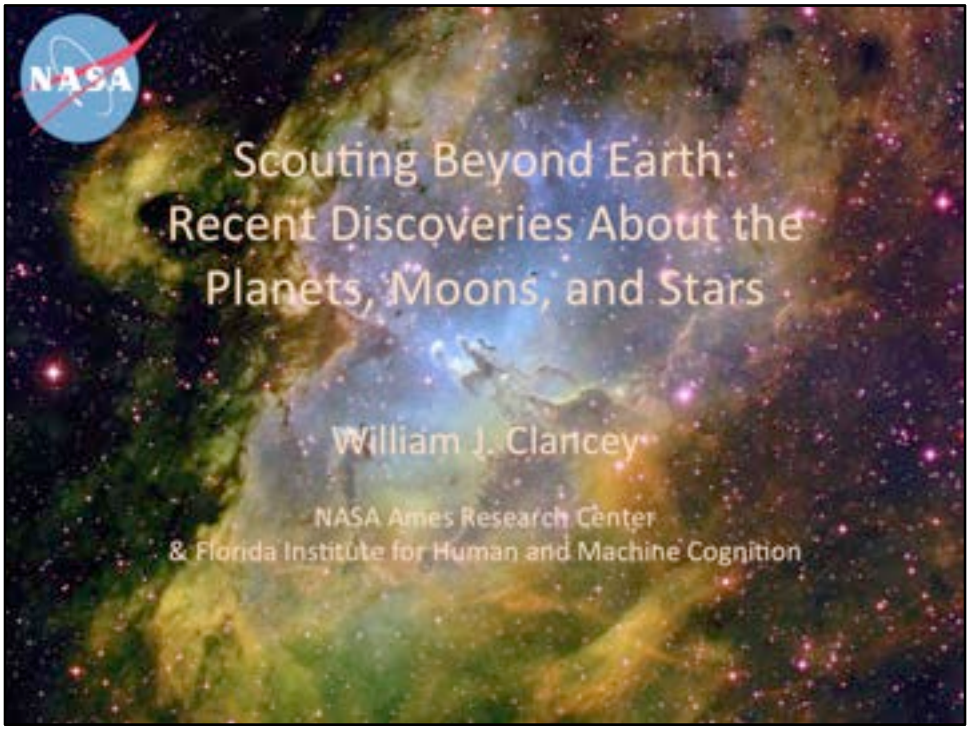
This banquet on May 24, 2012 honored the 2011-2012 Eagle Scouts, Sea Scout Quartermasters and Venture Crew Silver Award recipients in the Mt. Diablo Silverado Council. The event was hosted by Las Aguilas de Diablo, whose members received the Eagle Award and are local Scouting business, professional, and civic leaders.

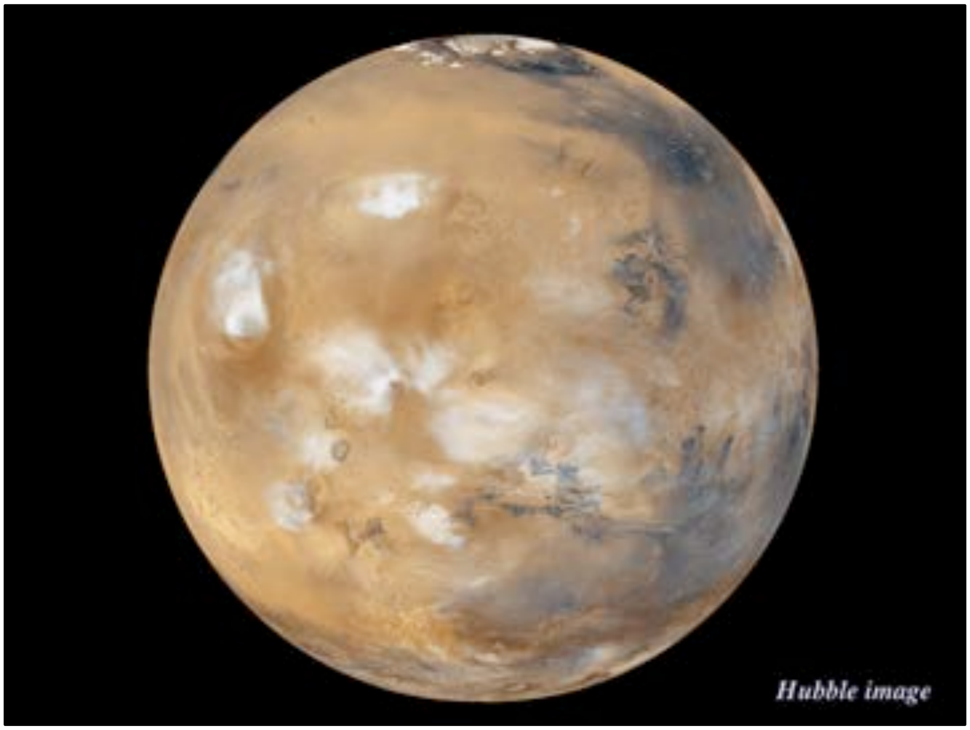


Good evening. My presentation tonight is about current NASA space science missions and what they are revealing about our solar system and our place in the Universe.

First on this occasion tonight, I thought you might enjoy knowing about my own Eagle Award dinner. Here is the story from the local paper in 1968, I'm on the right, with Mr. Rupp our scoutmaster. In the upper left, I've selected two merit badges – rowing because it taught me skills I still enjoy today and personal fitness because it was one I had to work at for a long time to master.

