History of Saturn Discovery
(modified from Cassini Educators Guide)

Procedure

1. Look at the Sky Observations by Ancient Cultures handout. Explain how people were able to follow the planets without a telescope.

2. Look at the group of the History of Discovery Cards. Make sure you understand the information on the cards.

3. Complete the timeline based on the information from the cards.

Select and answer one of the following on a separate sheet of paper. (Your response must be complete, neatly written, and fully cover the topic. A sentence or two will not adequately answer the question):

- Compose a letter to Galileo explaining how scientific understanding of Saturn has changed since the time of his observations. Address questions like: What news would be most exciting to share with Galileo? What advances have been made in technology? What additional discoveries were made due to these advances? What do we hope to learn by the year 2010, after the Cassini spacecraft has toured the Saturn system?
- Explain the different categories of technologies that have been used to explore Saturn.
- Explain why we use spacecraft to explore Saturn. What is the advantage of having Cassini orbit Saturn vs. having Pioneer 11 and the Voyagers fly-by the Saturn?
In 1610, Galileo Galilei observed Saturn through a refractor telescope, which used lenses a few inches across to magnify distant objects by 20 to 30 times. He observed Saturn to be “triple,” thinking that he was seeing two “lesser stars” (moons) or companions to the planet, or perhaps they were two bulges that were features of the main body. In the fall of 1612 he observed Saturn again and to his surprise he found the planet to be perfectly round! In 1616, he found that Saturn’s “companions” had reappeared and grown, and he made a drawing that today would be readily interpreted as Saturn and its ring system. Galileo died never knowing that he’d been the first to observe Saturn’s rings.

In March 1655, at age 26, Christiaan Huygens viewed Saturn through a more powerful telescope than Galileo’s. Huygens’ skill at crafting lenses allowed his instrument to magnify objects about 50 times. Huygens’ observations and his study of other astronomers’ observations led him to determine that Saturn had a flat ring encircling its equator, and unlike Galileo, he could see that the ring did not touch the planet. Huygens discovered Saturn’s largest moon, which would be named Titan 200 years later. He observed that the moon orbited Saturn every 16 days. Its orbit was well beyond the extent of the ring, but like the ring, it was in the plane of Saturn’s equator. He recognized that the disappearance of Saturn’s “companions,” which Galileo had observed in 1612, occurred whenever Saturn’s thin ring appeared edge-on to Earth observers. This event occurs about every 15 years because, like the Earth, Saturn’s north–south axis is tilted. This tilt causes our view of Saturn’s rings to change as the planet travels in its 30-year orbit around the Sun. The Huygens probe to Titan, built by the European Space Agency, is named after Christiaan Huygens.
In the late 17th century, Jean-Dominique Cassini studied Saturn from the Paris Observatory using a series of refracting telescopes. Cassini’s largest telescope was 136 feet long, dwarfing Galileo’s 4-foot telescope and allowing him to see far greater detail. In 1675, Cassini discovered that Saturn’s “solid” ring had a gap in it that divided it into two separate rings. Today this gap is called the Cassini Division. The ring outside the division is the A ring, while the brighter ring within is the B ring. No one yet knew what the rings were made of, how thick they were, or whether they were permanent features around Saturn. Cassini also discovered four moons of Saturn (the moons weren’t named until later): Iapetus (1671), Rhea (1672), and Tethys and Dione (1684). Other moons would not be discovered until over a century later. Cassini is the astronomer for whom NASA’s Cassini mission to Saturn is named.

(Left) Many astronomers of Cassini’s time used tubeless telescopes. A framework structure or a rope, as shown here, was used to align the eyepiece with the objective lens.

In 1781, William Herschel discovered the planet Uranus beyond the orbit of Saturn, ending Saturn’s long reign as the most-distant planet. The discovery also effectively doubled the size of the Solar System because Uranus is twice as far away from the Sun as is Saturn. In 1789, Herschel discovered the sixth and seventh moons of Saturn, which would later be named Mimas and Enceladus. Herschel was among the first to use a reflecting telescope, which used mirrors instead of lenses to focus the light coming from distant objects. He constructed and used a telescope with a 48-inch mirror that weighed a ton and was housed in a tube 40 feet long. The telescope was located in his backyard in Bath, England. To reach the eyepiece, he climbed a scaffolding that rose 50 feet into the air! Herschel was often assisted by his sister Caroline, who was also an accomplished astronomer.

(Above) Caroline Herschel.

In 1888, James Keeler observed Saturn with the telescope at the Lick Observatory in California. On the first night the observatory began operating, Keeler saw a narrow, dark gap close to the outer edge of Saturn’s A ring. This gap is now called the Encke Gap (the astronomer Johann Encke received the credit, though he could not quite resolve the gap in detail when he observed it in 1837). In 1895, Keeler observed Saturn’s rings using a telescope at the Allegheny Observatory in Pennsylvania. Connected to the telescope was a spectrograph, which analyzed the light reflected from the rings. The light he saw indicated that the innermost parts of the rings were moving around Saturn faster than the outermost parts. This offered experimental evidence that the rings were not a solid disk, but instead made up of individual particles moving like tiny moons around Saturn.

