

The Thousand Yard Model

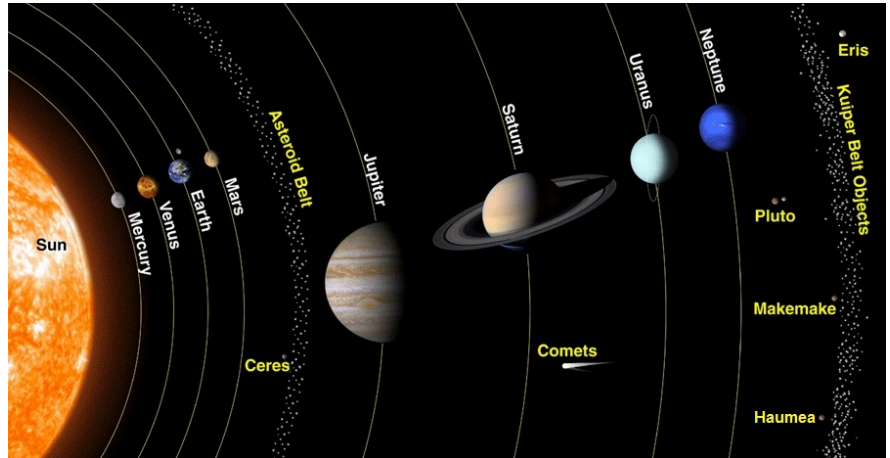
Modified from NoirLab.edu

Introduction

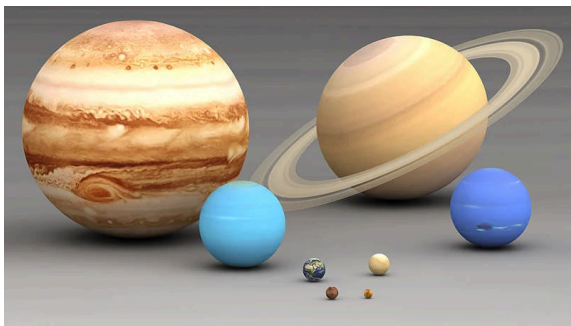
Can you picture the dimensions of the solar system?

It may be difficult to do so, for they are of an order so amazing that it is difficult either to realize or to show them.

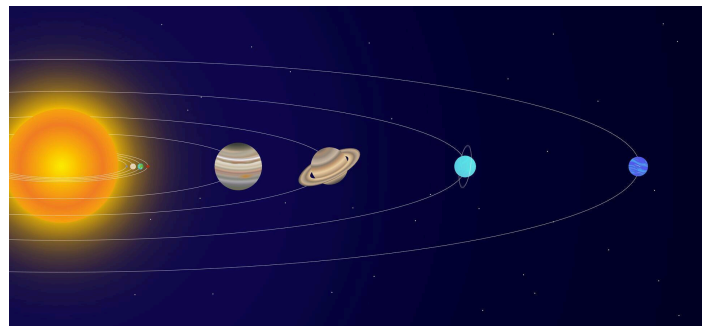
You may have seen a diagram of the Sun and planets in a book or you may have seen a revolving model of the kind called an orrery (because the first was built for an Earl of Orrery in 1715). But even the largest of such models--such as those that cover the ceilings of the Hayden Planetarium in New York and the Morehead Planetarium at Chapel Hill--are far too small. They leave out the three outermost planets, yet still cannot show the remaining ones far enough apart because showing the planet's scale of size and distance on one sheet of paper is impossible to do!



To Scale (by size)



To Scale (by distance)



The fact is that the planets are small and the distances between them are almost ridiculously large. To make any representation whose scale is true for the planet's sizes and distances, we must go outdoors.

This peppercorn will represent the Earth we live on. ●

The Earth is eight thousand miles across! The peppercorn is eight hundredths of an inch wide.

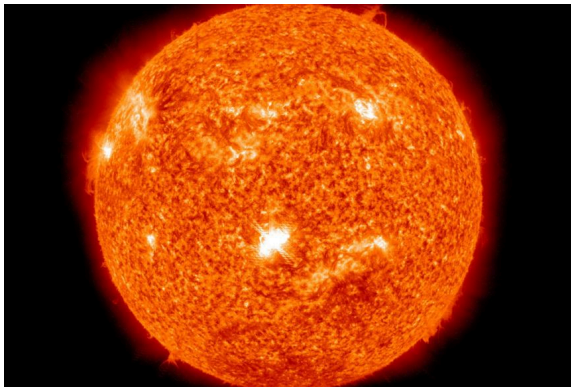
What about the Sun? It is eight hundred thousand miles wide. The ball representing it is eight inches wide. So, **one inch in the model represents 100 hundred thousand miles** in reality.