In the lower corner you see the program for the evening, with my short bio inside. (Yes, they misspellled my name.) The month-long trip to Philmont when I was 14 was my first trip west of Philadelphia; and inspired where I have lived and many of my travels since then.

I of course had no idea that my Boy Scout experience would serve me well working for NASA thirty years later! Here I am at Haughton Crater on Devon Island in the Canadian North Arctic in July 1999. As a computer scientist, I was working with geologists and other scientists and NASA engineers to understand how we might explore Mars.



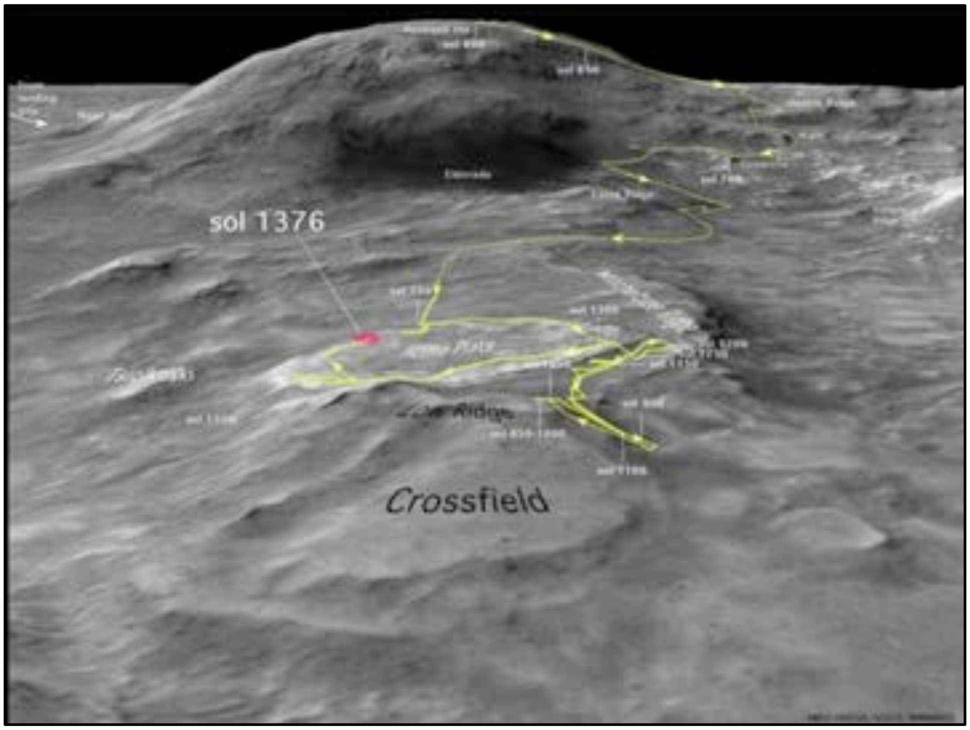
Here's a Hubble picture of Mars. We call Haughton Crater on Devon Island a Mars analog site because its glacial landforms and almost lifeless desert landscape resemble places on Mars.

By studying how scientists explore Haughton Crater, we can learn what tools they will need on Mars to record data, navigate, and schedule their time and supplies. A few years later my team at NASA Ames developed a voice commanding system that would serve as a kind of astronaut's assistant on Mars. We were using some of the same technology that later became Apple's SIRI, but we went far beyond that in using computer agents to integrate GPS devices, biosensors, cameras, robots, email, and so on.

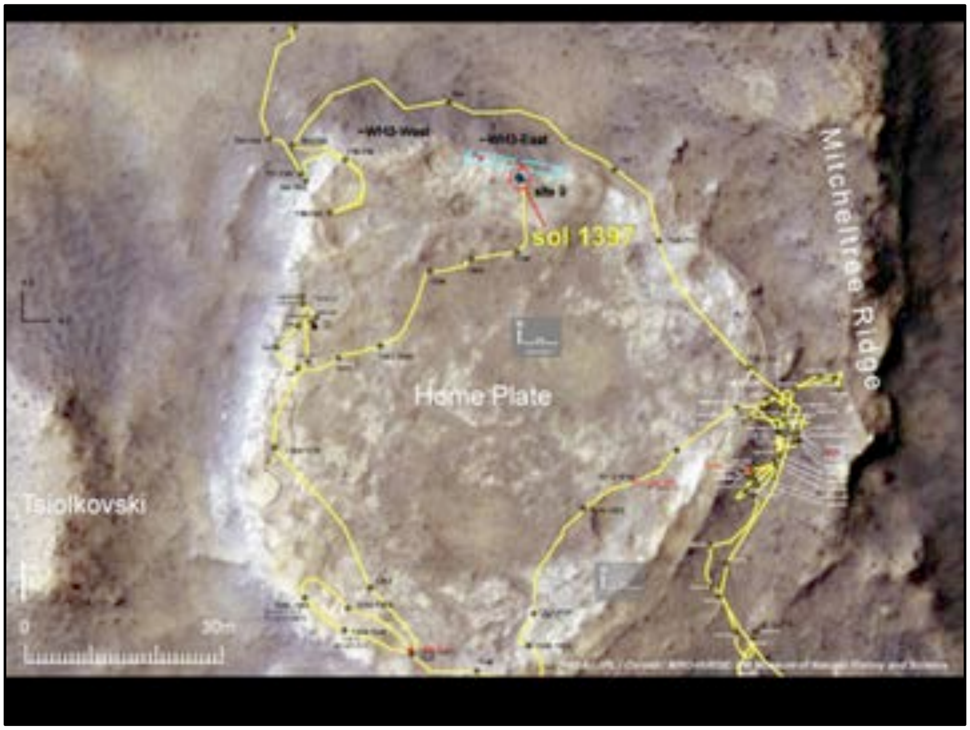
Those studies on Devon Island, and similar work with geologists in the Utah desert, New Mexico, Idaho, and Hawaii, taught me a lot about how field science is done on Earth. This led to my study of the scientists who have been doing field science on Mars using the Mars Exploration Rovers since 2004. I was interested in how they built on their experience on Earth, but had to adapt to working indoors in teams, using photographs and computer programs to plan and control the operations of the robotic laboratory on Mars.

