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## A thorough illustration of Neptune, Uranus, Pluto, and their corresponding moons

In our Solar System, there are 9 main celestial bodies not including the Sun: the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and the dwarf planet Pluto. Each planet has its own special features and own list of orbiting satellites. The main focus of this report will be Uranus, Neptune, Pluto, and their moons.

Uranus is the seventh planet from the Sun (Uranus). It is the third largest by diameter (Uranus). The name Uranus comes from the Greek god of the Heavens (Uranus). William Hershel discovered Uranus on March 13, 1781, making it the first planet discovered in modern times (Uranus). It had previously been seen on many different accounts only to be dismissed as another star (Uranus). The earliest sighting of Uranus was in 1690 when John Flamsteed listed it as 34 Tauri (Uranus). The planet was originally named “the Georgium Sidus” and Hershel before it was officially named Uranus by Bode (Brewer 9).

Uranus is tilted on its axis 98 degrees in relation to the Sun (Uranus Facts). It is said to be “rolling” around the Sun (Uranus Facts). The mass is  $8.681 \times 10^{25}$  kg, which is 14.536 times more massive than Earth (Uranus Facts). The polar diameter of Uranus is 49,946 km, the equatorial diameter is 51,118 km, and the equatorial circumference is 159,354 (Uranus Facts). Uranus is substantially further from than Sun compared to Earth, with an orbital distance of 19.22 AU ( $2.87 \times 10^9$  km), and an orbital period of 30,687.15 Earth days or 84.02 Earth years (Uranus Facts).

Uranus is mostly composed of Hydrogen and Helium, making it a gas giant (Uranus Facts). The surface is an amazing frigid -197°C and the atmosphere reaches a minimum of -224°C, making Uranus the coldest planet in the Solar System (Uranus Facts). The upper layer of the planet is a Hydrogen-Helium mix, with its mantle made mostly of ice, surrounding a rock and ice core (Uranus Facts). Uranus’s atmosphere contains 83% Hydrogen, 15% Helium, and 2% Methane (Uranus). The water, ammonia, and methane in the atmosphere give Uranus its pale blue color (Uranus Facts).

Uranus has 13 rings – discovered over the course of 28 years - consisting of small particles ranging from dust-sized to small boulders (Rings of Uranus). The first 9 were discovered on March 10, 1977 by Edward W. Duncan, James L. Elliot, and Douglas J. Mink (Rings of Uranus). The next two were discovered by Voyager 2 in 1986, and last two by the Hubble Space Telescope between the years 2003 and 2005 (Rings of Uranus). They are named, in order of

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closest to furthest, 1986U2R/zeta (?), 6, 5, 4, alpha (α), beta (β), eta (?), gamma (?), delta (δ), lambda (?), epsilon (ε), nu (?), and mu (μ) (Rings of Uranus). The radii of the rings range from 1986U2R/zeta's 38,000 km to mu's 98,000 km (Rings of Uranus). The rings were probably formed when either one or multiple of Uranus's moons were destroyed in a collision around 600 million years ago (Rings of Uranus).

The closest contact we have had with Uranus is when Voyager 2 passed by on January 24, 1986, which gave us the majority of the information we know on the planet to date (Uranus). There is currently a proposed mission to Uranus set to launch between 2020-2023 (Uranus Orbiter and Probe). The spacecraft is planned to use solar-electric propulsion as its means of power, making the trip around 13 years in length (Uranus Orbiter and Probe).

Uranus currently has 27 known satellites (Uranus Facts). All of its moons are named after characters from works of William Shakespeare and Alexander Pope (Uranus Facts). The moons we'll be touching on are Puck, Miranda, Ariel, Umbriel, Titania, Oberon, Caliban, Stephano, Sycorax, Prospero, Cordelia, Ophelia, Bianca, Cressida, Desdemona, Juliet, Portia, Rosalind, Belinda, S/1968 U10, and Setebos.

