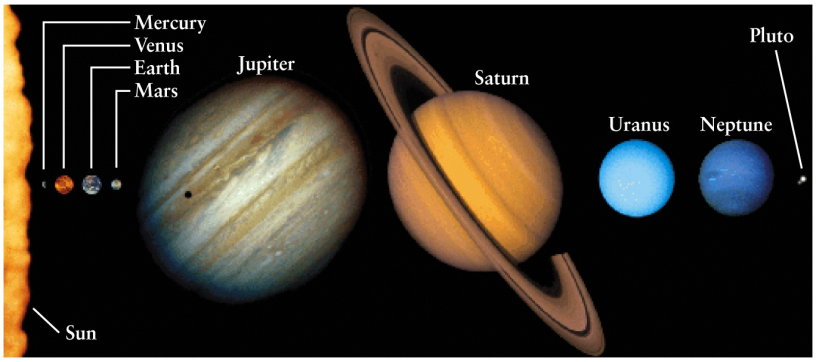
The Solar System

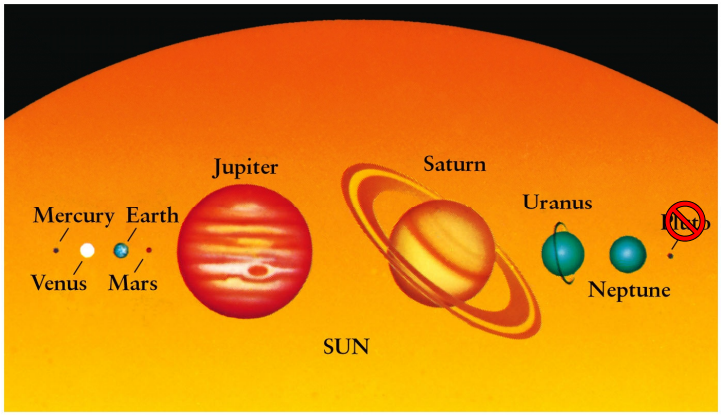


Question

Since the time of Isaac Newton, the numbers and types of Solar System bodies are much greater. Why?

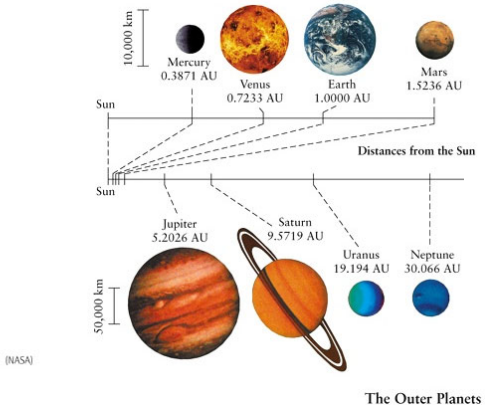
The Sun

The Planets



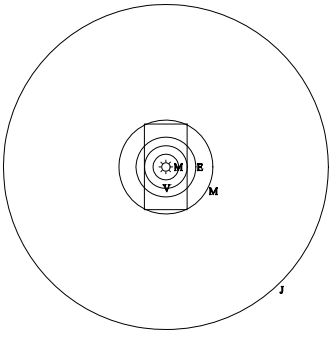
My Very Energetic Mother Just Served Us ~~Nine Pies~~
Nothing

Terrestrial & Jovian Planets



The Outer Planets

Scale of the Solar System

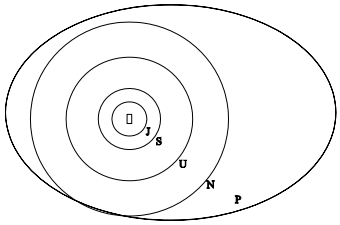


Shrink the Sun down to the size of a volleyball (8.25 inch diameter).

Put it on the 50 yard line of the GT football field.

Note the spacing of the inner planets – all would fit on the football field.

Scale (cont.)