My study of the Mars scientists will be published in August by MIT Press. I thought I'd spend a few minutes sharing some facts about the Mars Exploration Rovers, as we segue a bit more into my theme of "scouting beyond Earth."

In 2004 two MERs – Spirit and Opportunity – arrived on Mars. The MER is a mobile robotic laboratory, which we program from Earth to take photographs, scrape rocks, and analyze chemical composition. Of course the MERs can also move, and through virtual reality tools we have experienced the first overland expedition on another planet.

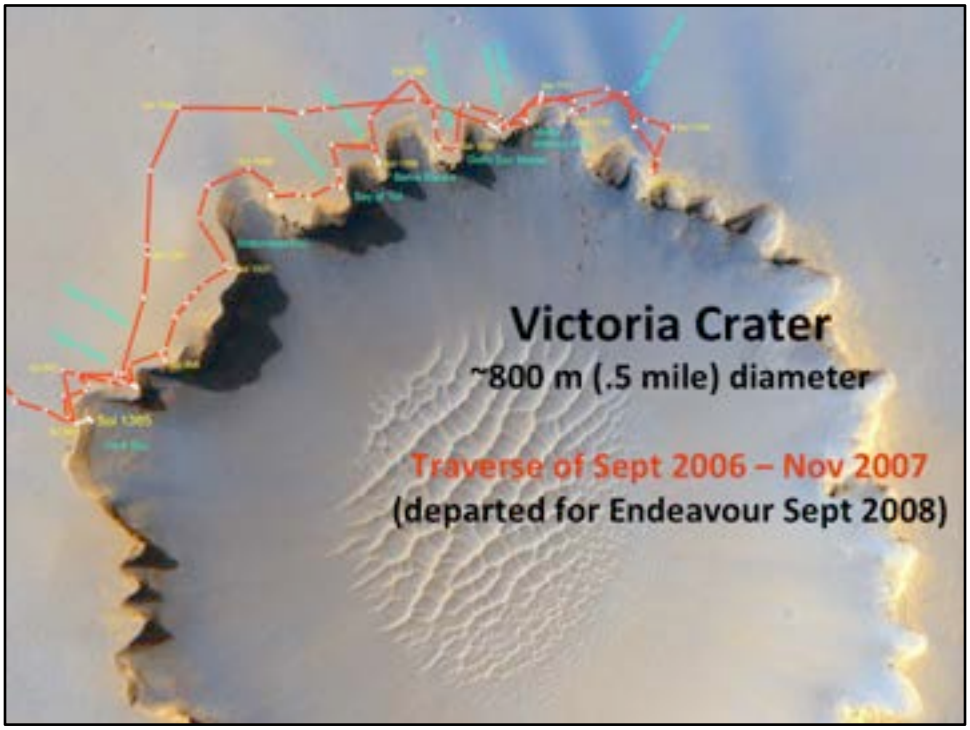


Here’s a map based on a photograph taken from Mars orbit. It shows how Spirit traveled from its landing site in Gusev crater about 100 meters up and over the Columbia Hills and down onto a kind of plateau called Home Plate.



Home Plate is about 100 meters across, and might be a remnant of large hot springs like those we find in Yellowstone Park. We spent about five years exploring the Columbia Hills and Home Plate with Spirit, way beyond the planned 90 martian days. This was possible because dust devils cleaned the solar panels, so the batteries could be recharged and the rover could survive the winters.

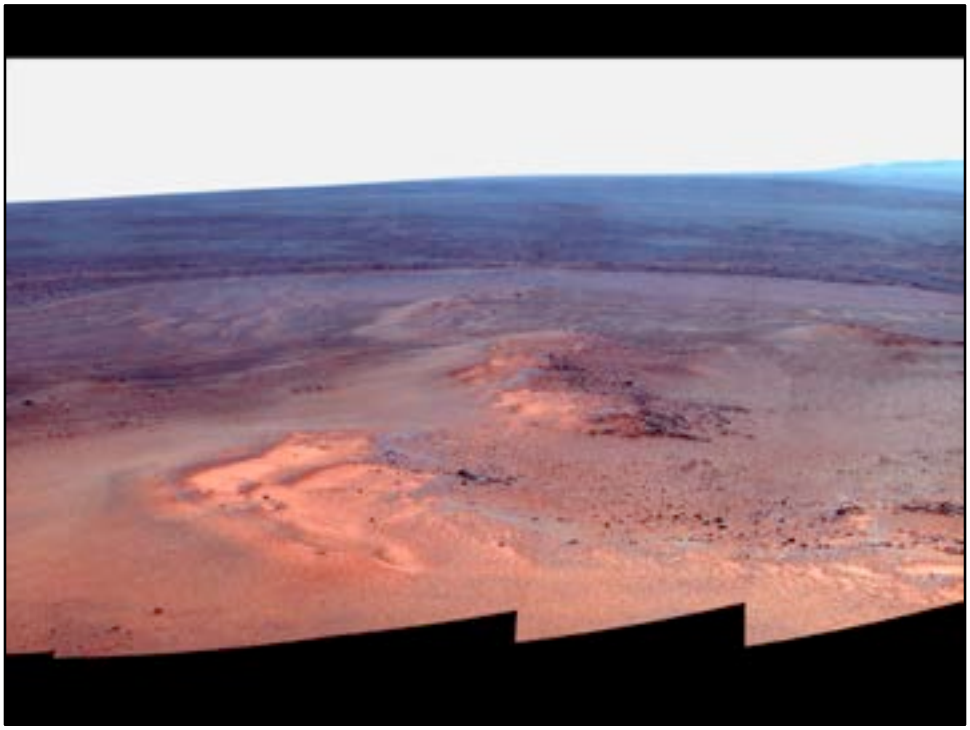
This is one of my favorite photos. It shows how we can use the rover to scuff the sand and get an up-close view, so it feels like we're looking at our own boot prints on Mars.