Stephen Synnott discovered Puck in 1986 from Voyager 2's data (Uranus). The moon orbits 86,006 km from Uranus (Uranus). Puck is apart of Uranus's ten innermost moons (Uranus). Its diameter is 154 km, which is roughly 90 miles, or a simple hour and a half drive at highway speeds (Uranus). Puck's average orbital velocity is 540,353.94 km/h (Solar System Exploration). Its mass, despite being relatively small for a celestial body, is  $2.894 \times 10^{18}$  kg and has a volume of 2,226,095 km<sup>3</sup> (Solar System Exploration). As for gravitational statistics, Puck's surface gravity is a whopping .029 m/s<sup>2</sup> and has a universe-warping escape velocity of ~155 mph (Solar System Exploration)! Puck was originally named S/1985 U1, but was then renamed to match the other moons' theme of names from William Shakespeare and Alexander Pope's literary works (Solar System Exploration). Puck was a mischievous fairy Shakespeare's "A Midsummer Night's Dream" (Solar System Exploration).

Gerard P. Kuiper discovered Miranda, the daughter of Shakespeare's Prospero from "The Tempest", on February 16, 1948; however, like every moon of Uranus, almost nothing was known about it until Voyager 2's flyby in the mid-80s (Solar System Exploration). Miranda is about 472 km in diameter, with an orbital radius of 129,850 km, average orbital velocity of 24,067.7 km/h, and mass of  $6.6 \times 10^{19}$  kg (Solar System Exploration). The volume of Miranda is 54,918,670 km<sup>3</sup> (Solar System Exploration). Its escape velocity is 432 mph and surface gravity is .079 m/s<sup>2</sup> (Solar System Exploration).

Miranda consists of about half silicate rock and about half water ice (Uranus). For an extraterrestrial body as small as Miranda, there is an abnormally large amount of tectonic

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activity on its surface (Solar System Exploration). There are three “coronae”, or large features, on the moon, one being 12 times as deep as the Grand Canyon (Solar System Exploration). There are two possible explanations to Miranda’s terrain, the least likely being the moon was smashed apart and reassembled chaotically several times (Uranus). The other theory suggests that coronas are the impact zones of metallic and/or rocky meteorite collisions, which melted ice underneath the surface, resulting in slushy water rising to Miranda’s surface and refreezing (Solar System Exploration).

William Lassell discovered Ariel, named after the airy, mischievous ghost in “The Tempest”, on October 24, 1851; however it was given its name by Sir William Hershel’s son, Sir John Hershel (Solar System Exploration). The mass of the moon is roughly  $1.27 \times 10^{21}$  kg and diameter is 1,158 km (Uranus). Ariel’s orbital radius is 190,930 km and average orbital velocity is 19,832.3 km/h (Solar System Exploration). The moon’s surface gravity is .258 m/s<sup>2</sup>, which is accompanied by an escape velocity of 1,222 mph (Solar System Exploration).

Out of the largest moons orbiting Uranus, Ariel is not only the brightest, but is also perceived to have the youngest surface (Solar System Exploration). Despite having the brightest surface, it does not reflect any more than a third of the sunlight that hits it, suggesting that its surface has been darkened by carbon materials (Solar System Exploration). Its surface is a medley of small craters and an extensive system of connected valleys up to hundreds of km long (Uranus). It is thought that Ariel was once very hot, causing the heavier elements to sink towards the core and the lighter elements to float to the surface (Solar System Exploration). This would also explain the blemishes on the surface, which would have been a result of the moon freezing (Uranus).

Out of all the larger moons of Uranus, Umbriel is the darkest (Solar System Exploration). Only 16% of the sunlight that hits it is reflected (Solar System Exploration). The surface is heavily cratered, which possibly contributes to it being so dim (Uranus). William Lassell discovered the moon on October 24, 1851 (Solar System Exploration). It was named after a character from Alexander Pope’s “The Rape of the Lock” (Uranus).