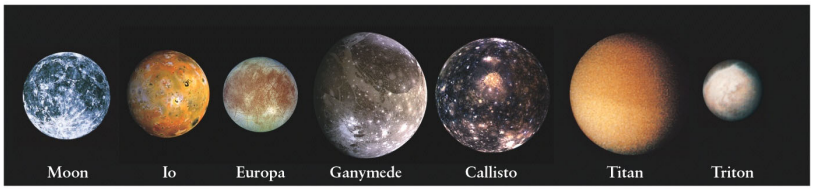


Note the spacing of the outer planets – much larger than the football field.

How far to the nearest star?

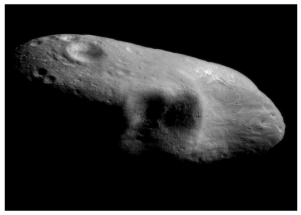
PLANET	DISTANCE		DIAMETER		MASS
	(AU)	(yd)	(E=1)	(mm)	(E=1)
Mercury	0.39	10	0.38	1	0.06
Venus	0.72	18	0.95	2	0.81
Earth	1.00	25	1.00	2	1.00
Mars	1.52	37	0.53	1	0.11
Jupiter	5.20	128	11.20	22	317.8
Saturn	9.54	235	9.41	18	94.3
Uranus	19.18	472	4.11	8	14.6
Neptune	30.06	740	3.81	7	17.2
Pluto	39.44	971	0.17	0	0.01

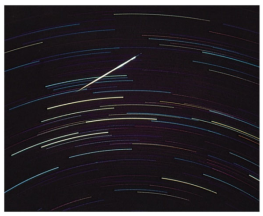
Moons



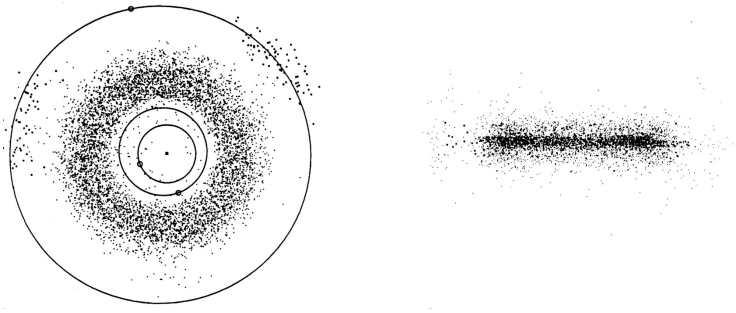
Large, Spherical Moons	7	Most made of ice & rock
Small Moons	~100	Most made of rock

Comets, Asteroids, & Meteors

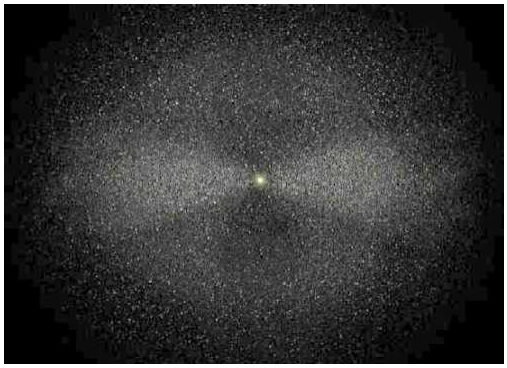




Asteroid Belt



Comets and the Oort Cloud



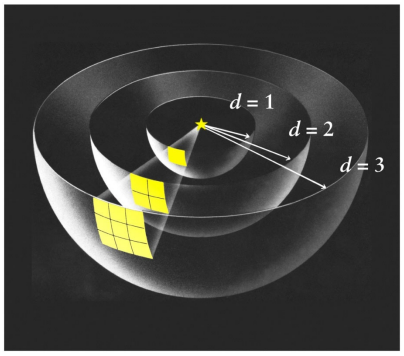
Propagation of Light

Apparent Brightness

Flux = Luminosity / $4 \pi d^2$

Inverse Square Law

$$\frac{\text{Flux}_1}{\text{Flux}_2} = \frac{4 \pi d_2^2}{4 \pi d_1^2} = \frac{d_2^2}{d_1^2}$$