Spirit eventually became stuck in the sand a few years ago and we've lost contact with it.

But Opportunity's route has been even more spectacular. It has traveled over 34 km or 21 miles in the past eight years and we're still using it to explore Mars.

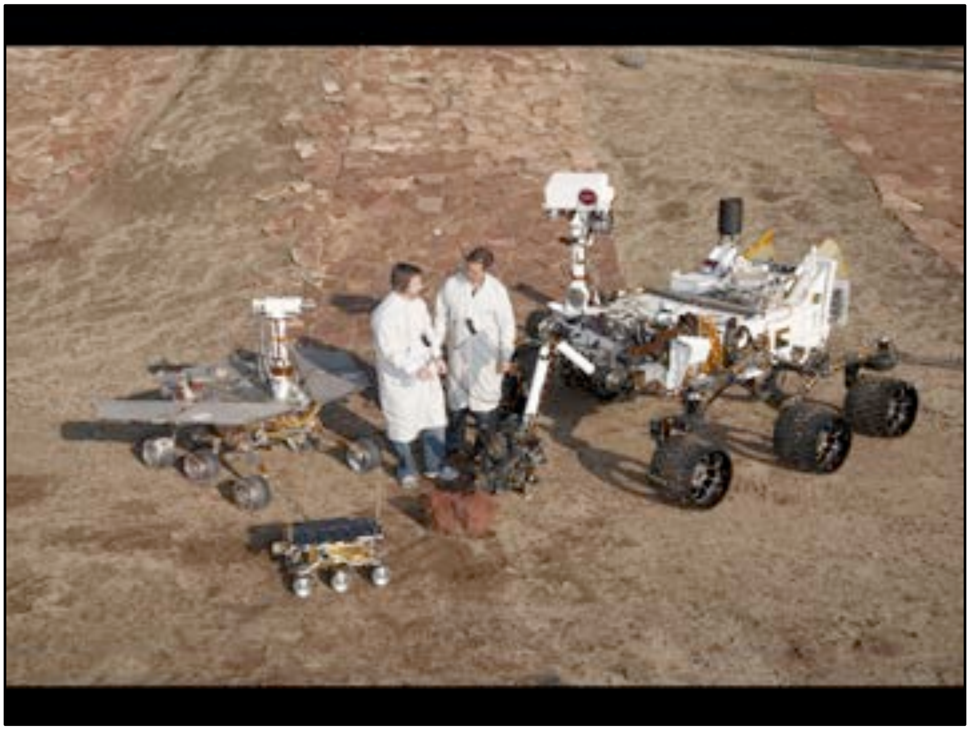
(advance) Here you see how we traveled around Victoria Crater.
After two years, (advance) we proceeded to Endeavour crater (advance), where we arrived last summer, three years since we left Victoria!



Here is Opportunity's view this past January (2012) from the edge of Endeavour whose distant rim you can see in the far right. It's about 22 km or 14 miles across. The crater's actually the darker depression.

This image of the nearby rim is presented in exaggerated color to make some differences between materials easier to see.

Near the rim of Endeavour, we've found something different than the minerals we've studied the past eight years. Notice the bright vein on the right side of the image. The vein is about as wide as a thumb and about 18 inches long. (advance) Using Opportunity's instruments, we examined it last November (2011) and found it to be rich in calcium and sulfur, possibly the mineral gypsum. (advance) So yes Mars is another planet, but its chemistry and geological processes are familiar. The basic science is the same, but we're learning about a different place with a very different history than Earth's.



Moving now to other NASA missions, here you see MER on the left and the Mars Science Laboratory, nicknamed Curiosity, which is on its way to Mars. Curiosity is about 5 x heavier than MER, and is powered by a radioisotope generator that converts heat to electricity, so it can operate for several years and even at night. It carries much more sophisticated instruments for sampling and atomic analysis.   In the bottom left you see tiny Sojourner the first martian rover, which operated 1997 as part of the Mars Pathfinder mission in which methods and tools for reprogramming the rovers on a daily basis were first tested.