Umbriel is roughly 1,170 km in diameter, follows an orbit that is 25,980 km from Uranus, and carries an average orbital velocity of 16,804.6 km/h (Solar System Exploration). The mass of the moon is approximately  $1.2214 \times 10^{21}$  kg, and the volume is 837,313,109 km<sup>3</sup> (Solar System Exploration). Umbriel’s surface gravity is just about .238 m/s<sup>2</sup>, with an escape velocity of 1,181 mph (Solar System Exploration).

Titania was named after the Queen of Fairies in William Shakespeare’s “A Midsummer Night’s Dream” (Uranus). Sir William Hershel discovered the moon on January 11, 1787 (Solar System Exploration). Titania is the largest of Uranus’s moons, being 1,578 km in diameter (Uranus). Its orbit radius is 436,300 km and it maintains an average orbital velocity of 13,120

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km/h (Solar System Exploration). The mass of Titania is roughly  $3.49 \times 10^{21}$  kg (Uranus). The surface gravity is  $.367 \text{ m/s}^2$  and its escape velocity is roughly 1,701 mph (Solar System Exploration). Titania's  $2,056,622,001 \text{ km}^3$  (Solar System Exploration). The moon's surface is fairly similar to that of Ariel's, having a large collection of craters and an impressive length of valleys, with a couple being almost 1,000 miles long (Solar System Exploration). One possible theory that could explain Titania's surface is that the moon used to be hot enough to be in liquid form until the surface cooled, then cracked when the core later solidified and expanded (Uranus).

Oberon, which is the king of fairies from "A Midsummer Night's Dream", was once again the discovery of Sir William Herschel (Solar System Exploration). It was discovered in January of 1787 (Solar System Exploration). Like pretty much every moon of Uranus, the majority of the information known about Oberon is from the Voyager 2 flyby in 1986 (Solar System Exploration). Oberon is the second largest moon of Uranus, just behind Titania (Solar System Exploration). The moon is composed of about 40-50% ice water, and the rest is rock (Uranus). Compared to the other larger moons, such as Ariel, Miranda, and Titania, Oberon is heavily cratered (Solar System Exploration). The southern hemisphere is also blemished with large faults which points to geologic activity in the early life of Oberon (Uranus). The moon also has at least one large mountain that is roughly 6 km tall (Solar System Exploration).

Oberon is just shy of Titania in size, with a diameter of 1,523 km and mass of  $3.03 \times 10^{21}$  kg (Uranus). The moon's average orbital radius around Uranus is 583,500 km, and its average orbital velocity is  $11,349.2 \text{ km/h}$  (Solar System Exploration). Oberon's volume is  $1,848,958,769 \text{ km}^3$  (Solar System Exploration). The surface gravity of the moon is  $.332 \text{ m/s}^2$  and its escape velocity is just around 1,590 mph (Solar System Exploration).

On the 6th and 7th day of September in 1997, a couple of brothers were looking through a 200-inch Hale Telescope and discovered Caliban (Uranus). The group of brothers included Brett Gladman, Phil Nicholson, Joseph Burns, and JJ Kavelaars, although the credit goes mostly to Brett Gladman (Uranus). Caliban was originally named S/1997 U 1, but it was later changed to match the theme of Uranus's other moons (Uranus). It ended up being named after the savage, deformed servant of Prospero from Shakespeare's "The Tempest" (Uranus). Caliban is unique because it orbits Uranus in the opposite direction of the other regular moons (Solar System Exploration). It also orbits at an unusually larger distance from Uranus, sometimes reaching 10 times the distance of Oberon, the farthest regular moon (Solar System Exploration). Evidence also points to the possibility that Caliban was an independent celestial body that was captured by Uranus's gravity (Solar System Exploration).