This means that **one yard (36 inches) represents 3,600,000 miles**. Take a large pace: this distance across the floor is an enormous space-journey called "three million six hundred thousand miles."

Now, what is the distance between the Earth and the Sun? It is 93 million miles. In the model, this will be 26 yards.

The Sun (0 paces / yards)

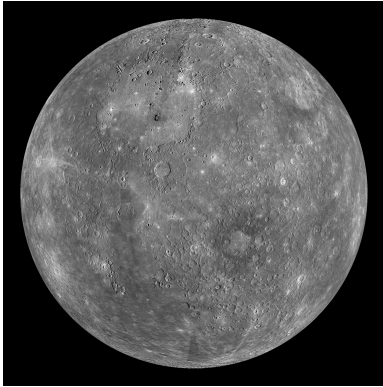
A size 4 soccer ball; diameter 8.00 inches



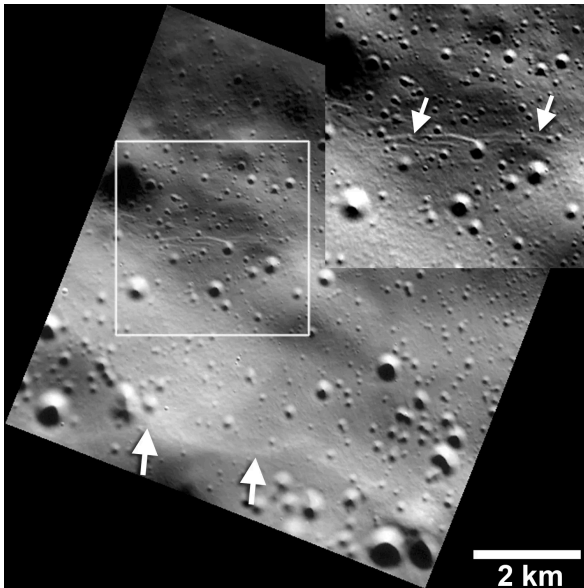
- The Sun is a yellow dwarf star at the center of our solar system and is roughly about 4.6 billion years old (about halfway through its lifespan).
- It accounts for 99.86% of the solar system's total mass and could easily fit over one million Earths inside it.
- **Temperature:** Its core reaches temperatures up to 27 million°F.
- It takes about 8 minutes and 20 seconds for sunlight to travel the 93 million miles to Earth.
- Because the Sun is not a solid sphere, its equator spins faster (around 25 Earth days) than its poles (around 36 Earth days).
- **Potential end:** Scientists believe that in about 5 billion years, the Sun will run out of hydrogen fuel, will expand into a Red Giant, and then will likely swallow Mercury, Venus, and possibly Earth before shrinking into a White Dwarf.

Mercury (walk 10 paces / yards; 10 yards total from the Sun)

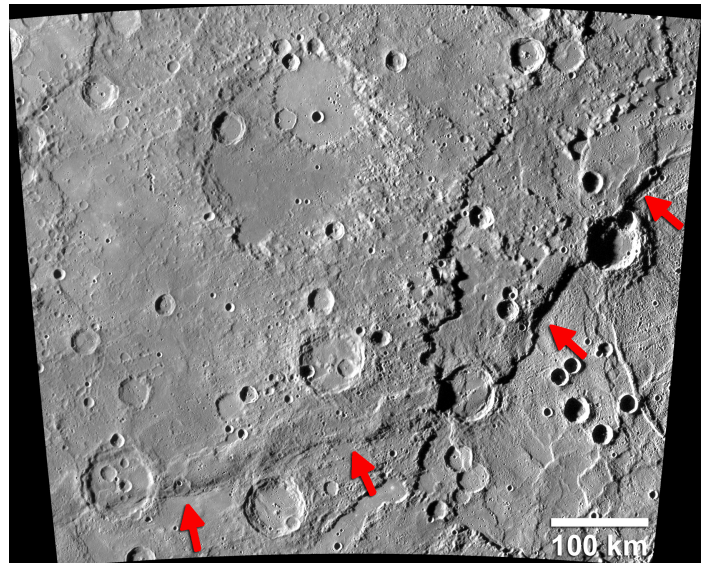
A pinhead; diameter 0.03 inch



- Mercury is the smallest planet in our solar system and the closest to the Sun.
- **No atmosphere:** Without a thick atmosphere to trap heat, day and night are vastly different. Daytime temperatures soar to 800° F, but plunge to a freezing -290° F at night.
- **Craters:** Because it lacks a thick atmosphere, weather, and tectonic activity, Mercury's heavily cratered surface looks much like Earth's Moon
- **No moons:** Due to its close proximity to the Sun, the gravitational force of the Sun pulls away any small satellites that could turn into moons for Mercury.
- It is slightly larger than our moon.



