Kuiper belt objects that seem to point to a more distant planet (Schilling, 2008, p. 30). Scientists David Jewitt and Mike Brown have started looking for this new Planet X (Schilling, 2008, p. 32).

The end is yet to come[10]

The path of science has drastically changed since Aristotle's days, but it's still moving forward. Planetary classification, although it appears to be set in stone, is actually quite fluid. Nearly every time a new planet was discovered, scientists changed the definition of a planet in some way. They will continue to change the criteria and the categories regardless of how perfect (or imperfect) the definition seems to be. Categorization helps us learn, but knowledge is the force behind these changes to our classification systems. These systems will be constantly changing and new things are discovered in the planetary world.

[10] Matthew 24:6

References

Bartusiak, M. (2004). *Archives of the universe: a treasury of astronomy's historic works of discovery.* New York: Pantheon Books.

Basri, G., & Brown, M. E. (2006). *Planetismals to Brown Dwarfs: What is a Planet?.* Annual Review of Earth and Planetary Science, 34, 193-216. Retrieved April 10, 2012, from http://www.annualreviews.org/doi/pdf/10.1146/annurev.earth.34.031405.125058

Beatty, J. K. (2008, December. Still Debating Pluto's Fate. Sky & Telescope, 114, 34-35.

Boyle, A. (2010). *The case for Pluto: how a little planet made a big difference*. Hoboken, N.J.: John Wiley & Sons.

Brown, M. (2010). *How I killed Pluto and why it had it coming*. New York: Spiegel & Grau.

Cook, N. (Director). (2006). Bye-Bye, Planet Pluto [Documentary]. BBCW Production: Films for the Humanities & Sciences.

Fienberg, R. T. (2006, November). Pluto Doesn't Care. Sky & Telescope ,112, 8.

Gingerich, O. (2006, November). Losing it in Prague: The inside story of Pluto's demotion. Sky & Telescope. 112. 34-39.

Grinspoon, D. (2009, March*). This is not a Planet? Let's save Pluto and rescue planetary science from endless ridicule*. Sky & Telescope , 117, 20.

International Astronomical Union. (2006a). The Final IAU Resolution on the definition of "planet" ready for voting. [Press Release] Retrieved from http://www.iau.org/public_press/news/release/iau602.

International Astronomical Union. (2006b). IAU 2006 General Assembly: Result of the IAU Resolution Votes. [Press Release] Retrieved from http://www.iau.org/public_press/release/iau603.

International Astronomical Union. (2008). *Plutoid choses as name for Solar System objects like Pluto.* [Press Release] Retrieved from http://www.iau.org/public_press/news/release/iau804.

Levy, D. H. (2006, December). *What is a Planet?.* Sky & Telescope , 112, 110-111.

Levy, D. H. (2010). *Pluto's Second Chance: the planetary scientists of tomorrow choose a definition of planet for today*. Astronomy, 38(10), 18. Retrieved April 11, 2012, from the Gale database.

Schilling, G. (2008, January 12). *The Mystery of Planet X.* New Scientist, 30-33. Retrieved April 11, 2012, from NewScientist.com

Standish, E. (1993). *Planet X: No Dynamical Evidence in the Optical Observations.* The Astronomical Journal, 105(5), 2000-2006. Retrieved April 19, 2012, from http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1993AJ....105.2000S&defaultprint=YES&page_ind=0&filetype=.pdf

Stark, R. (2005). *The victory of reason: how Christianity led to freedom, capitalism, and Western success.* New York: Random House.

Stern, S. A., & Levison, H. (2000). *Regarding the Criterion for Planthood and Proposed Planetary Classification Schemes*. Retrieved April 6, 2012, from http://www.boulder.swri.edu/~hal/PDF/planet_def.pdf

Taylor, A. G. (2004). Systems for Categorization. *The Organization of Information* (2nd ed., pp. 297-322). Westport, CT: Libraries Unlimited.

Tyson, N. D. (2009). *The Pluto files: the rise and fall of America's favorite planet*. New York: W.W. Norton & Company.

Weintraub, D. A. (2007). *Is Pluto a planet?: a historical journey through the solar system*. Princeton, NJ: Princeton University Press.

Woodruff, J. (2003*). Firefly astronomy dictionary*. Toronto: Firefly Books.