Like most irregular moons, Caliban is most likely a captured asteroid (Uranus). Based on its composition of rock and ice and unusual red color, it is believed to have strayed from the Kuiper Belt (Uranus). Caliban's orbit has an amazing 7.2 million km radius but an average orbital

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velocity of 3.238.5 km/h (Uranus). Caliban's size is based on its apparent brightness, which is assumed to be an albedo of .04 or 7% (Solar System Exploration). So, using this postulation as a foundation, the diameter is roughly 72 km, volume of 195,432 km<sup>3</sup>, and mass of about 2.9973 x 10<sup>17</sup> kg (Solar System Exploration). As for its gravitational statistics, the surface gravity is just about .015 m/s<sup>2</sup> and has a Earth shattering escape velocity of 75 mph (Solar System Exploration).

Stephano was discovered on July 18, 1999 by the same man that discovered Caliban, Brett Gladman (Solar System Exploration). It was discovered along with two other moons, Setebos and Prospero, to make it apart of Uranus's group of "new moons" (Uranus). Stephano, like most other irregular moons of Uranus, is very similar to Caliban in composition, name and locational origin, and orbital characteristics (Solar System Exploration). It was originally named S/1999 U2, but was then named after the rowdy alcoholic butler of King Alonso in "The Tempest" (Solar System Exploration). It orbits in the opposite direction of the regular moons and at an absurdly large distance from Uranus (Solar System Exploration).

Stephano's orbit around Uranus has a huge radius of roughly 8 million km (Solar System Exploration). Its average orbital velocity is 3,054.9 km/h (Solar System Exploration). Stephano's diameter is only 32 km, with an equatorial circumference of a celestial microscopic 100.5 km (Solar System Exploration). The mass is roughly 2.55 x 10<sup>16</sup> kg and has a volume of only 17,157 km<sup>3</sup> (Solar System Exploration). The surface gravity of Stephano is .007 m/s<sup>2</sup> and has an escape velocity 33.5 mph (Solar System Exploration).

Sycorax is the twin of Caliban, since they were both discovered on the same date and has the same father, Brett Gladman (Uranus). S/1997 U 2 was its original name, but was later changed to the name of the witch from the "The Tempest" (Uranus). Sycorax is very similar to Caliban since they rotate opposite of regular Uranus moons, have the same apparent brightness, and are both composed of rocks and ice (Uranus). They also both have an unusually colored surface, red, which possibly points to formally inhabiting the Kuiper Belt (Uranus).

The irregular moon has a diameter of 150 km in diameter, a little more than twice that of Caliban, and orbital radius of 12.2 million km (Uranus). The average orbital velocity is just about 2,297 km/h (Solar System Exploration). Sycorax has a mass of 2.698 x 10<sup>18</sup> kg and volume of 1.77 x 10<sup>6</sup> km<sup>3</sup> (Solar System Exploration). The moon's surface gravity is .032 m/s<sup>2</sup> and has an escape velocity of 155 mph (Solar System Exploration).

Prospero was discovered by the same group and in the same observation as Stephano and Setebos on July 18, 1999 (Uranus). It was originally named S/1999 U3, but later had its name changed to that of "The Tempest's" sorcerer (Solar Exploration). Prospero shares orbit characteristics with its fellow irregular moons, such as rotational direction, which indicates it may

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be from the Kuiper Belt; however, unlike the its fellow irregular moons, its gray in color, disagreeing with the its origin being of the Kuiper Belt (Solar System Exploration).

Similar to all of the recently discovered irregular moons, Prospero has an abnormally large orbital radius (Uranus). Its orbital distance from Uranus is approximately 16.3 million km and has a sluggish average orbital velocity of 2,043.2 km/h (Solar System Exploration). Its mass is  $9.89 \times 10^{16}$  kg and the volume is 65,450 km<sup>3</sup> (Solar System Exploration). The surface gravity is a very weak .011 m/s<sup>2</sup> and escape velocity is only about 52 mph (Solar System Exploration).

Cordelia is the innermost of all Uranus's known satellites (Uranus). It was named after the daughter of Lear in "King Lear", a work of Shakespeare's (Uranus). Voyager 2 discovered it on its flyby of Uranus on January 20, 1986 (Uranus). It also seems to constrain Uranus's epsilon ring through its gravitational forces (Uranus). Its surface is thought to be composed of unprocessed, dark carbon material (Solar System Exploration).

