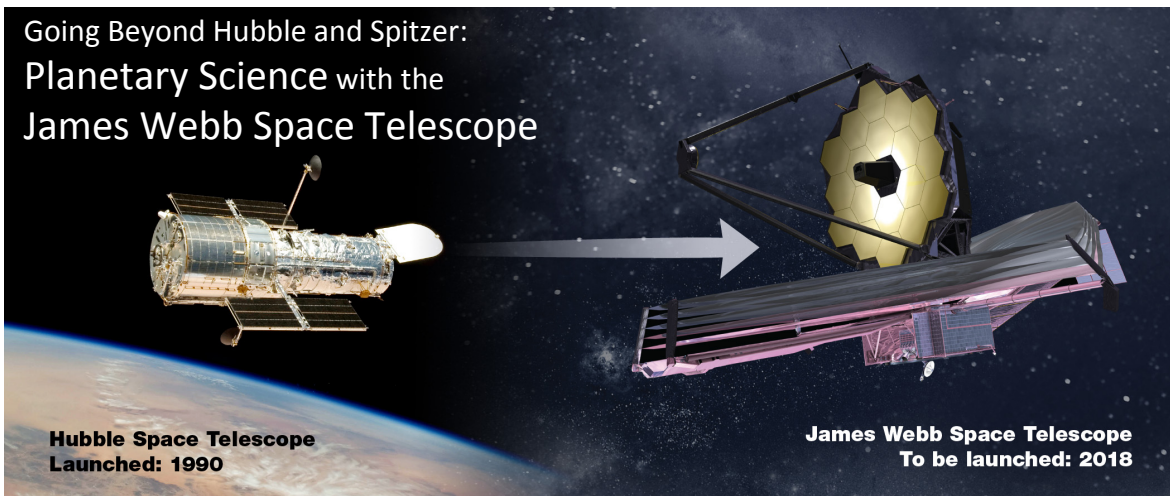


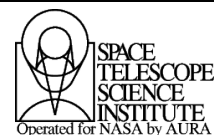
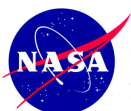
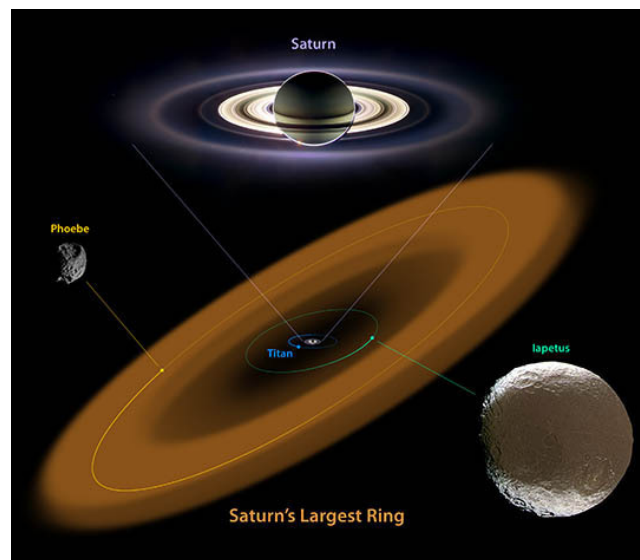
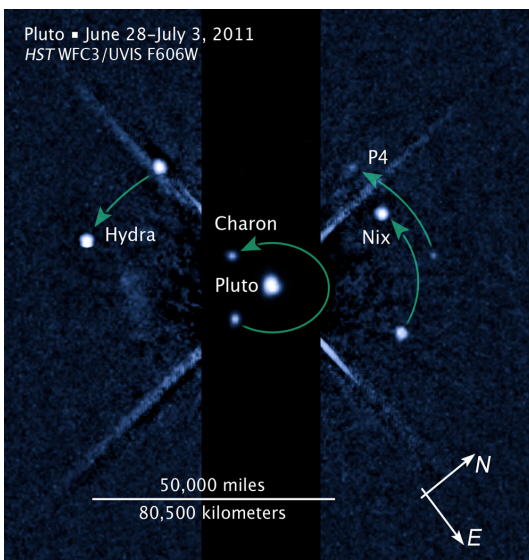
"There are three main areas in which collaboration with other parts of NASA could benefit the solar system exploration program....the Hubble Space Telescope has a long history of successful planetary observations, and this collaboration can be a model for future telescopes such as the James Webb Space Telescope."