Mercury's surface is forming "stress wrinkles" from the cooling of its iron core. This cooling is causing the planet to shrink which causes the surface to buckle and crack, like a rocky raisin.



Cracks from the shrinking and cooling process affecting old craters on the planet. The cracks have created large cliffs on the planet's surface.

Venus (walk 9 more paces / yards; 19 yards total from the Sun)

A peppercorn; diameter 0.08 inch



- Earth's "sister" planet - Earth and Venus are similar in size.
- **Extreme temperatures:** Due to the "Runaway Greenhouse Effect", Venus is covered in thick clouds of carbon dioxide and sulfuric acid that trap the Sun's heat. This creates daytime temperatures of over 900° F!
- Venus actually spins a different direction compared to most planets in our solar system and actually spins clockwise.
- Venus has a longer day (243 Earth days) than its actual year (takes 225 days to orbit the Sun).
- **No moons:** Due to its close proximity to the Sun, the gravitational force of the Sun pulls away any small satellites that could turn into moons for Venus.
- **Brightest in the Sky:** Due to the highly reflective atmosphere, Venus is the third brightest natural object in the sky after the Sun and the Moon.
- **Volcanoes:** Venus is covered in over 1,600 major volcanoes, and evidence shows that it remains volcanically active today.



Surface photo from the Russian spacecraft Venera 13 in 1982.

It is yellow from the thick clouds in the atmosphere.

Earth (walk 7 more paces / yards; 26 yards total from the Sun)

A peppercorn; diameter 0.08 inch



- **Moons:** 1 moon
 - Only known planet with life (at the current moment) - water exists in solid, liquid, and gaseous forms.
 - **Water content:** Roughly 71% of the surface is covered with water.
 - **Shape:** It is an oblate spheroid (slightly squashed) rather than a perfect sphere, meaning it bulges at the equator due to its rotation.
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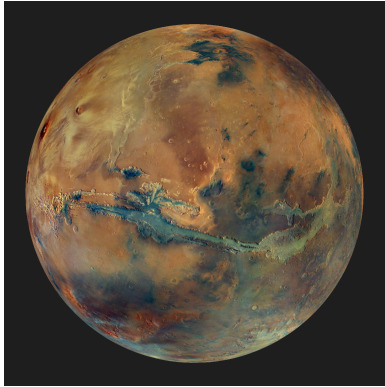
The Moon

- The Moon is, on our scale, another pinhead (theoretically between the sizes of Mercury and Pluto) and 2.4 inches from the Earth.
- **Look down on this distance, the length of your thumb; the greatest distance that humans have yet leaped from our home planet.**
- The Moon has a similar composition to the inner layers of Earth; due to this, scientists believe that something Mars-sized might have crashed into Earth early on while it was cooling and the debris formed the Moon.

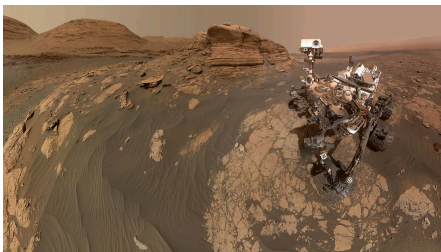


Mars (walk 14 more paces / yards; 40 yards total from the Sun)

A pinhead; diameter 0.03 inch



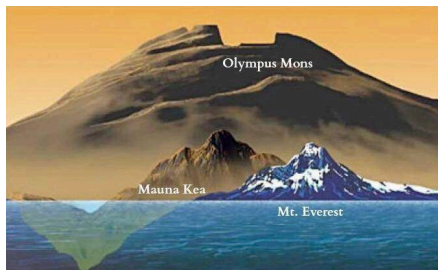
- **Vulcanology:** the largest volcano in our solar system is found on Mars and is called Olympus Mons. It is two and a half times taller than Mount Everest and could cover the entire state of Arizona.
- **Cool Geology:** Mars currently experiences seismic activity called “marsquakes”. There is also a canyon that is as long as the entire United States!
- Mars has **two moons**: Deimos and Phobos.