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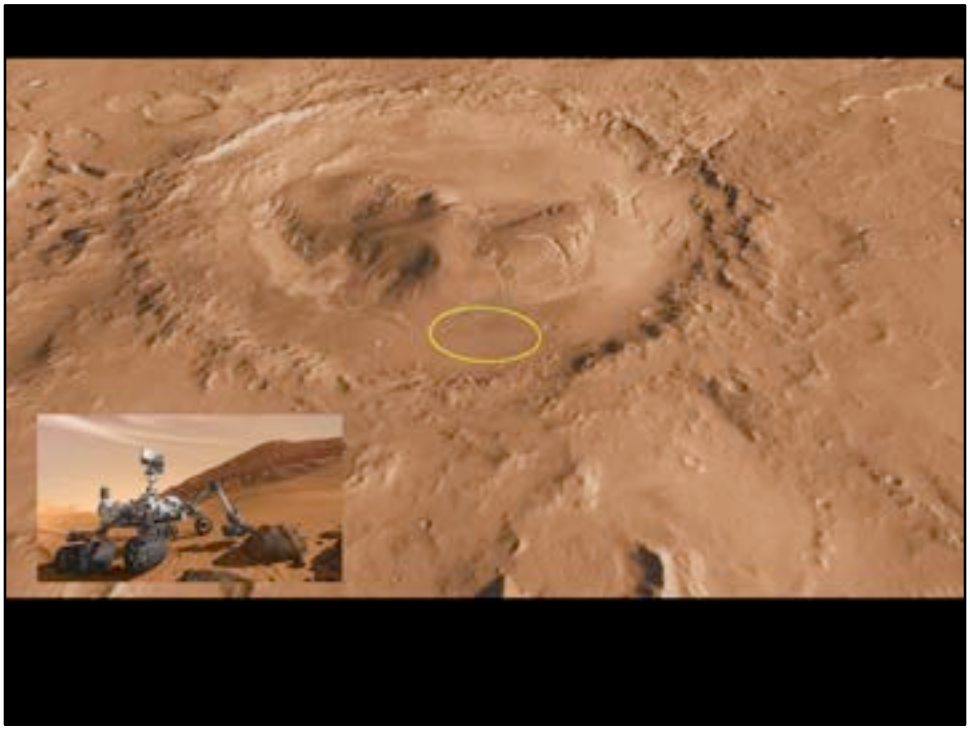
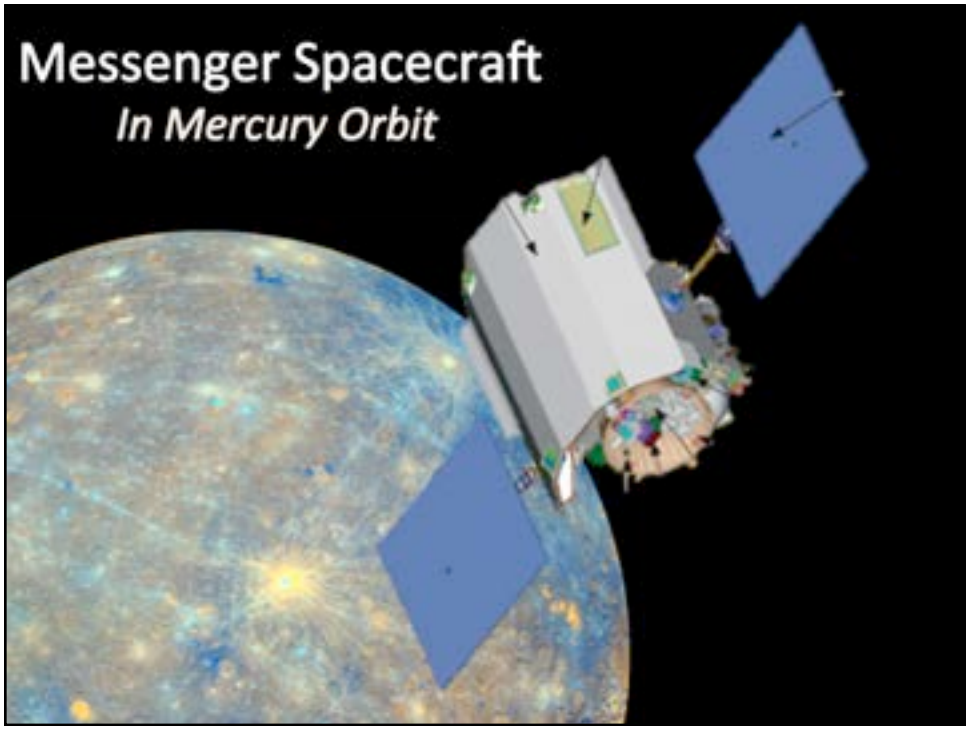
Sojourner and its flight spare, named Marie Curie, are 2 feet (65 centimeters) long. The Mars Exploration Rover Project's rover, including the "Surface System Test Bed" rover in this photo, are 5.2 feet (1.6 meters) long. The Mars Science Laboratory Project's Curiosity rover and "Vehicle System Test Bed" rover, on the right, are 10 feet (3 meters) long.