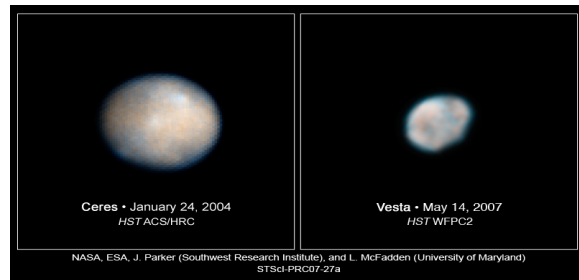
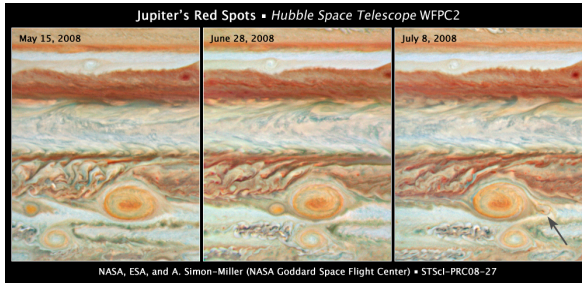
Vision and Voyages for Planetary Science in the Decade 2013-2022



NASA's Great Observatories have provided both astronomers and planetary scientists unique imaging and spectroscopic capabilities for many years. The **Hubble Space Telescope** and **Spitzer Space Telescope** have advanced research on virtually every topic in space science, and planetary scientists have led proposals on these telescopes that have helped to reshape our view of the solar system. Among the many discoveries that these telescopes have provided are:

- Discovery of new moons around Pluto.
- Discovery of the largest ring around Saturn.
- Characterization of Ceres, Vesta, and other dwarf planets and asteroids.
- Discovery of new Kuiper Belt Objects (KBOs).
- Detailed studies of cloud structure in outer gas giants.
- Long-term monitoring of the Martian atmosphere.
- And much more...

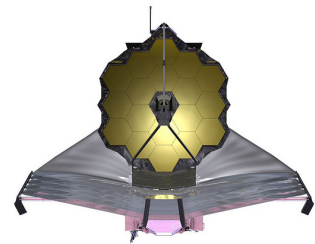




As **Hubble** and **Spitzer** near the end of their lives, NASA, ESA, and the CSA are building their successor, the **James Webb Space Telescope (JWST)**. JWST is a flagship mission that will revolutionize our understanding of the Universe. It is much larger, more sensitive, and has higher resolution than other Great Observatories. A significant amount of time on JWST is expected to be devoted to planetary science, where it will be more than 100 times as powerful as Hubble and Spitzer at infrared wavelengths.

#### JWST Quick Facts

- 6.5 meter primary aperture
- 0.6 – 28.5 micron wavelength range
- Diffraction-limited 65 mas resolution at 2 microns
- Unprecedented IR sensitivity: S/N = 10 at K = 27.5 AB mag in 10 min



### Planetary Science with JWST

Pointing control system enables observations of solar system objects with rates of motion up to 0.03 arcsec per second. This includes all planets and asteroids beyond Earth's orbit.

#### **1.) Kuiper Belt Objects (KBOs)**

##### **JWST will:**

- Image all known KBOs in the mid-infrared.
- Perform near-infrared spectroscopy with R = 100 of all known KBOs (V < 25); S/N = 20 in 3 hours.
- Provide higher resolution spectra of bright KBOs.

Spectral coverage and resolution will directly constrain surface composition (H<sub>2</sub>O, CH<sub>4</sub>, CH<sub>3</sub>OH) and volatile inventories of all known KBOs, and provide the first spectra of these objects at 2.5–5 microns. The ice/water hydration band at 3.1 microns is easily within the reach of NIRSpec in the vast majority of all KBOs. Such results will directly address the dynamical (and chemical) history of the solar system and test formation theories. The observations will also elucidate the role that giant planet migration has played in the evolution of the solar system. Radiometry of KBOs will enable better characterization of their albedos and hence the size distribution within the Kuiper Belt.



## 2.) Dwarf Planets

### JWST will:

- Perform time-resolved imaging of Pluto, Eris, Sedna and other dwarf planets.
- Provide infrared spectroscopy of large bodies in the outer solar system.

JWST observations will reveal seasonal behavior of the largest outer solar system bodies and provide a new level of understanding on their surface compositions. The spectra will be well suited to track variations in  $N_2$  and  $CH_4$ , and will also likely result in the discovery of new organic molecules or previously undetected ices. The combination of high-resolution temporal imaging and spectroscopy will explore correlations between atmospheric chemistry changes and albedo.