Cordelia's orbital radius is roughly 49,800 km and maintains an average orbital velocity of 38,918.2 km/h (Solar System Exploration). Like Puck, Cordelia has an assumed albedo of .07, which is the basis of its predicted ~40 km diameter (Solar System Exploration). The mass and volume of it is  $4.496 \times 10^{16}$  kg and 34,015 km<sup>3</sup> (Solar System Exploration). The surface gravity is only .007 m/s<sup>2</sup> and escape velocity a slow 39 mph (Solar System Exploration).

Ophelia is apart of the ten innermost moons to which Puck and Cordelia belong, and was discovered by Voyager 2 as well (Solar System Exploration). Ophelia was named after the daughter of Polonius in William Shakespeare's famed "Hamlet" (Uranus). Ophelia and Cordelia both appear to be the shepherding moons (moons that constrain a planetary ring with its gravitational forces) of the epsilon ring (Uranus).

Ophelia's orbital size is a little larger than Cordelia's, at 53,800 km (Solar System Exploration). The average orbital velocity is 37,458.7 km/h (Solar System Exploration). Ophelia has a mass of  $5.395 \times 10^{16}$  kg and has a volume of 41,052 km<sup>3</sup> (Solar System Exploration). On the surface of the moon, the gravity is just .001 larger than Cordelia at .008 m/s<sup>2</sup>, and had has an escape velocity of 41 mph (Solar System Exploration).

Bianca is another one of Uranus's ten inner moons discovered by Voyager 2 in 1986 (Uranus). It's named after Katherine's sister in "Taming of the Shrew" (Uranus). Very little is actually known about Bianca, except for its orbital characteristics (Solar System Exploration). What are known about its physical attributes and composition are only guesses based on Puck's physical attributes and composition (Solar System Exploration).

The orbital radius of Bianca around Uranus is approximately 59,200 km and its average orbital

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velocity is 35,628.8 km/h (Solar System Exploration). The diameter of the moon is roughly 44 km, volume is 71,103 km<sup>3</sup>, and mass is roughly  $9.29 \times 10^{16}$  kg (Solar System Exploration). The gravity on the surface is calculated to be .009 m/s<sup>2</sup> and the escape velocity is 49 mph (Solar System Exploration).

Cressida is another one of the ten inner moons of Uranus (Uranus). In Shakespeare's "Troilus and Cressida", Cressida is the daughter of Calchas (Uranus). The moon was discovered, along with the other ten innermost moons, by Voyager 2 in 1986 (Uranus). Like Bianca, very little is known about its composition or physical attributes; however, the size and orbital characteristics are known (Solar System Exploration). The albedo is known, though, giving an idea of what the surface is made of, which could be a dark, carbon-rich substance (Solar System Exploration).

Cressida has a diameter of approximately 66 km (Uranus). The distance of which the moon orbits around Uranus is roughly 61,800 km, its average orbital velocity is 34,869 km/h, and volume is 264,081 km<sup>3</sup> (Solar System Exploration). The mass is about  $3.43 \times 10^{17}$  kg, the surface gravity is .014 m/s<sup>2</sup>, and escape velocity is roughly 76 mph (Solar System Exploration).

Desdemona is yet another one of Uranus's ten inner moons (Solar System Exploration). Desdemona appears in William Shakespeare's "Othello" and the wife of Othello (Uranus). It was discovered, along with the other innermost moons, in 1986 by Voyager 2 (Uranus). Its diameter is 58 km and orbits 62,659 km from Uranus (Uranus). The average orbital velocity is 34,630.4 km/h and the mass is  $1.783 \times 10^{17}$  kg (Solar System Exploration). The surface gravity is .012 m/s<sup>2</sup> and the escape velocity is 61 mph (Solar System Exploration).

Juliet is another one of Uranus's innermost satellites (Uranus). The moon was named after the famous tragic heroine from Shakespeare's "Romeo and Juliet" (Uranus). It was also one of the moons discovered by Voyager 2 in 1986 (Uranus). Like most of the other nine innermost moons, very little, other than the size and orbital characteristics, is known about it (Solar System Exploration).