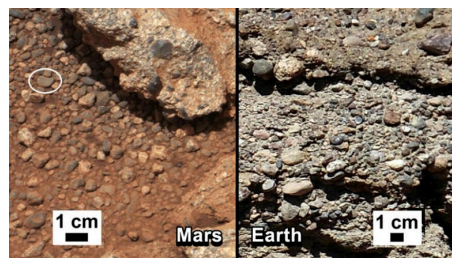
NASA's Curiosity Mars rover took this selfie in front of Mont Mercou; this panorama is made up of 60 images from the MAHLI camera on the robotic arm along with 11 images from the Mastcam on the head of the rover. 2021



This martian 'dust devil' filmed by NASA's Perseverance rover is five times taller than the Empire State Building! 2023



The size of Olympus Mons, the largest volcano in our solar system.



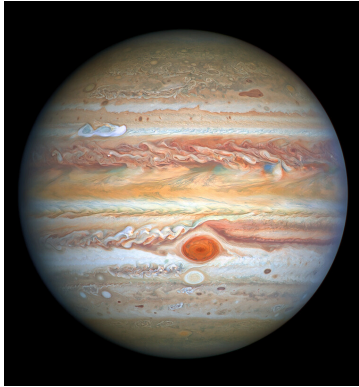
Watery past: The rovers on Mars have found signs of ancient water by studying rock formations that typically only form on Earth in the presence of water. Scientists believe that Mars used to be wetter and warmer, with a thicker atmosphere.



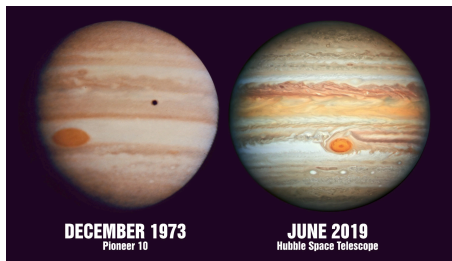
Sunset on Mars. Due to the red dust in the atmosphere, this causes the planet to observe blue-colored sunsets.

Jupiter (walk 95 more paces / yards; 135 yards total from the Sun)

A walnut; diameter 0.90 inch



- Jupiter is the largest planet in our solar system and is the first of the gas giants. It has 2.5 times more mass than all of our other planets combined.
- **Incredible Size:** You could fit over 1,300 Earths inside Jupiter. Despite its size, it rotates faster than any other planet, completing a single day in just 9.9 hours.
- **The Galilean Moons:** Jupiter has **over 95 recognized moons**. The four largest—Io, Europa, Ganymede, and Callisto—are known as the Galilean moons. Ganymede is the largest moon in the entire solar system, even bigger than the planet Mercury!
- As a gas giant, Jupiter has no solid ground. Instead of water, it has the solar system's largest ocean, made of liquid and metallic hydrogen compressed by extreme pressure.

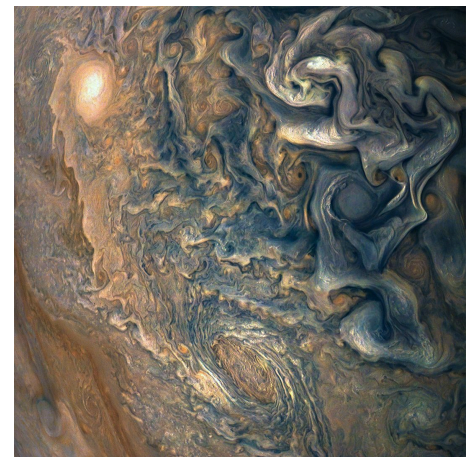


Great Red Spot: This giant hurricane has wind speeds from 268 mph up to 400 mph. It is currently a little bigger than one Earth. Observations have shown that the storm is shrinking.



These rings are visible using near-infrared wavelength cameras that see the ultrafine dust.

Cool rings: All of the gas giants; Jupiter, Saturn, Uranus, and Neptune have rings!

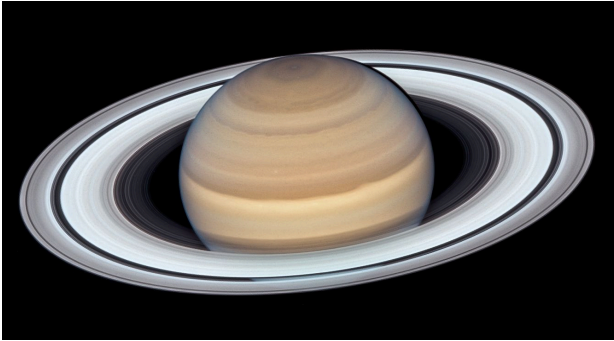


There are lots of great and up-close images taken from the Juno Missions!

