Solar system update

During the 20-year period from 1979 to 1999, it was not unusual for solar system savvy students to ask their teacher to name the most distant planet from the Sun. At that time, due to its inclination and eccentric orbit, Pluto was closer to the Sun than the planet Neptune. Pluto is now back at its position as the ninth planet, and will remain so for the next 230 years or so, until its orbital path again brings it closer to the Sun than Neptune. But is Pluto really the ninth planet, or even a planet at all? Is Pluto actually a member of a different group of solar system objects? Recent discoveries in the outermost parts of our solar system are not only allowing questions such as these to be asked, but these discoveries are also introducing us to many objects heretofore unknown.

Our knowledge of the solar system and of orbital dynamics has undergone some changes as telescope technology improved. The original solar system of seven members consisted of the Sun and the naked-eye visible planets. William Herschel added the planet Uranus to the solar system following its discovery in 1781. Two astronomers working independently, Johann Galle and Heinrich d'Asrest, discovered the planet Neptune in 1846. Then in 1930 Clyde Tombaugh discovered the planet Pluto. Interestingly, between the discoveries of Uranus and Neptune, the number of planets in the solar system reached 11 with the addition of Vesta, Juno, Ceres, and Pallas (now considered asteroids or minor planets). These four are located between the orbits of Mars and Jupiter. However, this idea was soon dropped as the number of asteroids increased to more than a dozen by the middle of the century and it was realized that there was a region of the solar system where there were numerous smaller objects.

The traditional solar system has been considered to be composed of our Sun; nine planets, some with moons; and other objects of various sizes and orbital properties that include the rocky asteroids and meteoroids, and the icy comets. Based on orbital characteristics and/or physical compositions, these members of the solar system have been classified into specific groups. There are the rocky, terrestrial (Earth-like) planets, sometimes known as the *inner planets*, which include Mercury, Venus, Earth, and Mars. There are the Jovian (Jupiter-like) planets or *outer planets*, including the gas giants of Jupiter, Saturn, Uranus, and Neptune, and the icy, rocky planet Pluto. Simply based on this arrangement, it is obvious that Pluto, while a member of the outer planet group, is not at all like the other four Jupiter-like planets. There are also the *minor planets*, which include the smaller rocky asteroids within the main asteroid belt between Mars and Jupiter, as well as near-Earth asteroids, Mars orbit-crossing asteroids, and the Trojan asteroids near Jupiter. Additionally, there are numerous icy objects ranging in size from several miles in diameter to larger than Pluto that have been grouped together as the *trans-Neptunian objects* (TNOs) or *Kuiper belt objects* (KBOs).

This is an artist's impression of noontime on Sedna, the farthest known planetoid from the Sun.

What is a planet?

Surrounding the solar system and possibly extending two to three light years from the Sun is a spherical-shaped region of our solar system known as the *Oort cloud*, named after Dutch astronomer Jan H. Oort. Within this vast region of space are many icy objects, some of which we know as *long-term comets*, like comet Halley, and the more recent bright comets, Hyakutake and Hale-Bopp. This region, like the Kuiper belt, is important because the objects within probably formed early in the history of the solar system and contain materials from that time. During the past decade there have been several discoveries of Pluto-like objects within these

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regions. Most notably three—Sedna, Quaoar, and 2003 UB313 (also mistakenly called Xena)—have reopened the discussion about what the definition of *planet* is, and subsequently restarted the debate as to whether or not Pluto is a planet. Both Sedna and Quaoar are somewhat smaller than Pluto, while 2003 UB313 is estimated to be larger than Pluto. If the size of 2003 UB313 is confirmed, it would be the largest solar system object discovered since the discovery of Pluto in 1930, and would make Pluto the second largest KBO.

Historically, a planet has been described as one of the nine objects orbiting the Sun. We have typically called the nine planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. More recently, a planet has also been described as a *non-fusor*—an object that does not have enough mass for nuclear fusion to occur, as would be the case for a *fusor*, or star. A planet could also be considered to be an object with enough mass for its self-gravitational force to pull it into a spherical or round shape. A planet might also be any object orbiting the Sun that is larger than Pluto. If we also include objects orbiting the Sun that have satellites, or their own moons, then the number of planets would grow tremendously due to at least 80 currently known asteroids with satellites. Using one of the various definitions of *planet*, or a combination thereof, would allow recently discovered Oort cloud objects and KBOs (and presumably others yet to be discovered) to be counted as planets.