The diameter of the moon is 84 km and the orbital radius is roughly 64,358 km (Uranus). The mass of Juliet is  $5.575 \times 10^{17}$  kg and the volume is 429,365 km<sup>3</sup> (Solar System Exploration). The average orbital velocity is approximately 34,198.5 km/h, the gravity on the surface is .017 m/s<sup>2</sup>, and the escape velocity is about 90 mph (Solar System Exploration).

Portia, another one of the ten innermost Uranus moons, is named after the rich heiress in "Merchant of Venice" (Uranus). Voyager 2 discovered it in 1986, along with the other ten inner moons (Uranus). It is one of the largest of Uranus's lesser moons with a diameter of 140 km (Solar System Exploration). Very little is known about its composition, though (Uranus). Portia is a fast-moving moon; completing one orbit around Uranus is less than one Earth day (Solar

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System Exploration).

The moon Portia orbits Uranus at a distance of 66,100 km at an average speed of 33,732.8 km/h (Solar System Exploration). The mass of the satellite is  $1.682 \times 10^{18}$  kg and the volume is roughly 1,293,983 km<sup>3</sup> (Solar System Exploration). The gravity on the surface of Portia is just about .025 m/s<sup>2</sup> and has an escape velocity of about 129 mph (Solar System Exploration).

Rosalind, number eight of the ten inner moons of Uranus, is the daughter of the exiled Duke in "As You Like It" by the famous William Shakespeare (Uranus). Very little is known about anything concerning the moon, except for the size and orbital statistics (Solar System Exploration). Rosalind is around 72 km in diameter and has a volume of 195,432 km<sup>3</sup> (Solar System Exploration). The mass is about  $2.548 \times 10^{17}$  kg, surface gravity is .013 m/s<sup>2</sup>, and the escape velocity is about 69 mph (Solar System Exploration). Rosalind's orbital diameter is roughly 69,900 km and it maintains an average orbital velocity of 32,795.3 km/h (Solar System Exploration).

Belinda is number nine in the list of Uranus's ten inner most moons (Uranus). Discovered by Voyager 2 in 1986, it was named after Alexander Pope's heroine in "The Rape of the Lock" (Uranus). Its diameter is roughly 80 km and its mass is just about  $3.567 \times 10^{17}$  kg (Solar System Exploration). It orbits at a distance of 75,300 km from Uranus at an average speed of 31,592 km/h (Solar System Exploration). The escape velocity is just about 77 mph and its surface gravity is .015 m/s<sup>2</sup> (Solar System Exploration).

Our rubric says to research the Uranus moon S/1968 U10 but MR. VINING'S DISLEXIA THREW US OFF! What he meant to put was S/1986 U10, which would make more sense, since that is the moon Perdita (Common Sense). Perdita was originally discovered in 1986 along with the other Voyager 2 moons, but was recognized as a moon until 13 years later on May 18, 1999, when Erich Karkoschka of the University of Arizona found it in pictures from Voyager 2 and compared them to pictures taken by the Hubble Space Telescope (Solar System Exploration). It was named after the daughter of Hermoine and Leontes from Shakespeare's "The Winter's Tale" (Solar System Exploration). Perdita is almost identical in orbit to Belinda (orbital radius of 75,300 km) with its orbital radius being 76,400 km (Solar System Exploration). The mass of Perdita is currently unknown, along with its force of gravity and escape velocity; however, its average orbital velocity is known to be 31,356.2 km/h (Solar System Exploration).

Setebos is apart of the group of small, irregular moons recently discovered on July 18, 1999 by Brett Gladman (Uranus). The moons discovered along with it were Prospero and Stephano (Uranus). Like Prospero and Stephano, Setebos orbits in the opposite direction of the ordinary moons (Solar System Exploration). Setebos is named after a Patagonian deity that Shakespeare played off of for the god that Sycorax and Caliban worshipped in "The Tempest"

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(Solar System Exploration).

