MESSENGER
Mission to Mercury
MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) mission is a scientific investigation of the planet Mercury.

Messenger is the 9th NASA Discovery Program Mission
**Mission Timeline**

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<td>Launch</td>
<td>August 3(^{rd}) 2004</td>
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<td>Earth Flyby</td>
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<td>Venus Flyby #1</td>
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MESSENGER’s science goals are to provide the first images of the entire planet and collect detailed information on the composition and structure of Mercury’s crust, its geologic history, the nature of its thin atmosphere and active magnetosphere, and the makeup of its core and polar materials.
The Long and Winding Road

It’s pretty easy to fly by a planet.

Point your spacecraft in the right direction to pass by the planet as it orbits the Sun, and get whatever information you can during the high speed pass.

The difficulty level gets turned up a notch when talking about "orbital insertion." You're not just flying by the planet; you're getting there and then slowing down to the point where the world that you want to explore pulls your spacecraft into orbit around it. Too slow and your probe will drop into the planet's atmosphere and burn up. Too fast and you'll fly off into space, stuck helpless in a solar orbit for billions of years.
NASA's MESSENGER will head into space with all the energy and speed it had when it left the Earth, and then have to slow down to meet up with Mercury. This means MESSENGER has to burn off a lot of energy during its journey.

The technique, which MESSENGER is going to undertake on its journey, is called "gravity assist." Most people think of speeding up a spacecraft when they hear about this concept, but it can actually work to slow one down as well.
This is due to "angular momentum," the tremendous amount of energy a planet orbiting the Sun has because of its enormous size and speed. When a spacecraft flies past that giant body, it can tap into the planet's gravity to increase its speed. When a spacecraft flies along in front of it, the opposite happens: the vehicle gives up some of its energy to the planet.

This gyroscope remains upright while spinning due to its angular momentum.
MESSENGER's dual-mode, liquid chemical propulsion system is integrated into the spacecraft’s structure to make economical use of mass. The structure is primarily composed of a graphite epoxy material.

Two large solar panels, supplemented with a nickel-hydrogen battery, provide MESSENGER’s power.
Spacecraft Design

The "brains" of the spacecraft are redundant integrated electronics modules (IEMs) that house two processors each – a 25-megahertz (MHz) main processor and a 10-MHz fault-protection processor.

A key MESSENGER design element deals with the intense heat at Mercury. The Sun is up to 11 times brighter than we see on Earth and surface temperatures can reach 450 degrees Celsius (about 840 degrees Fahrenheit), but MESSENGER will operate at room temperature behind a sunshade made of heat-resistant ceramic cloth.
The Payload

**Mercury Dual Imaging System (MDIS):** This instrument consists of wide-angle and narrow-angle imagers that will map landforms, track variations in surface spectra and gather topographic information.

**X-Ray Spectrometer (XRS):** Gamma rays and high-energy X-rays from the Sun, striking Mercury’s surface, can cause the surface elements to emit low-energy X-rays. XRS will detect these emitted X-rays to measure the abundances of various elements in the materials of Mercury's crust.

**Mercury Atmospheric and Surface Composition Spectrometer (MASCS):** This spectrometer is sensitive to light from the infrared to the ultraviolet and will measure the abundances of atmospheric gases, as well as detect minerals on the surface.

**Mercury Laser Altimeter (MLA):** This instrument contains a laser that will send light to the planet’s surface and a sensor that will gather the light after it has been reflected from the surface. Together they will measure the amount of time for light to make a round-trip to the surface and back. Recording variations in this distance will produce highly accurate descriptions of Mercury’s topography.
Gamma-Ray and Neutron Spectrometer (GRNS): This instrument will detect gamma rays and neutrons that are emitted by radioactive elements on Mercury's surface or by surface elements that have been stimulated by cosmic rays. It will be used to map the relative abundances of different elements and will help to determine if there is ice at Mercury’s poles, which are never exposed to direct sunlight.

Energetic Particle and Plasma Spectrometer (EPPS): EPPS measures the composition, distribution, and energy of charged particles (electrons and various ions) in Mercury’s magnetosphere.

Magnetometer (MAG): This instrument is at the end of a 3.6 meter (nearly 12-foot) boom, and will map Mercury’s magnetic field and will search for regions of magnetized rocks in the crust.

Radio Science (RS): RS will use the Doppler effect to measure very slight changes in the spacecraft's velocity as it orbits Mercury. This will allow scientists to study Mercury’s mass distribution, including variations in the thickness of its crust.
Mercury, Venus, Earth, and Mars are terrestrial (rocky) planets. Among these, Mercury is an extreme: the smallest, the densest, the one with the oldest surface, the one with the largest daily variations in surface temperature, and the least explored. Understanding this "end member" among the terrestrial planets is crucial to developing a better understanding of how the planets in our solar system formed and evolved.
To develop this understanding, the MESSENGER mission, spacecraft, and science instruments are focused on answering six key outstanding questions that will allow us to understand Mercury as a planet.
Question 1: Why is Mercury so dense?

Each of the terrestrial planets consists of a dense iron-rich core surrounded by a rocky mantle, composed largely of magnesium and iron silicates. The topmost layer of rock, the crust, formed from minerals with lower melting points than those in the underlying mantle.

The density of each planet provides information about the relative sizes of the iron-rich core and the rocky mantle and crust, since the metallic core is much denser than the rocky components.
Mercury's density implies that at least 60% of the planet is a metal-rich core, a figure twice as great as for Earth, Venus, or Mars! To account for about 60% of the planet's mass, the radius of Mercury's core must be approximately 75% of the radius of the entire planet!