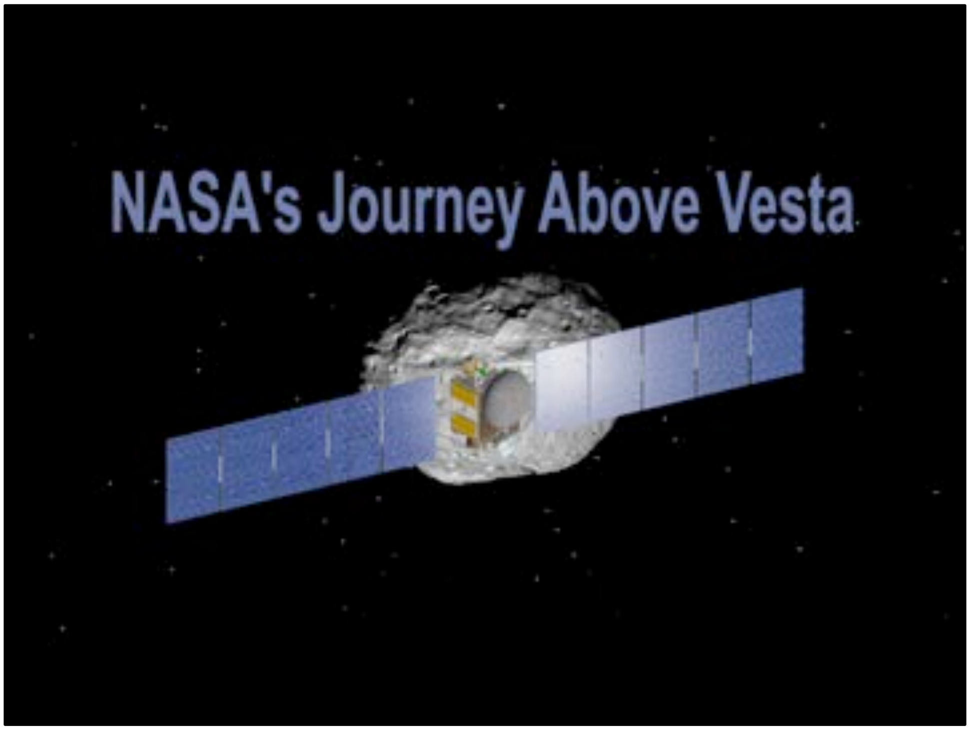


Curiosity is on its way to land in Gale Crater in early August. If we are successful we will climb and explore its central mound over several years. It's actually a mountain, towering 5 kilometers over the landing site on the floor of the crater and has been built up for perhaps 2 billion years.

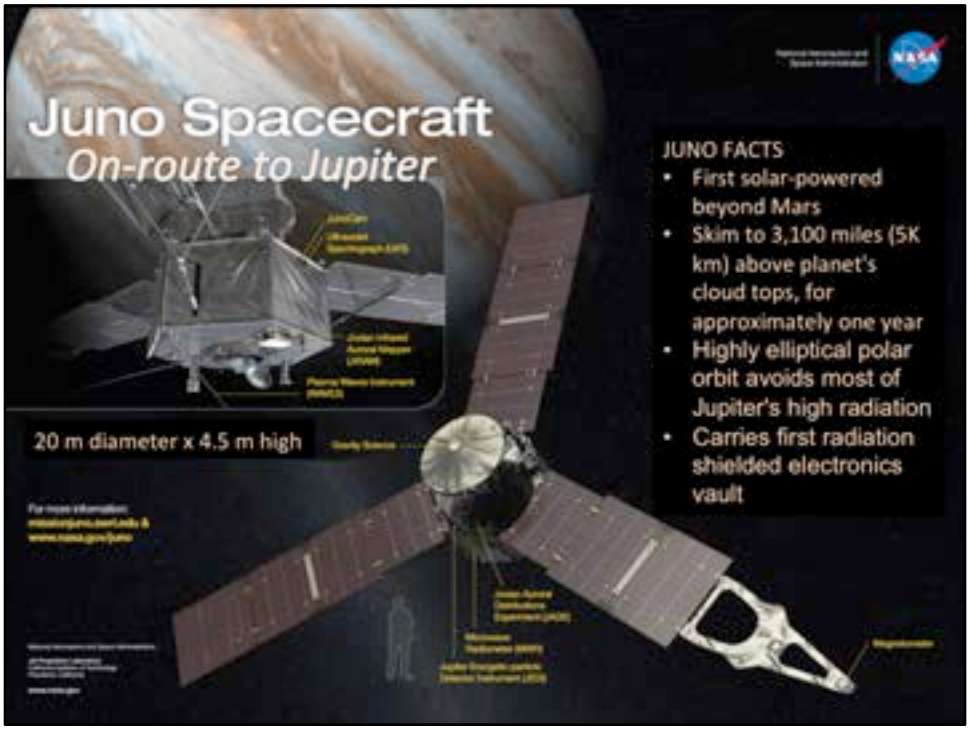


So I need to move along on our tour of missions….

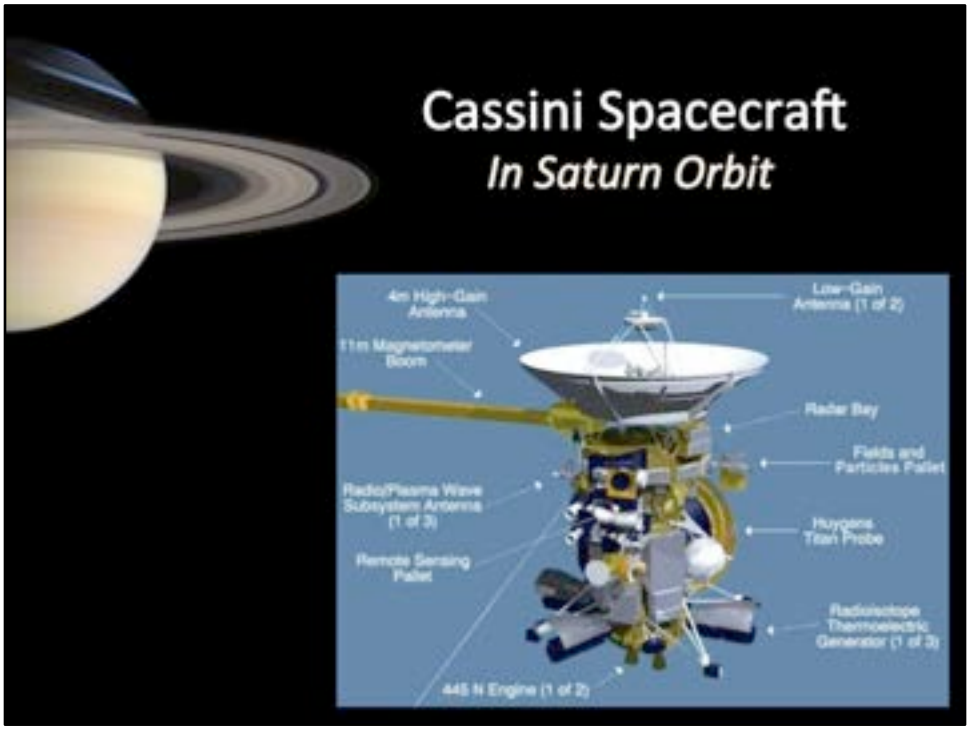
First I will mention briefly that since March of last year we have the first satellite in orbit around the planet Mercury, the closest to the sun. It is providing our first close-up study of the geology, topography, gravity, magnetism, and so on of this tiny planet. One point of interest you can see here is the ceramic cloth sunshade that Messenger requires to stay cool because it is operating so close to the sun, about 11 times brighter than we see on Earth.