In 1944, Gerard Kuiper [KOY-per] discovered Titan’s atmosphere using a spectrograph attached to a reflector telescope at McDonald Observatory in Texas. Unlike Keeler’s spectrograph, Kuiper’s spectrograph detected infrared light (that is, infrared radiation, often called heat) instead of visible light. Kuiper was particularly interested in finding out if any of the moons orbiting around other planets in the Solar System had atmospheres. He studied the infrared light reflected off the 10 largest moons, and in 1944 he reported that Titan, the largest moon of Saturn, was the only one having an atmosphere that could be easily detected. Astronomers observed the sky only in visible light until the 1930s, when the first radio-wavelength observations were made. Today, we view the Universe across the entire electromagnetic spectrum, in radio, microwave, infrared, visible, ultraviolet, x-ray, and gamma ray.
Pioneer 11 1979

NASA’s small robotic observer passed within 22,000 km of Saturn’s cloudtops in September 1979, providing the first close-up images of the Saturn system. Pioneer 11 took pictures of Saturn’s poles and clouds, detected heat generated deep from within Saturn, made the first measurements of Saturn’s magnetic field, confirmed the E ring (suggested in 1967 by scientists studying Earth-based telescope images), discovered the F ring just outside the A ring, and made a possible detection of the G ring (a faint, narrow ring just beyond the F ring). Pioneer 11’s view of Saturn was about 50,000 times closer than any Earth-based telescope could see. Pioneer 11 represented a new way for astronomers to explore the planets. Rather than scientists building their own telescopes and working individually to make new discoveries from observatories on Earth, a team of people — scientists, engineers, and different kinds of specialists working together — built a robot having various instruments and sent it into space to send back images and other kinds of data.

(Very left) A portion of Saturn’s rings observed by Pioneer 11.


Twin NASA spacecraft made extensive flyby studies of Saturn — in November 1980, Voyager 1 passed within 125,000 km of Saturn’s cloudtops, and in August 1981, Voyager 2 passed within 101,000 km. The Voyager missions sent back tens of thousands of color images of the Saturn system. They measured high wind speeds along Saturn’s equator, provided close-up pictures of several known moons, and discovered that Titan’s atmosphere is very thick and made mostly of nitrogen. The Voyagers also discovered several small moons: Telesto, Calypso, Pan, Atlas, Prometheus, and Pandora. Voyager cameras showed us that Saturn’s rings are actually made up of thousands of tiny “ringlets,” and that strange spoke-like structures hover above the B ring. The spacecraft confirmed the existence of both the innermost D ring as well as the outer G ring that had been tentatively identified by Pioneer 11. By observing the way radio waves and visible light pass through the rings, scientists inferred from Voyager data that ring particles range in size from nearly invisible dust to icebergs the size of houses.

(Bottom) A Voyager close-up image of Saturn’s rings.
NASA launched the Earth-orbiting Hubble Space Telescope (HST) in 1990 from Space Shuttle Discovery. HST’s main mirror is 2.4 meters across, and the entire telescope is about the size of a school bus. HST observes in visible, ultraviolet, and infrared light. It is not significantly closer to the planets and stars than are telescopes on the ground, but its views of the Universe are undistorted by Earth’s atmosphere. HST orbits the planet every 90 minutes from about 600 km (370 miles) above the surface. Astronauts can visit it every few years to upgrade the instruments. HST has provided views of cloud eruptions in Saturn’s atmosphere, monitored the thickness and density of the faint, outermost E ring, and searched for new Saturn moons during times when the rings appear edge-on to Earth observers. HST has also made infrared images of Titan’s surface that helped to show where the Cassini mission would land its Huygens probe.

(Top) Deploying the HST on April 25, 1990, from the Space Shuttle.
(Bottom) A nearly edge-on view of Saturn’s rings taken by the Wide-Field and Planetary Camera aboard HST.

Cassini–Huygens was launched in 1997 and will arrive at Saturn in 2004. During a 4-year tour of the Saturn system, the spacecraft will study the majestic planet, its extraordinary rings, and its moons. The Cassini orbiter carries six instruments to “see” in four kinds of “light” (visible, infrared, ultraviolet, and radio), as well as instruments for measuring dust particles, charged particles, and magnetic fields. The Huygens probe will parachute through Titan’s atmosphere and land on the surface, taking more than 1,000 images of Titan’s clouds and surface. No human has ever seen the sights that will be captured by the Huygens probe — will there be lakes, oceans, mountains, and craters? Compared with the instruments aboard the Voyagers or the Hubble Space Telescope, the Cassini orbiter instruments can observe in much finer detail. Cassini will have 4 full years to study the Saturn system instead of just a few days as did the Pioneer 11 and Voyager flyby missions. Cassini will fly within about 20,000 km of Saturn’s cloudtops, and as close as 1,000 km to some of the moons.

(Top) Cassini–Huygens in the assembly bay at JPL.
(Left) Artist’s concept of the Huygens probe landing on Titan.
History of Saturn Discoveries Timeline

Using the information recorded on the History of Discovery Table, complete the timeline (name, date, what they/it did).