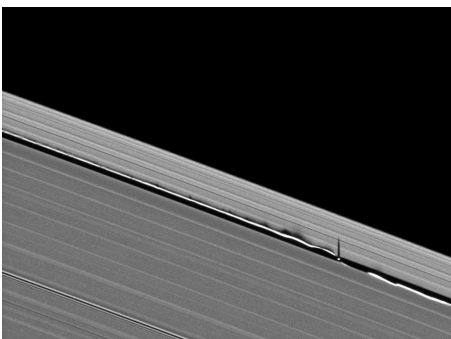
Gassy: This planet is made primarily of hydrogen and helium and has ammonia gas clouds.

Saturn (walk 112 more paces / yards; 247 yards total from the Sun)

An acorn; diameter 0.70 inch



- **Rubber ducky of the Solar System:** This gas giant is composed mostly of hydrogen and helium. Saturn has the lowest density of any planet in the solar system and since it is composed mostly of light gases, its density is about 30% less than water, meaning it would float if you could find an ocean big enough to hold it.
- **Rings:** Saturn has an extensive ring system. These rings are not solid, but rather made from billions of icy and rocky particles. The rings are relatively “young” and are currently being pulled in towards the planet. Scientists think that the rings of Saturn will be absorbed by the planet within the next 300 million years!
- **146 confirmed moons**, including the planet-sized moon Titan (it is larger than Mercury)! Titan is super neat because it also has a hydrocarbon cycle like Earth, meaning it has a liquid cycle: rain, rivers, and seas! The liquid unfortunately is methane and ethane, not water. 😞
- Saturn actually wobbles as it orbits. This means that sometimes we cannot see the rings from Earth because its tilt is exactly in line with us.



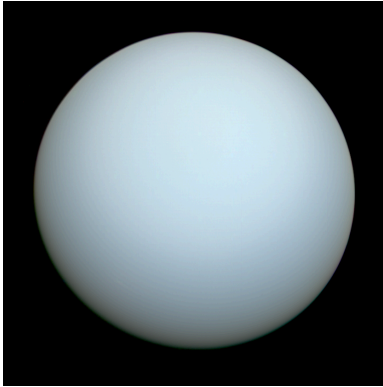
Saturn's moon Daphnis orbits inside of the rings and creates “waves” that disrupt the ice particles.



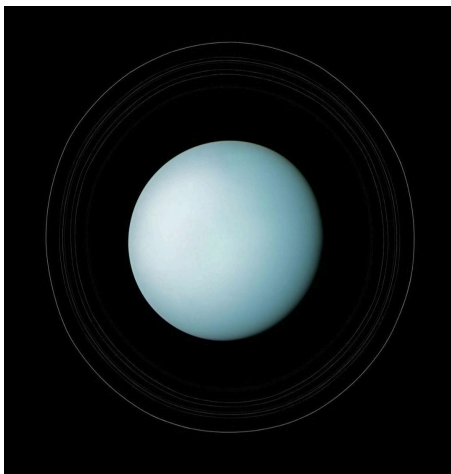
Bizarre storms: Saturn has a massive storm roaring at its north pole. Scientists are unsure as to why, but this storm is shaped like a perfect hexagon!

Uranus (walk 249 more paces / yards; 496 yards total from the Sun)

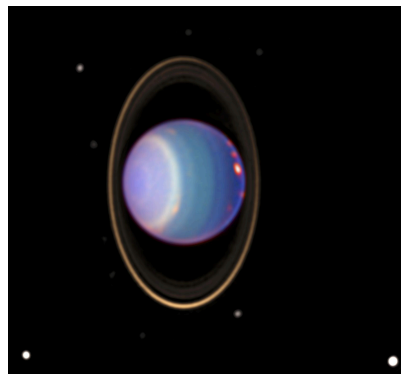
A peanut or coffee bean; diameter 0.30 inch