Appendix A:

Glossary of Subcategories of Planets

Asteroid: a small solar system body in an independent orbit around the sun (Woodruff, 2003) *also called Minor Planet*

Classical Planet: a regular planet as defined by the IAU; an object that has enough gravity to be round, orbits the sun, and has cleared its orbit of other bodies (IAU, 2006a)

Dwarf Planet: a planet with mass less than 10 earth masses (Stern & Levison, 2000 p. 8; Weintraub, 2007) or, as defined by the IAU, a small round planet that has not cleared its orbit.

Free Floating Planet: *see rogue planet*

Gas giant: a planet with a mass much larger than earth's and is made primarily of gas; planet with mass less than 1000 earth masses (Woodruff, 2003; Boyle, 2010, p 197; Weintraub, 2007)

Geocentric Planet: a planet that orbits the earth (Weintraub, 2007, p.64)

Giant planet: *see Gas Giant*

Heliocentric planet: a planet that orbits the Sun (Weintraub, 2007, p.64)

Hydrogen gas planet: a gas planet made up of mostly hydrogen (Weintraub, 2007)

Ice Dwarf Planet: *see Ice planet*

Ice Giant: a giant planet that is made up of mostly ice such as Neptune and Uranus (Stern & Levison, 2000 p. 1)

Ice planet: a small round body made up of mostly ice (Weintraub, 2007)

Inferior planet: a planet inside earth's orbit (Woodruff, 2003)

Inner planet: a planet inside the asteroid belt (Woodruff, 2003)

Jovian Centric planet: a planet that orbits Jupiter (Weintraub, 2007, p.64)

Life-bearing satellite: a satellite of the sun that could bear life (Weintraub, 2007, p.69)

Lifeless satellite: a satellite of a life-bearing satellite that could not have life (Weintraub, 2007, p.69)

Main Plane planets: planets in the plane of the ecliptic (Tyson, 2009, p. 106)

Major planet: a non-stellar body in orbit around a star, shining only by reflecting that star's light (Woodruff, 2003)

Medicean Planet: the four largest moons of Jupiter, discovered by Galileo (Weintraub, 2007)

Mesoplanet: a planet (or planetary-like-body) smaller than Mercury, but larger than Ceres (Weintraub, 2007)

Minor planet: another name for an asteroid, an object in orbit around the Sun that is too small to be a planet (Weintraub, 2007, p 216)

Outer Planet: a planet outside the asteroid belt (Woodruff, 2003)

Planemo: a planetary mass object, an object with approximately the same mass as a planet, but has not pulled itself into a round shape (Weintraub, 2007)

Planet: *see classical planet*

Planetar: *see rogue planet*

Planetary-Scale Satellites: planetary bodies in orbit around a larger planetary body (Weintraub, 2007)

Planetismals: building blocks of a planet, such as asteroids (Weintraub, 2007, p.104)

Planetoid: any spherical object in space (Weintraub, 2007, p227), an asteroid (Feinberg, 2006, p. 8)

Planet X: hypothetical planet beyond the orbit of the known planets (Woodruff, 2003)

Plutino: Kuiper Belt Objects with orbits similar to Pluto's with a distance from the sun between 39 and 40 AU (Weintraub, 2007)

Plutoid: celestial body in an orbit around the Sun at a semi-major axis greater than that of Neptune that have has sufficient mass for self-gravity to overcome rigid body forces so the object assumes a hydrostatic equilibrium shape and that has not cleared the neighborhood around it's orbit. Satellites of Plutoids are not plutoids even if they meet all the requirements (IAU, 2008)

Pluton: *see Plutoid*

Plutonian: *see Plutoid*

Rocky planet: planets made up of mostly rock, such as Earth (Boyle, 2010 p 197; Weintraub, 2007)

Rogue Planet: A planet that does not orbit any particular star (Weintraub, 2007)

Secondary Planet: a planet that orbits another planet such as a satellite or a moon. (Weintraub, 2007, p.4)

Sub-Brown Dwarf: an object smaller than a brown dwarf (star) that has not reached an interior temperature high enough to cause nuclear fusion (Weintraub, 2007)