The diameter of Setebos is just about 48 km, with a volume of 57,906 km<sup>3</sup> (Solar System Exploration). The mass is  $8.692 \times 10^{16}$  kg, giving it a surface gravity of .010 m/s<sup>2</sup> and escape velocity of 49 mph (Solar System Exploration). Setebos's orbit has a radius of 17.4 million km from Uranus with an average velocity of 1,857 km/h (Solar System Exploration).

Neptune, named after the Roman god of the sea, is the eighth planet from the sun (Neptune). When astronomers noticed that the orbit of Uranus was not as it should be, they predicted that there must be a more distant planet that is disturbing the orbit of Uranus (Neptune). This ice giant was the first planet found by calculations rather than observations (Solar System Exploration). The first time Neptune was observed was on September 23, 1846, by 2 astronomers named Galle and d'Arrest (Neptune). Amazingly, the planet was located very close to the locations predicted by Adams and Le Verrier, who predicted its location through observed positions of Jupiter, Saturn, and Uranus (Neptune).

Neptune is currently unexplored with modern spacecraft instrumentation. Because of this, everything we know about Neptune was figured out from clever calculations and careful observations (Agnor 2). Neptune is located 4.5 billion kilometers, or 2.8 billion miles, from the Sun and takes 165 years to orbit the sun just once (Neptune). One day on this planet is equivalent to 16.1 hours on Earth. This distance is equivalent to 30.06 AU from the sun. With an equatorial diameter of 49,532 km and a mass of  $1.0247 \times 10^{26}$  kg, this gas giant is about 3.9 times bigger than the Earth and also has 17 times the mass (Neptune). 150 lbs on Earth would be about 169 lbs on the surface of Neptune (The Outer Planets). Neptune also has a magnetic field that is about 27 times stronger than the magnetic field of Earth (Solar System Exploration). This magnetic field is tilted over by about 47 degrees when being compared to the planet's rotational axis (Solar System Exploration). Because of this tilt, the magnetosphere on Neptune has variations during each rotation (Solar System Exploration). Although they are not very noticeable, Neptune also has 6 known rings (Solar System Exploration). Images from Voyager 2 showed these rings to be complete and contain bright clumps while observations from Earth show only faint arcs instead of complete rings (Neptune).

Since Neptune is a gas giant, most of its size is due to its massive atmosphere. This atmosphere extends to enormous depths that eventually merge into water and other melted ices, which are sitting on a heavier, approximately Earth sized solid core (Solar System Exploration). The composition of the planet is most likely similar to that of Uranus (Neptune). It contains various ices and rock, a solid core about the size of the Earth made of rocky material, and an atmosphere made of mostly hydrogen and helium with small amounts of methane (Neptune). Because of many similarities, Neptune is called the sister planet of Uranus (Solar System Exploration). Another of these similarities would be the color. Neptune is a more vivid

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blue because, while both planets have methane which give absorbs red light giving off a blue-green color, Neptune must have an unknown component that is changing the color to this blue. (Solar System Exploration).

A strange feature that makes Neptune unique would be its uncommon wind speeds (The Outer Planets). In the upper atmosphere, these winds tip the scales with a common speed of 750 mph and a max of about 1000 mph (The Outer Planets). Although these wind speeds are incredibly high, they most likely wouldn't turn a windmill because the density of the gas at this altitude is very low (The Outer Planets). Since Neptune is far from the sun, scientists don't think that the energy source that powers these storms could be the sun alone (The Outer Planets). They believe that this energy is generated inside the planet (The Outer Planets). Observations from Voyager 2, the only spacecraft to travel near Neptune, showed that it radiates twice as much energy from the core than it gets from the sun, which is the highest ratio of heat output to input of any of the planets in the solar system (The Outer Planets). It is believed that this heat is coming from radioactive decay and other chemical processes inside the planet (The Outer Planets). Another theory is that the planet is still forming, and the falling gasses are releasing heat when they are compacted by gravity (The Outer Planets). This theory could explain the strange cloud patterns that are observed on Neptune (The Outer Planets).