Artist's impression of a binary KBO

## 3.) Comets

### JWST will:

- Provide Near-infrared spectroscopy with  $R = 1000$  of cometary comae.
- Provide Mid-infrared spectroscopy of cometary dust grains.
- Perform the first spectroscopic studies of the new class of icy comets in the main asteroid belt.

JWST will enable studies of the chemical composition of cometary ice and dust with unprecedented sensitivity. Spectroscopy will measure abundances of  $H_2O$ ,  $CO_2$ ,  $CO$ , and  $CH_3OH$  in the comae of faint comets and also constrain the ratio of ortho and para  $H_2O$  to reveal formation temperatures. This set of observations is a critical ingredient in understanding planetary system formation and evolution, when combined with synergistic JWST observations of circumstellar disks. Additionally, the study of icy comets in the asteroid belt may reveal the source objects that were responsible for the delivery of water to the Earth.

### **JWST Observing Modes**

Four science instruments with multiple imaging, coronagraphic, and spectroscopic capabilities.

#### **NIRCam**

- 0.6 – 5 micron sensitivity
- 26 wide, medium, and narrow band filters
- Diffraction limited
- Coronagraphs

#### **NIRSpec**

- 1 – 5 micron sensitivity
- Multi-object (>100) dispersive spectrograph
- $R = 100, 1000, 2700$  spectral resolution
- Integral Field Spectroscopy

#### **MIRI**

- 5.0 – 28.5 micron sensitivity
- $R = 100$  slit spectrograph
- Integral Field Spectroscopy ( $R = 3000$ )
- 3 phase masks and Lyot Coronagraph

#### **FGS and NIRISS**

- 1 – 5 micron sensitivity
- Near-IR imaging
- $R = 150$  and  $R = 700$  grism spectroscopy
- Non Redundant Mask for high res. imaging



#### **4.) Planets and Moons**

JWST's capabilities will provide unmatched imaging and spectroscopic studies of Mars and all outer solar systems planets and moons. These data enable new science investigations.

##### **Mars**

###### **JWST will:**

- Use time-resolved near-infrared spectroscopy to study the variability of atmospheric species including CO<sub>2</sub>, CO, and H<sub>2</sub>O and constrain radiative and absorptive properties of airborne dust, enabling photochemical and dynamical modeling of the Martian climate.
- Use direct near-infrared detection to assess magnitude and scale of diurnal, seasonal, and interannual volatile transport, and discriminate surface and atmospheric ices and clouds.
- Characterize potential large methane outbursts.

##### **Jupiter and Saturn**

###### **JWST will:**

- Use mid-infrared medium resolution spectroscopy and IFU data to study the rich planet and atmosphere composition. Fully explore infrared diagnostics such as phosphine and methane fluorescence, which link to vertical dynamics and thermal structure of the upper atmosphere.
- Provide a global context on large-scale weather patterns for high-resolution studies from complementary planetary missions (e.g., Juno and Cassini).

##### **Uranus and Neptune**

###### **JWST will:**

- Image spectral features coming from high latitudes in each planet with high sensitivity and map clouds in both planets.
- Perform spectral characterization of H<sub>3</sub><sup>+</sup>, CO in fluorescence, detailed mapping of 5 micron window, search for minor species, and measure isotopic ratios of major elements.
- Use mid-infrared observations to measure temporal variations in temperature, resolve sources of underlying driving dynamics, and disentangle causes of rotation modulation.

##### **Icy Moons**

###### **JWST will:**

- Complement and extend planetary missions such as Cassini.
- Perform long-time baseline observations of both atmospheric and surface changes.
- For Titan, use near-IR spectrometry with a resolution >6 times Cassini's to determine types of organic species present on the surface. The higher spectral resolution over midlatitude regions will reveal whether surface changes or secular atmospheric changes are in evidence over a decadal timescale.

###### **For More Information:**

- 1.) Lunine, J. et al. (2010), JWST White Paper, "[JWST Planetary Observations within the Solar System](#)"
- 2.) Sonneborn, G. et al. (2009), "[JWST Study of Planetary Systems and Solar System Observations](#)"

JWST website: <http://www.stsci.edu/jwst>

What can JWST do for you? Visit the JWST Exposure Time Calculator at <http://jwstetc.stsci.edu/etc/>