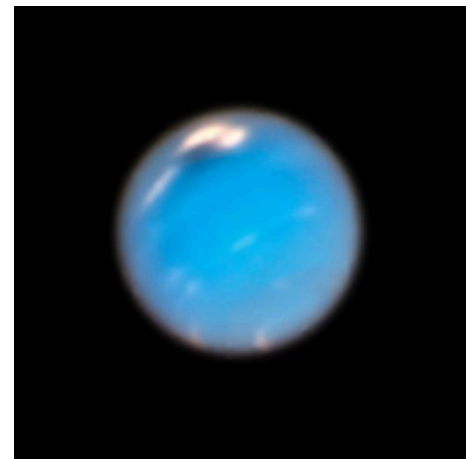
- **So cold:** Uranus is the coldest planet in our solar system with temperatures as low as -372°F
- **Rolling through space:** Scientists think that something large must have crashed into Uranus and caused it to “tip over” onto its side; so instead of spinning upright, it essentially rolls on its side as it orbits the Sun.
- **Wild Seasons:** Uranus takes 84 years to orbit the Sun and because of its sideways tilt, the planet's north and south poles experience 42 continuous years of sunlight followed by 42 years of total darkness.
- **Diamond Rain:** Due its dense and gaseous atmosphere, high pressures and temperatures can compress methane molecules into actual diamonds that rain down toward the core.
- **Moons and Rings:** Uranus has **27 known moons** and they are named after characters from William Shakespeare and Alexander Pope.



Uranus has a system of 13 faint, dark rings.



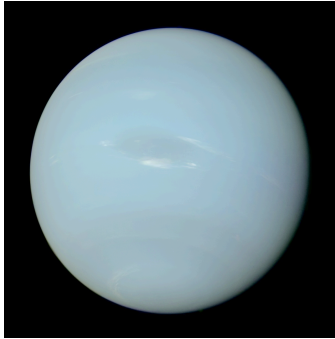
Uranus surrounded by its 4 major rings and 10 of its known satellites/moons. This false color image was generated using data taken with Hubble's Near Infrared Camera and Multi-Object Spectrometer. The HST recently found about 20 clouds (the orange and red dots). 1988



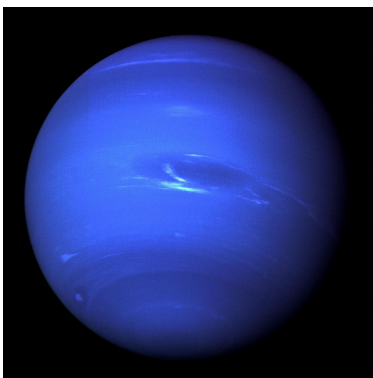
Cloud systems on Uranus.

Neptune (walk 281 more paces / yards; 777 yards total from the Sun)

A peanut or coffee bean; diameter 0.30 inch



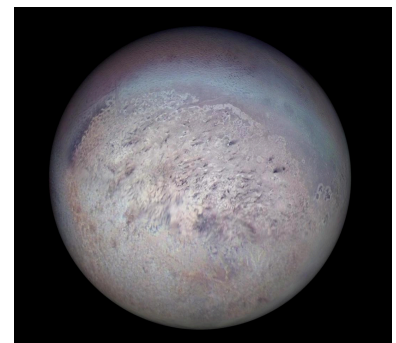
- **Ice Giant:** Technically classified as an “**ice giant**” instead of a “gas giant”; this planet is made mostly of heavier elements such as water, ammonia, and methane, instead of the typical gas giant elements of hydrogen and helium.
- **Math Planet:** This planet is the only mainstream planet discovered in our solar system that was discovered by mathematical predictions instead of direct observation.
- **Windy:** Has the fastest winds in our solar system and can reach supersonic speeds up to 1,300 mph!
- Even though it is further away from the Sun than Uranus, it is actually warmer on Neptune. Scientists believe that this is from the core retaining a significant amount of its early heat from formation whereas when Uranus “tipped”, it probably lost quite a large of its internal core heat.
- **Diamond Core:** Due to its dense, gaseous atmosphere, it also creates enough pressure and heat to break down methane into solid carbon, potentially resulting in an ocean of liquid carbon with “diamondbergs” and diamond rain.
- **Cool Moon:** Neptune has **16 known moons**, however, the largest one, called Triton, is believed to be a captured dwarf planet. It is as large as Pluto and has retrograde motion, which means it orbits the opposite direction of its planet’s rotation.



Storm system, called “The Great Dark Spot”. This storm has disappeared and reappeared over the years.



Neptune has five main rings, but two that are more “easily” visible.



