LDEO NGSS Summer Institutes: "Teaching about Astronomy" (GED 7214)

Lesson 6: Dwarf Planets, Asteroids, Comets, and Moons

Expect Time Required: 2 – 3 hr

Submitted by: **Date:** **Time Needed:**

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<u>Selected NGSS Connections</u>:

ESS1.B: Earth and the Solar System

- **The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.**

- **Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.**

Students who demonstrate understanding can:

MS-ESS1-3. **Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [*Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.*]**

Selected PS/ES Core Curriculum Concepts:

1.1a Most objects in the solar system are in regular and predictable motion
> These motions explain such phenomena as the day, year, seasons, phases of the Moon, eclipses, and tides.
> Gravity influences the motions of celestial objects. The force of gravity between two objects in the Universe depends on their masses and the distance between them.

1.1b Nine planets move around the Sun in nearly circular orbits.
>The orbit of each planet is an ellipse with the Sun located at one of the foci.
> Earth is orbited by one Moon and many artificial satellites.

1.2d Asteroids, comets, and meteors are components of our solar system.
> Impact events have been correlated with mass extinction and global climate change.
> Impact craters can be identified in Earth's crust.

Introduction

Herschel's accidental discovery of Uranus in the late 18th Century opened a new phase in Astronomy. Hundreds of professional and amateurs scanned the night skies in the hope of making their own discoveries.

Many relied on "Bode's Law," a mathematical description explaining the spacing of planets away from the Sun. The orbit of Uranus fit into this pattern. But no known planet had been found in the zone between Mars and Jupiter where there should be one, according to Bode's Law. Intense searches in the years after Herschel's discovery led to the sighting in 1801 of a small object in that zone. It was named "Ceres". However, it was clear that it could not be a 'real' planet because it was too small, less than 1000km in diameter. Soon, three similar small objects were observed in this zone. So they were called "minor planets" or, as they became better known, "asteroids."

In the early 20th Century as more became known about the orbit of Neptune, Percival Lowell predicted that there should be a ninth planet further out. After searching for many years, in 1930 one of his students, Clyde Tombaugh, discovered evidence of such an object through careful study of deep-space photographs. It was named for the Roman god of the underworld, brother of Jupiter and Neptune. [Sidenote: At about this time, Walt Disney had introduced a dog for Mickey Mouse that he originally called 'Homer the Hound.' With all the hoopla about the new planet, in the next cartoon Disney called him 'Pluto the Pup.']

For many years, Pluto was included as one of the 9 planets of our solar system, and astronomers continued to search further out for a 10th planet. Many small objects were discovered as telescopy improved. In the early 21st Century, despite public controversy, astronomers agreed to change the status of Pluto to that of a "dwarf planet."

In this lesson, you will learn about the smaller objects that are parts of the Solar System: dwarf planets, moons, asteroids, and comets.

Dwarf Planets and Asteroids

Dwarf planets, like the 8 major planets, revolve around the Sun in predictable orbits and are generally round, unlike many asteroids. Some even have moons. But because of the differences in size and the abundance of other relatively nearby objects, they are placed in a different category. There may be dozens of them, although to date only a few have been observed.

Pluto is the largest and most famous. It has a mean distance from Earth of about 5,900 million km, nearly 40 times further from the Sun. Earth. Smaller than Earth's Moon, astronomers have discovered 5 moons orbiting Pluto. The largest of these is "Charon." Recently, NASA's "New Horizons" space probe transmitted back to earth the most details images ever made of Pluto and its satellites.

Pluto and similar objects near it are now classified as members of the "Kuiper Belt." Since the first Kuiper Belt object was discovered in 1992, many others have been found, some with very odd shapes. Some comets that periodically go past Earth as they orbit the Sun are considered Kuiper Belt objects. Even further out are the Oort Clouds, probably the most distant parts of our solar system.

Ceres is the largest of the dwarf planets in the "Asteroid Belt" between Mars and Jupiter. It is less than 1,000 km wide, but exhibits some unusual characteristics: Ceres may have a thin atmosphere and a sub-surface ocean of water. NASA's Dawn mission is currently exploring Ceres.

There are tens of thousands of objects orbiting in the asteroid belt, ranging in size from Ceres to tiny solids less than a kilometer in size. Some are stony, made of silicates and iron-nickel minerals. Others are metallic, made only of iron and nickel. A third group is called "chondritic" and made of clay and silicates. As we find meteorites with these compositions, astronomers infer than many of these were dislodged from the asteroid belt and caught in Earth's gravitational pull. NASA and other space agencies have sent space probes to study asteroids during the past three decades.