Sub-Dwarf Planet: A planet with a mass less than 3% of the Earth's mass (Stern & Levison, 2000 p. 8; Weintraub, 2007)

Sub-Giant planet: a planet with a mass less than 100 earth masses (Stern & Levison, 2000 p. 8; Weintraub, 2007)

Super Giant: Planet with less than 30,000 earth masses (Stern & Levison, 2000 p. 8; Weintraub, 2007)

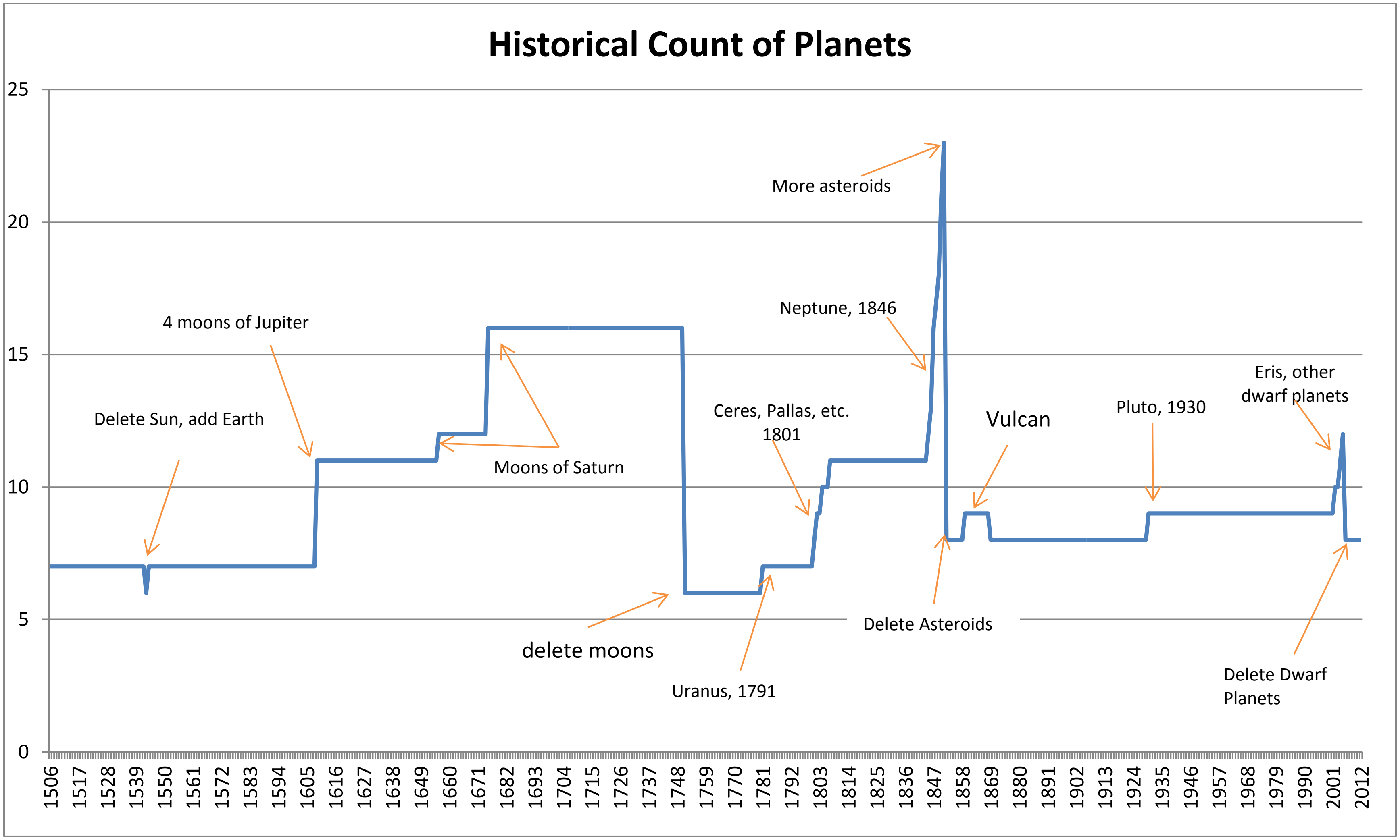
Superior planet: a planet outside earth's orbit (Woodruff, 2003)