A strange phenomenon that occurs on Neptune is its great dark spot, which is a storm that is bigger than the Earth and has wind speeds of around 1000 mph (The Outer Planets). Strangely, this storm appears and disappears without warning and also moves around in unpredictable patterns (The Outer Planets). Additionally, these storms vary in size in very short amounts of time (The Outer Planets). These storms are thought to be made from an instability in the atmosphere and its winds, which could help explain its unpredictable movement (The Outer Planets).

Neptune, like many of the other outer planets, has many moons. All of the moons of around Neptune are named after characters from Greek or Roman mythology associated with Neptune or Poseidon, or the oceans (Solar System Exploration). The irregular satellites around Neptune are named after the Nereids, which are the daughters of Nereus and Doris and the attendants of Neptune (Solar System Exploration).

One of these moons around Neptune is called Larissa. This moon was named after a nymph from Greek mythology (Solar System Exploration). The Voyager 2 science team officially discovered it in July 1989 (Solar System Exploration). Larissa has a total mass of  $4.9456 \times 10^{18}$  kg and diameter of 193 km (Solar System Exploration). The volume of Larissa is 3,822,996 km<sup>3</sup> (Solar System Exploration). The satellite is non-spherical and appears to be heavily cratered (Neptune). The force of gravity on Larissa is only .035 m/s<sup>2</sup> and the escape velocity is 297 km/h (Solar System Exploration). The orbital velocity is 34,693.4 km/h and its orbital radius is 73,548

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km (Solar System Exploration).

Proteus is one of Neptune's largest known moons (Neptune). It gets its name from the shape changing sea god in Greek mythology (Solar System Exploration). It was discovered by the Voyager 2 spacecraft in 1989 and most likely could not be seen from Earth because it is a very dark moon (Solar System Exploration). Its mass is  $5.0355 \times 10^{19}$  kg and it has a diameter of 418 km (Solar System Exploration). The volume of Proteus is 38,792,386 km<sup>3</sup> and it is both non-spherical and heavily cratered (Neptune). The surface gravity on Proteus is 0.76 m/s<sup>2</sup> and the escape velocity is calculated to be 644 km/h (Solar System Exploration). The orbital velocity is 27,450.7 km/h and it orbits at a distance of 117,600 km from Neptune (Neptune).

Triton, another one of Neptune's moons, intrigues astronomers mainly because it is massive enough that its gravity, when combined with its low temperature, allows it to retain gasses (Arny and Schneider 274). Triton is one of only a few moons in the entire solar system with its own atmosphere (Arny and Schneider 274). Triton is named after the son of Poseidon, who was also a god of the sea (Neptune). British astronomer William Lassell discovered Triton on October 10th, 1846. This was just 17 days after the discovery of Neptune (Solar System Exploration). Its mass is  $2.14 \times 10^{22}$  kg and its diameter is 2700 km (Neptune). The volume of Triton is 10,384,058,491 km<sup>3</sup> and is assumed to be composed of about 25% water ice and 75% rocky material (Neptune). The surface gravity on Triton is 0.779 m/s<sup>2</sup> and its escape velocity is 5,229 km/h (Solar System Exploration). The orbital velocity of Triton is 15,803.2 km/h and its orbital radius is 354,759 km (Solar System Exploration).

Neptune's moon Nereid is named after the Nereids, or sea nymphs, in Greek mythology (Neptune). Gerard P. Kuiper discovered it on May 1st, 1949, and it was the last moon discovered before Voyager 2's discoveries in 1986 (Solar System Exploration). The mass of Nereid is  $3.0873 \times 10^{19}$  kg and its diameter is 340 km (Solar System Exploration). The volume of Nereid is calculated to be 20,579,526 km<sup>3</sup> and it is the outermost of Neptune's known moons (Solar System Exploration). The surface gravity is 0.07

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