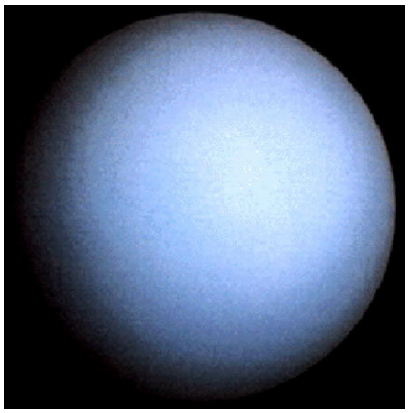
Discovery of Uranus

Uranus was discovered on March 13, 1781, by the German-English musician and amateur astronomer William Herschel, who was making a systematic telescopic survey of the sky in the constellation of Gemini.

Discovery of Uranus

Not a point source, thought it was a comet, until orbit was established as being circular and outside Saturn's. Plotted on star charts 20 times between 1690 and 1781. Wanted to name it *Georgium Sidus*, in honor of King George III.

Uranus



Titius-Bode Law

D = [(0, 3, 6, 12, 24, ...) + 4] / 10

Mercury	0.4	0.39
Venus	0.7	0.73
Mars	1.6	1.5
(Asteroids)	2.8	
Jupiter	5.2	5.2
Saturn	10.0	9.6
Uranus	19.6	19.2

Discovery of Asteroids

Most of the asteroids are located between the orbits of Mars and Jupiter. From the time of Kepler, it was recognized that this region of the solar system represented a gap in the spacing of planetary orbits. The Titius-Bode Law predicted a planet at 2.8 AU.

The discovery of Uranus seemed to confirm this “law”, so four astronomers felt there should be a concerted effort to locate this missing planet.

Ceres	January 1, 1801	1000 km
Pallas	March 1802	540 km
Juno	1804	265 km
Vesta	1807	510 km
Moon		3476 km

Discovery of Neptune

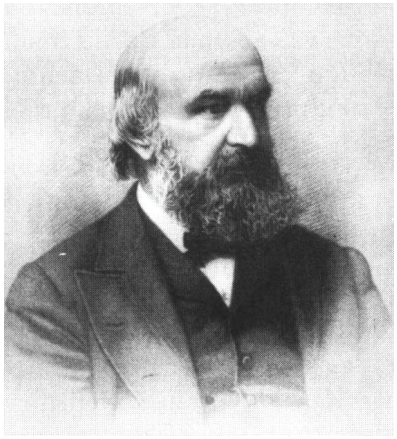
Neptune was found as the result of mathematical prediction.

By 1800's, it was apparent that Uranus' position was not quite where predicted. Since this difference was totally unacceptable in gravitational theory, it seemed clear that there must be an unknown planet providing additional gravitational perturbations on Uranus.

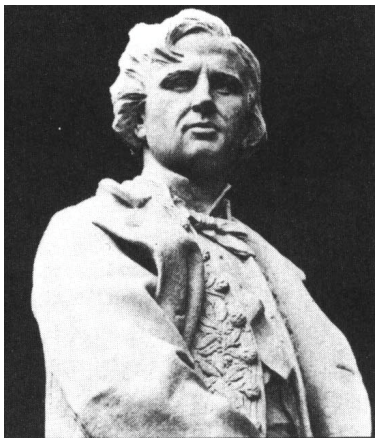
Discovery of Neptune

John Couch Adams
[1819 - 1892, England]

In September and October 1845, he tried to get Astronomer Royal George Biddell Airy to observe it. When Airy finally wrote back on November 5, he was skeptical.



Discovery of Neptune



Urbain Jean Joseph Leverrier
[1811 - 1877, France]

On November 10, he had completed the first part of his calculations and had this information published in a French journal. During the winter and spring of 1846, he completed his analysis, and got a position within 1^{o} of Adams'.