Terrestrial planet: a planet similar in size and density to earth (Woodruff, 2003)

Unbound planet: *See Rogue Planet*

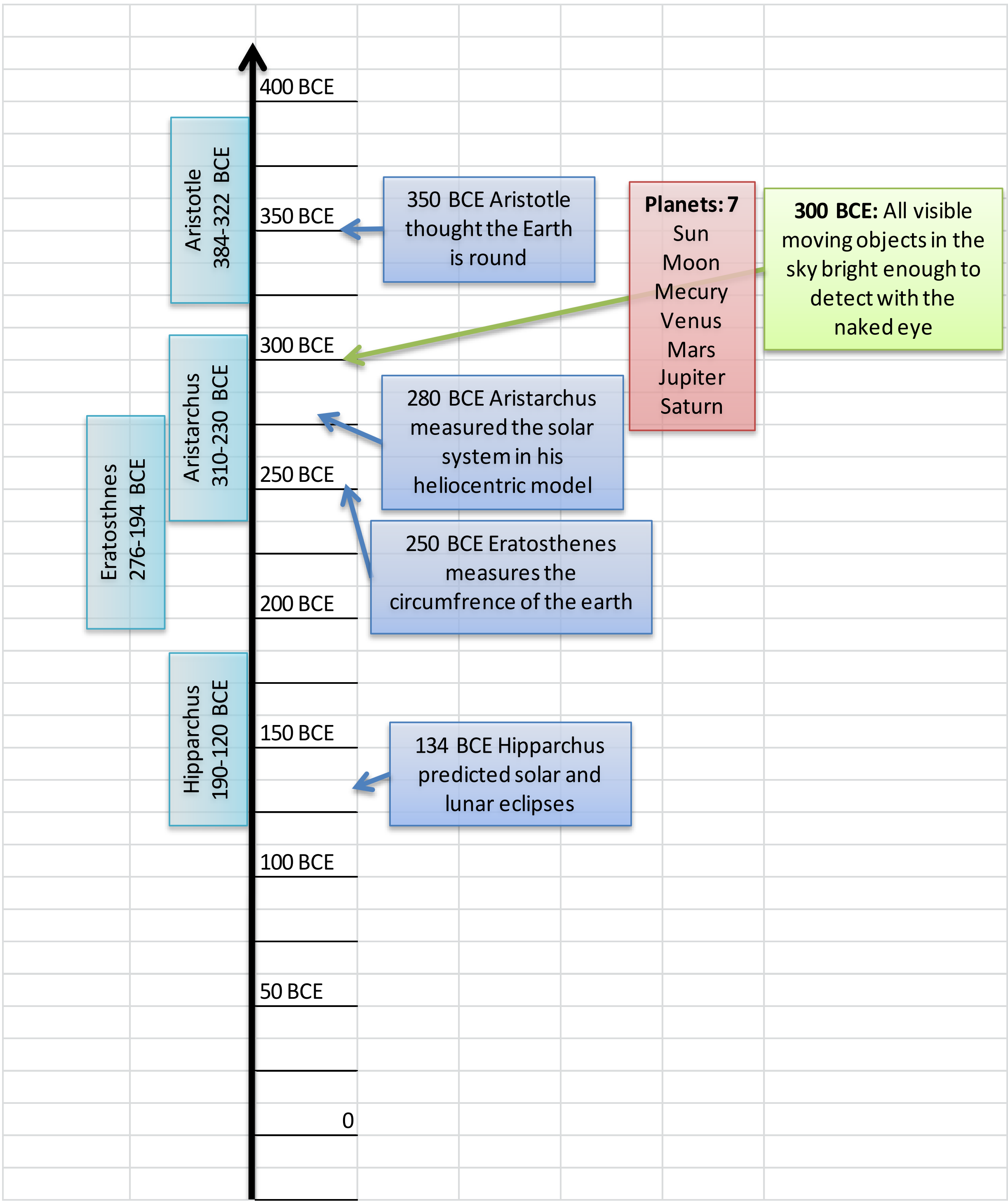
Appendix B:

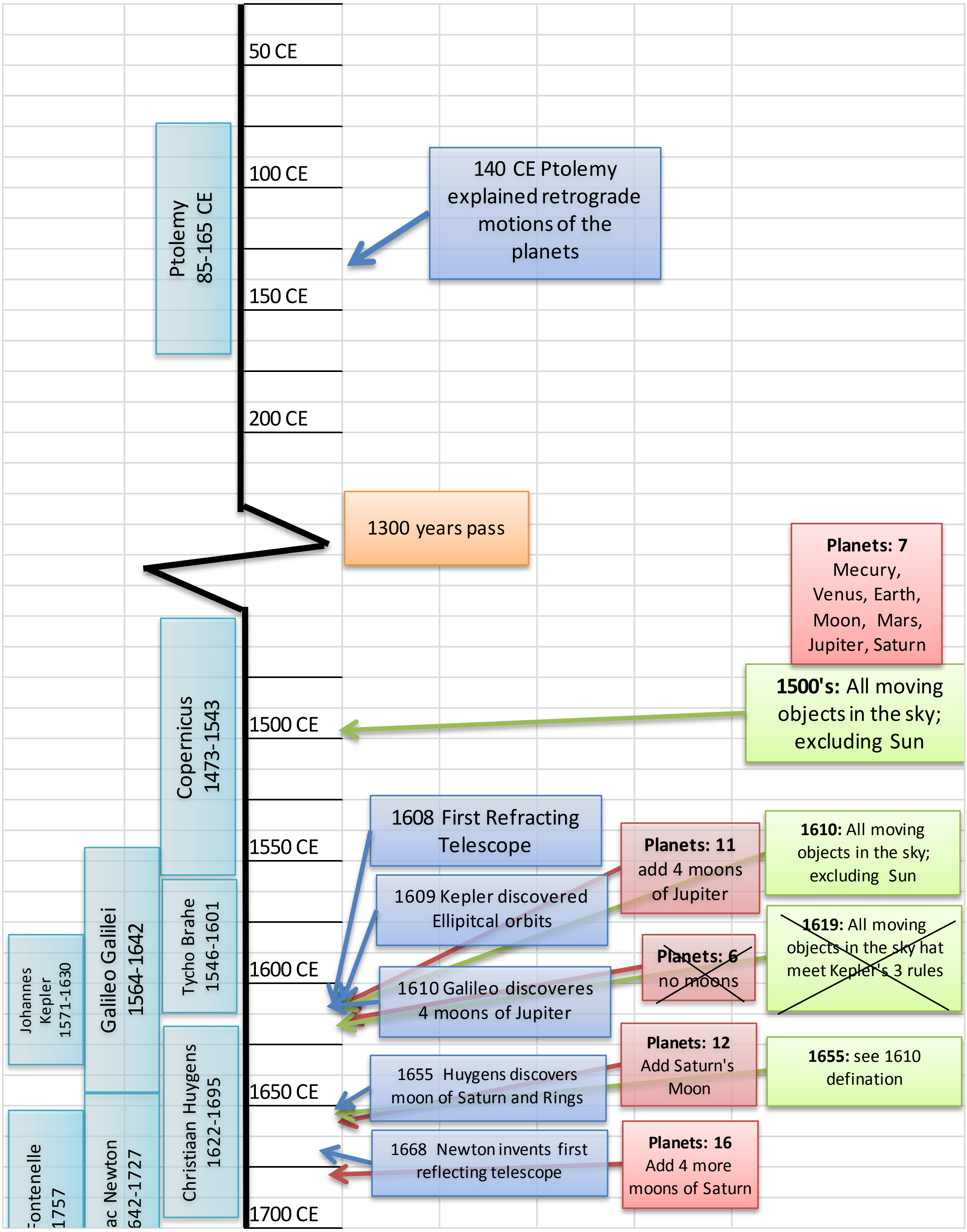
Historical Count of Planets

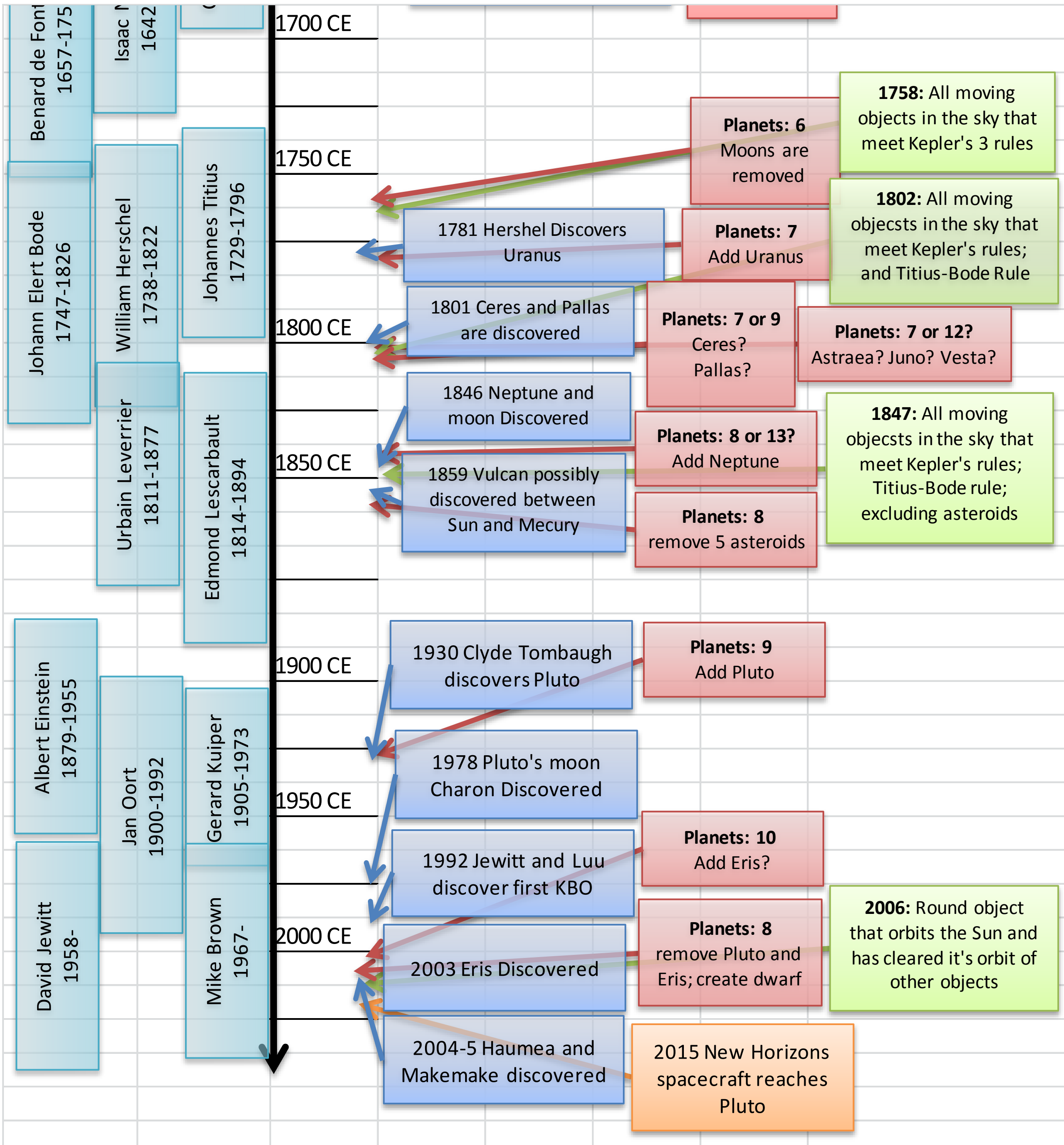


Appendix C:

Time Line




50 CE
100 CE
150 CE
200 CE
1500 CE
1550 CE
1600 CE
1650 CE
1700 CE
Ptolemy
85-165 CE
140 CE Ptolemy explained retrograde motions of the planets
1300 years pass
Planets: 7
Mecury, Venus, Earth, Moon, Mars, Jupiter, Saturn
1500's: All moving objects in the sky; excluding Sun
Copernicus
1473-1543
Galileo Galilei
1564-1642
Tycho Brahe
1546-1601
Johannes Kepler
1571-1630
Christiaan Huygens
1622-1695
1608 First Refracting Telescope
1609 Kepler discovered Ellipitcal orbits
1610 Galileo discoveres 4 moons of Jupiter
Planets: 11
add 4 moons of Jupiter
1610: All moving objects in the sky; excluding Sun
Planets: 6
no moons
1619: All moving objects in the sky hat meet Kepler's 3 rules
1655 Huygens discovers moon of Saturn and Rings
Planets: 12
Add Saturn's Moon
1655: see 1610 defination
1668 Newton invents first reflecting telescope
Planets: 16
Add 4 more moons of Saturn