A proposal by the astronomers at Caltech, who discovered Sedna, suggests an alternate definition for *planet—population classification*. By grouping or classifying objects as individuals, or members of a group or population of similar objects, our solar system essentially becomes a collection of two groups. By this definition, *population* would be characterized by members having a consistent range of sizes with no extremes and with similar orbital paths. The main asteroid belt, the KBOs, and the inner and outer parts of the Oort cloud are examples of populations. Included within the KBOs' population would be Pluto, as well as the recently discovered Quaoar and Sedna. On the other hand, *individuals* would include the Earth and the other seven objects that we call planets, Mercury through Neptune. These are considered individuals because there are no close objects of similar size and orbital path.

A new solar system?

Regardless of how a planet is defined, we are learning more and more about what our solar system is composed of and how these various members are arranged with regard to the Sun. This table shows the 14 largest known solar system members arranged from largest to smallest diameter and a proposed designation. The number of moons is current as of January 2006.

Object name	Diameter	Number of moons	Designation
Jupiter	142,984 km	63	Individual: Planet
Saturn	120,536 km	47	Individual: Planet
Uranus	51,118 km	29	Individual: Planet
Neptune	49,532 km	13	Individual: Planet
Earth	12,756 km	1	Individual: Planet
Venus	12,104 km	0	Individual: Planet
Mars	6,794 km	0	Individual: Planet
Mercury	4,880 km	0	Individual: Planet
2003 UB313	3,380 km	1	Population: KBO
Pluto	2,274 km	3	Population: KBO
Sedna	~1,800 km	?	Population: Oort Cloud
2003 EL61	~1,800 km	2	Population: KBO
2004 DW	~1,600 km	0	Population: KBO
Quaoar	~1,300 km	?	Population: KBO

Moon phases

	April	May
First quarter	4/5	5/5
Full Moon	4/13	5/13
Last quarter	4/21	5/20
New Moon	4/27	5/27

Visible planets

- **Mercury** will be visible but low over the eastern horizon at sunrise for the first two weeks of April, and then visible in the evening skies during the last week of May.
- **Venus** will be visible low over the southeast horizon at sunrise.
- **Mars** will be over the southwestern horizon at sunset and will set around midnight local time.
- **Jupiter** will reach opposition during early May so it will be visible all night, from sunset to sunrise.
- **Saturn** will end retrograde motion on April 5, and will be visible over the west-northwest horizon at sunset.

Celestial events

4/2 Start daylight saving time (Spring forward!)
4/22 Lyrid meteor shower peak
5/6 Astronomy Day

Resources

2003 EL61—*www.gps.caltech.edu/~mbrown/2003EL61/index.html*
Asteroids with satellites—*www.johnstonsarchive.net/astro/asteroid-moons.html*
Astronomy Day—*www.astroleague.org/al/astroday/astroday.html*
Discovery of a large Kuiper belt object with an unusual orbit—*www.cfeps.astrosci.ca/4b7*
Discovery of 2003 UB313, the 10th planet—*www.gps.caltech.edu/~mbrown/planetlila/index.html*
Jan H. Oort—*www.phys-astro.sonoma.edu/BruceMedalists/Oort*
Quaoar—*www.gps.caltech.edu/~chad/quaoar*
Sedna—*www.gps.caltech.edu/~mbrown/sedna*
SFA star charts—*observe.phy.sfasu.edu*
Starchild—*starchild.gsfc.nasa.gov/docs/StarChild/questions/question48.html*
The nine planets—*www.nineplanets.org/nineplanets.html#toc*
The Oort cloud—*www.solarviews.com/eng/oort.htm*
Tracking the planets—*http://currentsky.com/planets.html*
When did the asteroids become minor planets?—*aa.usno.navy.mil/hilton/AsteroidHistory/minorplanets.html*

Additional information

Sobel, D. 2005. *The planets*. New York: Viking.

Questions for students

1. Is Pluto always the farthest planet from the Sun? *(No. Due to its inclination and eccentric orbit, Pluto is closer to the Sun than the planet Neptune for 20 years of its 248-year orbit around the Sun.)*
2. How are comets, asteroids, and members of the Kuiper belt important for understanding the early solar system? *(These objects appeared early during the formation of the solar system and may be composed of materials present at that time, thus offering a record of conditions when the solar system formed.)*

Use the web resources to research the answer to this question:

3. How do astronomers determine the size of distant objects such as Sedna? *(Astronomers use several methods, including measurement of the brightness of the object. They use infrared telescopes that measure the temperature of the object and then infer its size from these measurements.)*
4. How do we get the names for planets and their satellites? *(The International Astronomical Union is responsible for the names chosen for planets and their satellites. Except for the Earth, planets are named after Greek or Roman gods from mythology. Most satellites of planets, except for Uranus, get their names from characters or events associated with the god the planet is named for. The satellites of Uranus's names come from William Shakespeare and Alexander Pope.)*