Discovery of Neptune

Leverrier completed his final calculations and presented his paper to the French Academy on August 31. Leverrier did not have Adams' problem of establishing his credibility; his work was warmly received.

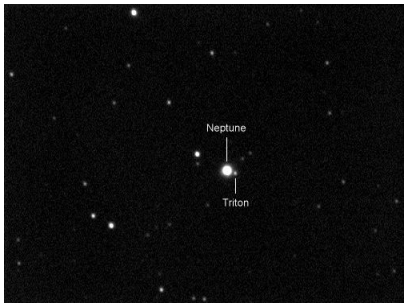
Leverrier's paper convinced Airy to begin the observations. However, the Cambridge astronomers did not possess up-to-date star charts against which to compare suspected planets, so their progress was slow.

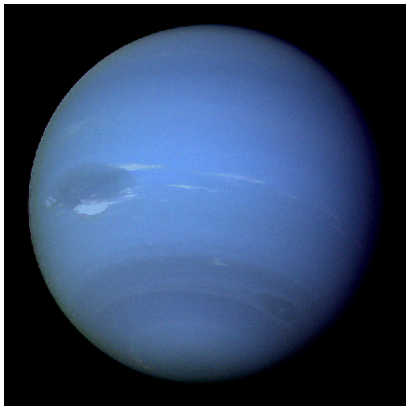
On the other hand, Leverrier had no success whatsoever convincing the French astronomers that they should bother to look for the new planet.

Wrote to a friend, Johann Galle, at Berlin. On the first night of observing, September 23, 1846, Neptune was found!

A search of old records revealed two pre-discovery observations made in 1795. Also, Galileo may have seen it!

Neptune





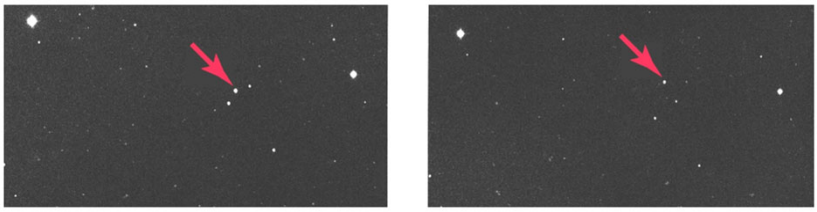
Discovery of Pluto

Pluto was discovered through a systematic search, not (like Neptune) as the result of a position calculated from gravitational theory. Nevertheless, the history of the search for Pluto began with indications of departures of Uranus and Neptune.

Percival Lowell and his contemporaries based their calculations on the remaining irregularities of the motion of Uranus. Unlike the calculations for Neptune, many solutions were derived by Lowell and others, and there was no consensus as to a general area in the sky to search.

Discovery Photographs

Lowell (and observatory) searched from 1906 until his death in 1916. His brother donated a telescope that could photograph large areas of the sky. In February 1930, **Clyde Tombaugh**, comparing photographs made on January 23 and 29 of that year, found an object whose motion appeared to be right. It was within 6° of the position Lowell had predicted, and the announcement was made on Lowell's birthday.



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(Asteroids)	2.8	
Jupiter	5.2	5.2
Saturn	10.0	9.6
Uranus	19.6	19.2
Neptune	38.8	30.1
Pluto	77.2	39.5

What Constitutes a Planet?