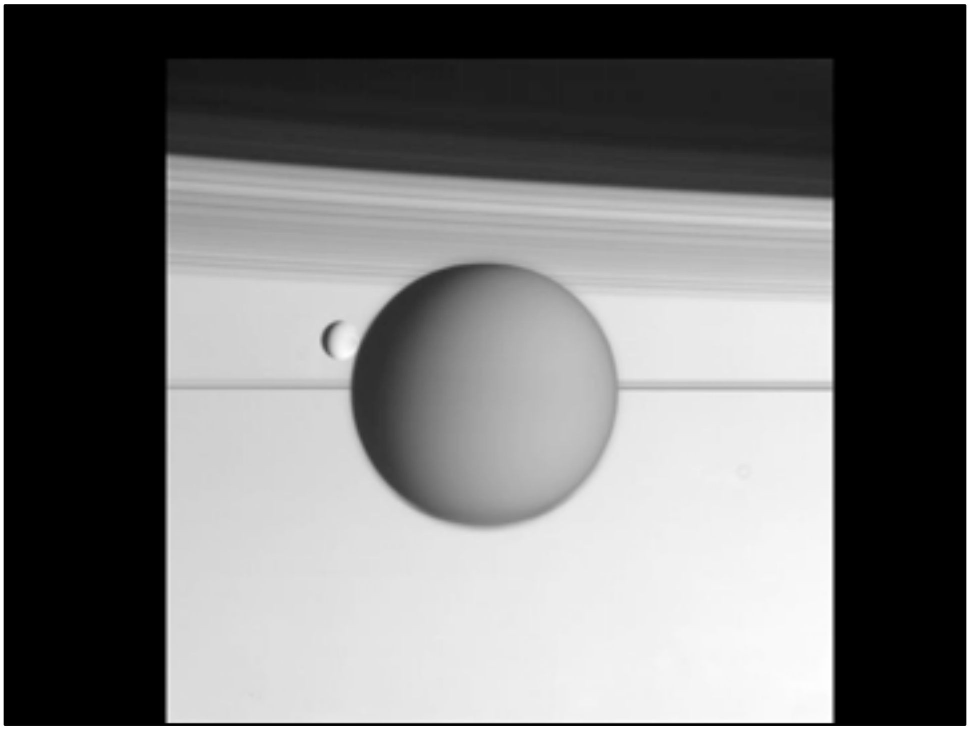
Right now we also have a satellite called Dawn orbiting the second largest asteroid, Vesta (over 500 km or 300 miles in diameter).
The Dawn spacecraft is of particular interest because it uses ion propulsion, a science fiction idea that has come to life.
Dawn will leave Vesta in August and fly next to Ceres the largest asteroid, which roughly twice the size of Vesta and classified as a dwarf planet. Like Vesta, Ceres is orbiting the sun between Mars and Jupiter.
Here's a video montage of the images taken from orbit since we arrived last July.



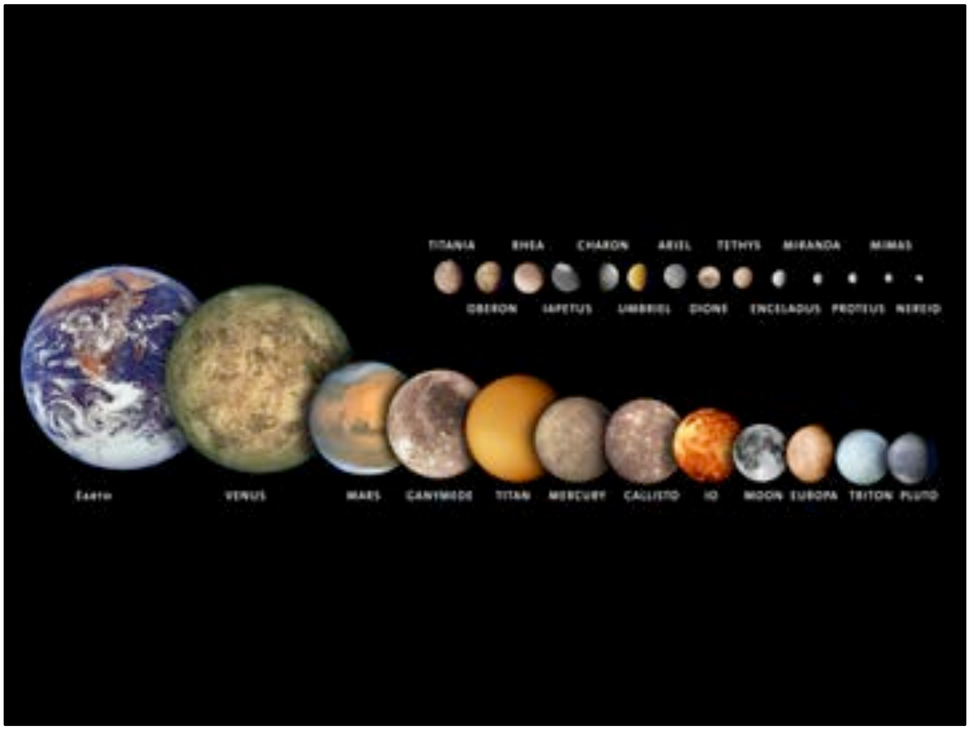
Another spacecraft called Juno is on its way to Jupiter.   It's the first solar powered spacecraft to operate so far from the sun, so It's quite large, about 60 feet across. With a polar orbit and radiation shielding to protect the electronics, Juno will fly within about 5000 km of the surface clouds in a one year mission.