There are three major theories to explain why Mercury is so much denser and more metal-rich than Earth, Venus, and Mars. Each theory predicts a different composition for the rocks on Mercury's surface. MESSENGER will determine which of these ideas is correct by measuring the composition of the rocky surface.
Question 2: What is the geologic history of Mercury?

It is more than 30 years after Mariner 10 visited Mercury and still only 45% of Mercury's surface has been imaged by a spacecraft. The part that has been seen appears cratered and ancient, with a resemblance to the surface of Earth's Moon.
Mercury's tectonic history is unlike that of any other terrestrial planet. On the surface of Mercury, the most prominent features due to tectonic forces are long, rounded, scarps and cliffs, some over a kilometer in height and hundreds of kilometers in length. These giant scarps are believed to have formed as Mercury cooled and the entire planet contracted on a global scale.

Understanding the formation of these scarps thus provides the potential to gain unique insight into the thermal history and interior structure of Mercury.
Mercury's magnetic field and the resulting magnetosphere, caused by the interaction of Mercury's magnetic field with the solar wind, are unique in many ways. Perhaps one of the most noteworthy observations about Mercury's magnetic field is the simple observation that the small planet has one.
Earth's magnetic field is very dynamic and constantly changing in response to activity of the Sun, including the solar wind and solar flares. Mercury's magnetic field was shown by Mariner 10 to experience similar dynamics; understanding those variations will help us to understand the interaction of the Sun with planetary magnetospheres in general, including that of Earth.
Question 4: What is the structure of Mercury’s core?

Mercury is known to have a very large iron-rich core and a global magnetic field; this information was gathered by the Mariner 10 flybys. More recently, Earth-based radar observations of Mercury have also determined that at least a portion of the large metal core is still liquid to this day!
Fundamental questions about Mercury's core remain to be explored, such as what is the composition of the core?

A core of pure iron would be completely solid today, due to the high melting point of iron. However, if other elements, such as sulfur, are also present in Mercury's core, even at only a level of a few percent, the melting point is lowered considerably, allowing Mercury's core to remain at least partially molten.
Mercury's axis of rotation is oriented nearly perpendicular to the planet's orbit, so that in the polar regions sunlight strikes the surface at a near constant grazing angle. Some of the interiors of large craters at the poles are thus permanently shadowed and remain perpetually very cold.
Earth-based radar images of the polar regions show that the floors of large craters are highly reflective at radar wavelengths, unlike the surrounding terrain. Furthermore, the radar-bright regions are consistent with radar observations of the polar cap of Mars or the icy moons of Jupiter, suggesting that the material concentrated in the shadowed craters is water ice! MESSENGER's neutron spectrometer will search for hydrogen in any polar deposits, the detection of which would suggest the polar deposits are water-rich.
Question 6: What volatiles are important at Mercury?

Mercury is surrounded by an extremely thin envelope of gas. It is so thin that, unlike the atmospheres of Venus, Earth, and Mars, the molecules surrounding Mercury don't collide with each other and instead bounce from place to place on the surface like many rubber balls. This is called an "exosphere."
This figure was generated from Earth-based measurements and shows the uneven distribution of sodium in Mercury's exosphere at the time of the observations. The outline of the surface of Mercury is shown as a white circle in the images.

MESSENGER will determine the composition of Mercury's exosphere using its ultraviolet spectrometer and energetic particle spectrometer.
Is Mercury Shrinking?

Mercury could be shrinking as its core slowly freezes. Pictures from Mariner 10 revealed the planet's surface appears to have buckled from within, resulting in gigantic cliffs more than a mile high and hundreds of miles long biting into Mercury. MESSENGER will look for any evidence of such crumpling on the world's hidden side.
Land of Confusion

When the Messenger spacecraft reaches Mercury in 2011, it will be the planet's first Earthly visitor in more than 36 years. The Mariner 10 spacecraft was Mercury's original and only guest back in 1974 and 1975. However, we haven't visited since and still don't know very much about the planet.
Mission update: First Mercury flyby on January 14th, 2008

The MESSENGER spacecraft passed 200 kilometers (124 miles) above the surface of Mercury relaying more than 1,200 new images and other data back to Earth. Extensive scientific observations were executed during this flyby encounter, including imaging a large portion of Mercury's surface that had never before been seen by a spacecraft.
This plot shows Lyman-alpha emission at 121.6 nm associated with neutral hydrogen in the near vicinity of Mercury. This is the first detection of hydrogen tail emission at Mercury and the first time that neutral hydrogen and sodium atoms have been observed in the tail simultaneously.
This plot shows the intensity of emission of light associated with sodium atoms in the vicinity of Mercury. The observations were made with the Ultraviolet and Visible Spectrometer (UVVS) section of the Mercury Atmospheric and Surface Composition Spectrometer (MASCS). The sodium emission is at 589 nm (in the visible part of the spectrum and the same wavelength, or color, as in sodium lamps and street lights on Earth).
MESSENGER saw an internal magnetic field that is well described by the field from a dipole nearly aligned with the planet's spin axis (dipole tilt ~ 10°).
At top center is the first laser altimeter profile of Mercury’s topography, taken by MESSENGER’s Mercury Laser Altimeter (MLA) instrument during the spacecraft’s flyby of Mercury on January 14, 2008. At bottom center is the MLA ground projected onto a mosaic of radar images obtained at the Arecibo Observatory in Puerto Rico.
Mercury Flyby #2  October 6th 2008

For More Information:

http://messenger.jhuapl.edu/