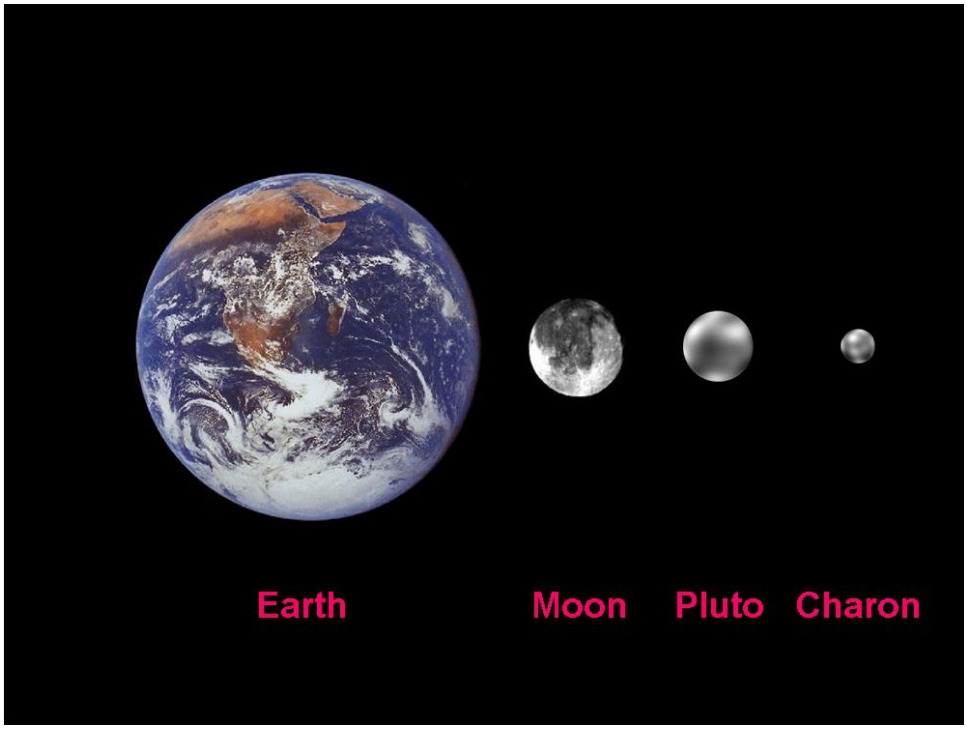
The International Astronomical Union (IAU) developed some definitions in 2001, modified them again in 2003, and as of August 24, 2006, the IAU has come up with another definition. The IAU said in a statement that the definition for a planet is now officially known as

"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."

What About Pluto?

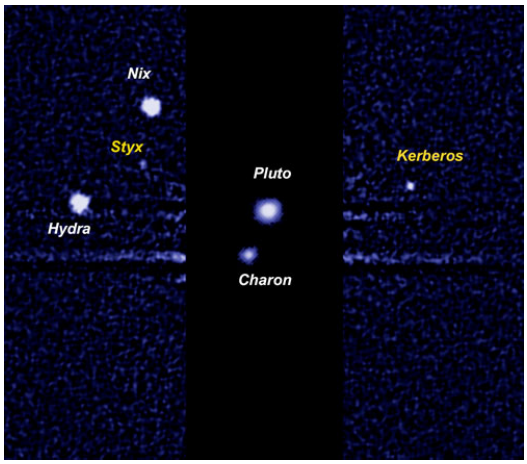
1. It is in orbit around the Sun.
2. It does have sufficient mass to be spherically shaped.

However, it is small.



More About Pluto

3. Although not a criteria, Pluto now has **five** known moons!



Final Comment about Pluto

4. Pluto has NOT cleared out other objects – of comparable size – in its general orbital area.

Dwarf Planets

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

Trans-Neptunian Dwarf Planets

Plutoids are celestial bodies in orbit around the Sun at a semi-major axis greater than that of Neptune that have sufficient mass for their self-gravity to overcome rigid body forces so that they assume a hydrostatic equilibrium (near-spherical) shape, and that have not cleared the neighborhood around their orbit. Satellites of plutoids are not plutoids themselves, even if they are massive enough that their shape is dictated by self-gravity.

The four known and named *plutoids* are **Pluto, Eris, MakeMake**, and **Haumea**. It is expected that more plutoids will be named as science progresses and new discoveries are made.

While all plutoids are dwarf planets, it is interesting to note that not all **dwarf planets** are plutoids, as is the case with the asteroid **Ceres**.