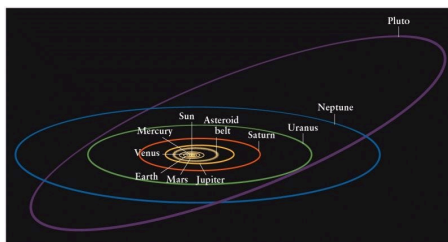
Triton; Neptune's largest moon. 2024
Spacecraft images show the moon has a sparsely cratered surface with smooth volcanic plains, mounds and round pits formed by icy lava flows.

Pluto, a dwarf planet (walk 242 more yards; 1019 yards total from the Sun)

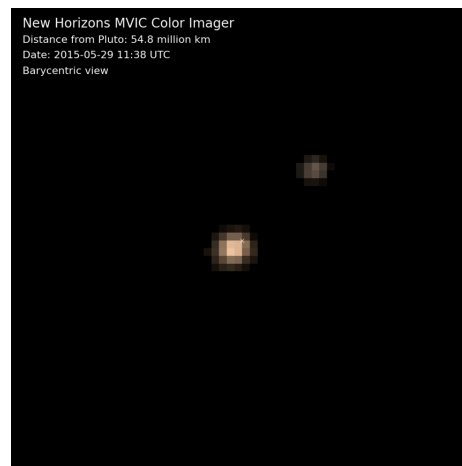
A small pinhead; diameter 0.01 inch



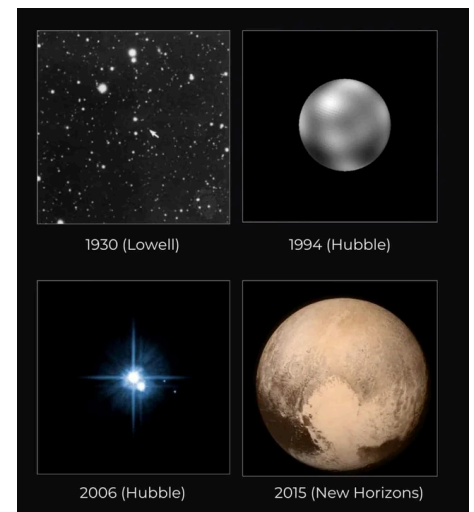
- Located in the Kuiper Belt. The Kuiper Belt is similar to the asteroid belt past Mars, but is made of icy objects rather than rocks.
- It was discovered in 1930 and since it takes 248 years to orbit the Sun, we still have not seen it complete one full revolution yet. It will finish its first full orbit since discovery On Monday, March 23, 2178.
- **So Tiny:** It is about 1,473 miles wide which means that Pluto is only about half the width of the United States and is smaller than Earth's Moon!
- **Heart-Shaped Glacier:** Pluto features a "heart" shape on its surface which is actually a massive glacier made from frozen nitrogen.
- **Binary System:** Pluto has **five known moons**: Charon, Nix, Hydra, Kerberos, and Styx. Charon is so large (~half Pluto's size) that they actually orbit each other, basically acting as a "double planet" system.
- **Kicked Out:** Pluto has a highly elliptical orbit (it orbits in a long, skinny oval) and due to this, it actually crosses into Neptune's path and is closer to the Sun than Neptune for a period of 20 years! This is ultimately what got Pluto removed from being a mainstream planet. 😞



Pluto's odd, highly elliptical orbit (purple oval).



Pluto and moon, Charon, orbiting each other. Seen from the New Horizon's Mission in 2015



Images over the years.

Congratulations! You have marched more than half a mile! (The distance in the model adds up to 1,019 paces. A mile is 1,760 yards.)

To do this, to look back toward the Sun ball, which is no longer visible even with binoculars, and to look down at the pinhead Pluto, is to feel the terrifying wonder of space.

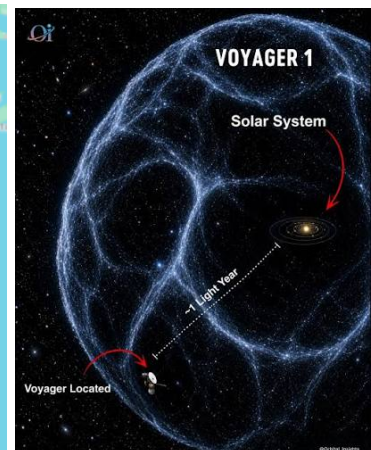
That is the outline of the Thousand-Yard Model.

Greater Distances

The solar system does not really end with the Kuiper Belt. Besides the planets, there is a thin haze of dust (some of it bunched into ice and comets).

On this scale, 1,000 miles is the equivalent of 1 light year (the distance light travels in one year).