1700 CE
1750 CE
1800 CE
1850 CE
1900 CE
1950 CE
2000 CE
Johann Elert Bode 1747-1826
William Herschel 1738-1822
Johannes Titius 1729-1796
Urbain Leverrier 1811-1877
Edmond Lescarbault 1814-1894
Albert Einstein 1879-1955
Jan Oort 1900-1992
Gerard Kuiper 1905-1973
David Jewitt 1958-
Mike Brown 1967-
1781 Hershel Discovers Uranus
1801 Ceres and Pallas are discovered
1846 Neptune and moon Discovered
1859 Vulcan possibly discovered between Sun and Mecury
1930 Clyde Tombaugh discovers Pluto
1978 Pluto's moon Charon Discovered
1992 Jewitt and Luu discover first KBO
2003 Eris Discovered
2004-5 Haumea and Makemake discovered
Planets: 6 Moons are removed
Planets: 7 Add Uranus
Planets: 7 or 9 Ceres? Pallas?
Planets: 7 or 12? Astraea? Juno? Vesta?
Planets: 8 or 13? Add Neptune
Planets: 8 remove 5 asteroids
Planets: 9 Add Pluto
Planets: 10 Add Eris?
Planets: 8 remove Pluto and Eris; create dwarf
2015 New Horizons spacecraft reaches Pluto
1758: All moving objects in the sky that meet Kepler's 3 rules
1802: All moving objecsts in the sky that meet Kepler's rules; and Titius-Bode Rule
1847: All moving objecsts in the sky that meet Kepler's rules; Titius-Bode rule; excluding asteroids
2006: Round object that orbits the Sun and has cleared it's orbit of other objects

Appendix D:

IAU Resolutions defining a planet and dwarf planet

From http://www.iau2006.org/mirror/www.iau.org/iau0602/index.html

Resolutions

Resolution 5A is the principal definition for the IAU usage of "planet" and related terms. Resolution 5B adds the word "classical" to the collective name of the eight planets, Mercury through Neptune.

Resolution 6A creates for the IAU usage a new class of objects, for which Pluto is the prototype. Resolution 6B introduces the name "plutonian objects" for the class. The Merriam-Webster dictionary defines "plutonian" as:

Main Entry: plu-to-ni-an; **Pronunciation**: plü-'tO-nE-&n; **Function**: *adjective*; **Usage**: *often capitalized* : of, relating to, or characteristic of Pluto or the lower world

After having received inputs from many sides – especially the geological community – the term "Pluton" is no longer being considered.

IAU Resolution: Definition of a "Planet" in the Solar System

Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature of objects reflect our current understanding. This applies, in particular, to the designation "planets". The word "planet" originally described "wanderers" that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.

RESOLUTION 5A

The IAU therefore resolves that planets and other bodies in our Solar System, except satellites, to be defined into three distinct categories in the following way:

(1) A "planet"[11] 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 (nearly round) shape, and (c) has cleared the neighborhood around its orbit.
(2) A "dwarf planet" 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

[11] The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

equilibrium (nearly round) shape[12], (c) has not cleared the neighborhood around its orbit, and (d) is not a satellite.

(3) All other objects[13], except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

RESOLUTION 5B

Insert the word "classical" before the word "planet" in Resolution 5A, Section (1), and footnote 1 [footnote 11 in this paper]. Thus reading:

(1) A classical "planet" is a celestial body…

and

IAU Resolution: Pluto

RESOLUTION 6A

The IAU further resolves:

Pluto is a "dwarf planet" by the above definition and is recognized as the prototype of a new category of trans-Neptunian objects.

RESOLUTION 6B

The follow sentence is added to Resolution 6A:

This category is to be called "plutonian objects."

---

[12] An IAU process will be established to assign the borderline objects into either "dwarf planet" and other categories.

[13] These currently include most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs), comets, and other small bodies.