Response: Create a "compare-contrast chart" that shows similarities and differences between the major and dwarf planets.

Response: Create a simple lesson plan for a student-developed study of asteroids.

Comets

"I came in with Halley's Comet and I'll go out with Halley's Comet." So predicted Mark Twain/Sam Clemens. He was born shortly after Halley's Comet appeared in 1835 and died shortly after it reappeared in 1910.

Comets are among the most unusual celestial objects because of the way they appear and disappear. Early people thought of them as omens sent by their gods. Astronomers now know them to be frozen chunks of gases, ice, and rocks. As they approach the Sun and can be seen from Earth, they look somewhat like a head with hair flowing outward—this gave them their name from the Greek for "hair." More than 3,000 have been identified, but there may be millions or even billions in our solar system.

Comets travel in highly elliptical orbits. Comets from the Kuiper Belt may take centuries to orbit the Sun; those originating in the more distance Oort Clouds may take thousands of years.

The most famous comet is "Halley's Comet," named for Edmund Halley, the 17th Century scientist and friend of Newton. Legend has it that Halley asked Newton whether the object they saw would ever return, and Newton responded to the effect the he would provide an answer after he invented Calculus, the mathematics of motion. Studies over the next couple of decades led Halley and Newton to the conclusion that it would re-appear about 75 or 76 years later, and was the same object that had been seen by Kepler in 1607 and also in 1531. Although Halley died before the comet reappeared within a month or so of its predicted appearance, his name has been associated with it to honor his seminal work.

This comet was easily seen with the unaided eye during its 1910 pass, receiving global attention (and some creative scams, such as "comet-protection hats.") [Sidenote: One of the first popular bands in Rock 'n Roll was Bill Haley and the Comets, whose hits include 'Rock Around the Clock."] The comet was much less visible when it returned in 1986, but during this passage the European Space Agency's Giotto probe made the first close-up examination of a comet. It will re-appear in 2061. This comet may be the one depicted in the Bayeux Tapestry in commemoration of the 1066 Battle of Hastings. There may even be mention of it in the Talmud, the collection of Biblical commentaries written about two thousand years ago.

Amateur and professional astronomers continue to discover new comets and witness the return of others. NASA and other agencies have sent many probes to learn more about these "dirty snowballs" as they pass through our solar system.

Response: Create a simple lesson plan for a student-developed study of comets.

Moons

People have always seen the Moon, Earth's natural satellite. But it wasn't until Galileo used his first telescope to scan the night skies that anyone knew other planets also had moons. Because most people at that time believed in a geocentric (Earth-centered) Universe based on the Bible, such an inconvenient truth created great intellectual upheavals. Over the next centuries, Earth-based astronomers discovered more Jovian moons, as well as satellites orbiting Mars, Saturn, Uranus, Neptune, and even Pluto.

Space probes sent to examine our Solar System neighbors in more detail showed that there were more satellites revolving around the Gas Giants than previously suspected. The current counts are: Jupiter (67); Saturn (62); Uranus (27); and Neptune (14). Pluto is now thought to have 5 moons, and some of the dwarf planets have satellites.

Unlike our Moon which is basically rocky—unsurprisingly because it is thought to have formed from material knocked off the primordial Earth—many of these moons appear to be quite varied in their composition and characteristics due to very diverse origins. We will examine only a few to represent this diversity.

"Galilean Moons" of Jupiter: Galileo discovered four objects orbiting Jupiter within a year of making his first telescope, and as noted above, the implications have been revolutionary. He named them after four of Jupiter's loves: Ganymede, Europa, Io, and Callisto. Ganymede is the largest moon in the solar system, even greater in size than Mercury. Europa is slightly smaller than our Moon, and may have a watery ocean above a rocky sea floor. Io is the most volcanically active of all moons. Callisto is the most heavily cratered object in the solar system.

Moons of Saturn: Titan is the largest moon in this system, only slightly smaller than Ganymede. It has an atmosphere composed of nitrogen and methane. Rivers of liquid methane and ethane flow over the surface. Tethys has a density lower than water, indicating it may be made mostly of ice and some rocky material. Tethys has a smaller moon that always trails it, Calypso. Enceladus is one of the most interesting objects in our solar system because it seems to have an underground ocean from which hydrothermal vents spew water and ice into Deep Space.

Response: Use the links available at NASA's "Solar System Exploration: Moons" pages to learn more and create your own lesson plan about the moons of our solar system.

What is your "Key Question" for this lesson?

{Submit your response as an attachment to michael@earth2class.org.}