On this scale, the edge of the solar system begins around 1,000 miles (think driving to Washington D.C. from Lake Iowa Park) and ends more than 3 light years away (imagine driving all the way up into Alaska) from Lake Iowa!



The distance to the nearest star, Proxima Centauri, is 4.2 such light-years. The rest of the stars in our galaxy are probably on the order of four to ten light-years apart from each other, as we are from our nearest neighbor.

This is a stunning thought when (having done the Thousand-Yard exercise) you go out at night and look at the Milky Way. It is a haze of light so delicate that it can no longer be seen from inside our light-polluted cities. It consists of the bulk of the stars in our galaxy, piled up in the distance, so numerous and so faint that we cannot see them separately. Yet they are all the same kind of distance from each other as we are from the nearest of them. That is to say, if we could hop to any one of them, cavernous black space would open out around us, and the Sun itself would become part of that same dense far-off wall of stars, the Milky Way!

3 Rules to Being a Planet

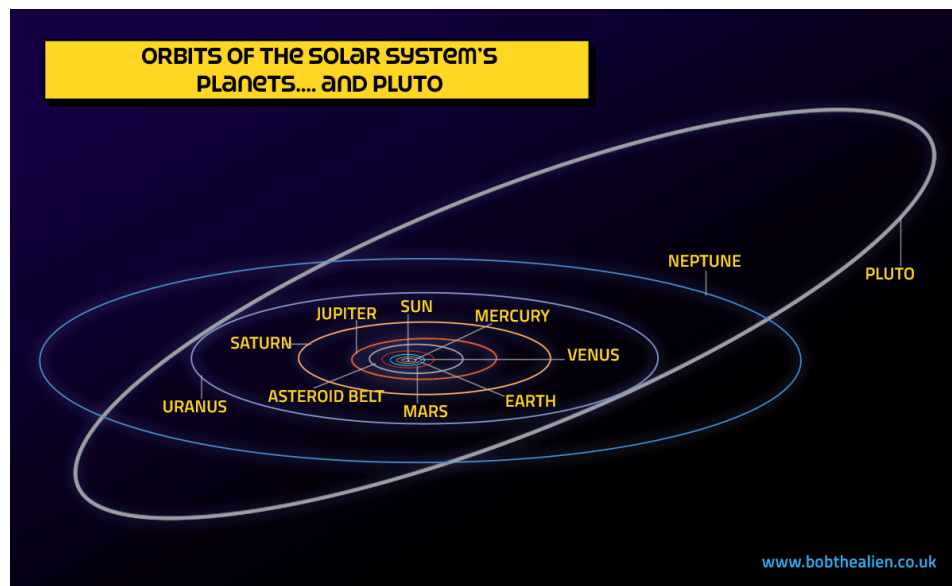
1. Planets must orbit a star (ex: the Sun)
 2. Planets must be a sphere (ex: round)
 3. Planets must “stay in their lane” and not cross into other planet’s pathways (*this is the main reason Pluto was demoted from a mainstream planet to a dwarf planet - Pluto crosses into Neptune’s path*)
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The Emptiness of Space

Space may appear black, however, it is just dark. Space is incredibly vast and empty. There is not a wall blocking us from seeing specific things (dark matter and dark energy are a whole different conversation), but however, just great distance. It is “clear” between us and space objects, it is just that we are so far away that the diffused light does not reach us. Just because we are so far away from a street light that we cannot see it, does not mean that it is not glowing nor that it is blocked, we are just too far away to see it clearly.

Orbits (or Revolutions) = 1 “year”

Planets do not stay in a straight line. They orbit in ellipses or ovals! Some planets have orbits that are more like a circle and some planets have orbits that look more like a long, skinny oval!



Speeds

Due to the planets all having different orbits, this means that the planets orbit at various speeds, leading to them all having different lengths of years. The inner planets (Mercury, Venus, Earth, and Mars) have shorter paths to travel but also move faster because the Sun's gravitational force is pulling on them with greater force, so their year is "shorter". Thus, Mercury goes around the Sun in about 3 months; the Earth, in a year; and Pluto in about 250 years.

The further away you get, the slower the orbit becomes due to being further away from the Sun's gravitational force which makes it weaker!

*Note: "Day" lengths are not determined by relative distance from the Sun. Smaller planets tend to have more of a reaction to the tidal pull from the Sun which acts like brakes on a car and slows their spin down. Larger planets also spin faster because they have more mass and material that is "pulled in" while spinning. Think of an ice skater pulling their arms in to spin faster, the larger planets have "larger arms" (more mass and material) which cause the planet to rotate faster!