One of the most incredible space missions of the past decade has been Cassini, a robotic laboratory in orbit around Saturn. It was launched in 1997. For eight years a dozen teams operating different instruments have been studying Saturn, its rings, the moon Titan, and the icy moons.



The photographs are spectacular. Saturn has 60 moons. Here is Titan, the second largest moon in the solar system. Titan has a thick atmosphere made up of hydrocarbons, mostly methane. This image shows Titan and the smaller moon Enceladus (en-sell-a diss) backed up by Saturn's rings.

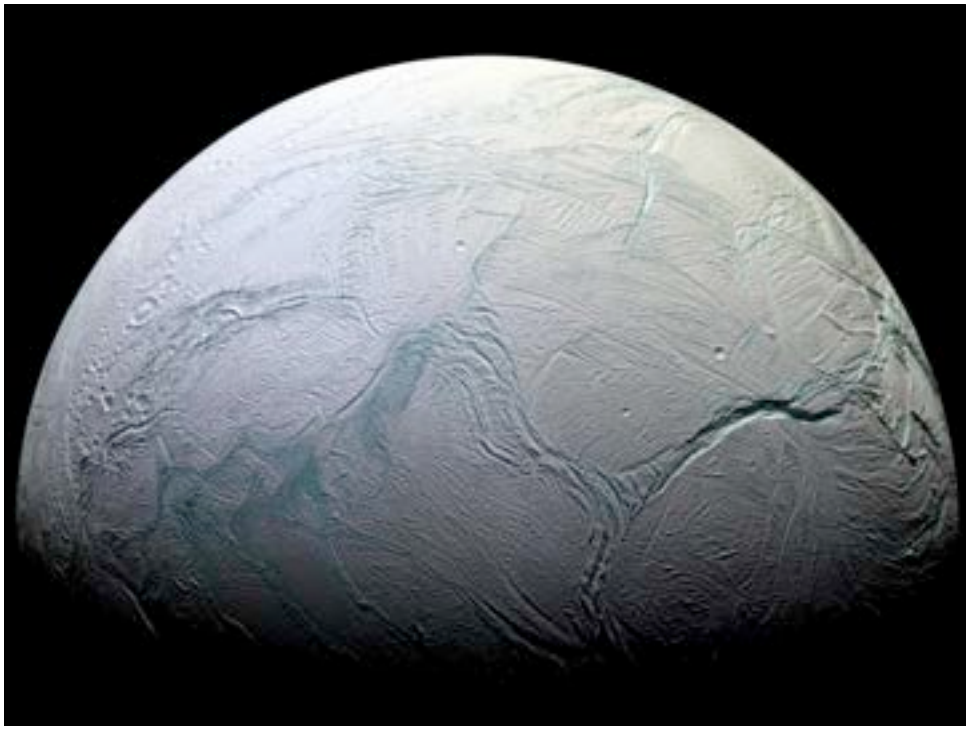


Here's a display of the largest moons in our solar system and how they compare to Earth, Venus, and Mars. The largest moon is Ganymede around Jupiter. You see that Titan is 50% larger than Earth's moon.

You may be amazed to see Titan is much larger than the planet Mercury. You might also be surprised to see that Earth's moon is larger than Pluto! So all those folks bemoaning the loss of Pluto the planet were mere poets. Pluto is part of thousands of objects in the Kuiper Belt beyond Neptune. Pluto is now classified as the second largest dwarf planet; it is smaller than Eris (which you probably never heard of). The Kuiper Belt is like the asteroid belt, but much larger and more massive. It was only discovered 20 years ago (1992). So you see that sorting and naming the objects in our solar system is still evolving. We have a lot to learn about how all of this formed.

Many people believe Titan is the most exciting landscape we are studying beyond Mars. One reason is that Titan is the only body besides the Earth to have stable liquid seas on its surface – but on Titan those seas are liquid methane. Titan is so cold it actually rains methane. Titan could be someday be a refueling station for spacecraft. (advance) Here's a map of some islands in a methane sea on Titan.

From http://www.evs-islands.com/2008/02/titans-islands-extraterrestrial-islands.html



Enceladus is another amazing moon of Saturn that we are studying with Cassini. It is about 500 km or 300 miles in diameter; a bit smaller than Vesta. Enceladus is the brightest object in our solar system, covered with snowy water ice.

Besides that beautiful surface, Enceladus has spectacular icy geysers at its south pole. These are a mixture of water vapor and organic materials such as methane, carbon dioxide, and propane, coming perhaps from a pocket of salt water within the moon. This water mixture is heated by the tidal forces exerted on Enceladus as it orbits the giant planet Saturn. It is possible that life could have formed in these conditions.

We are studying Saturn, too, of course. Here shown in true color is a great storm that occurred last year (2011).

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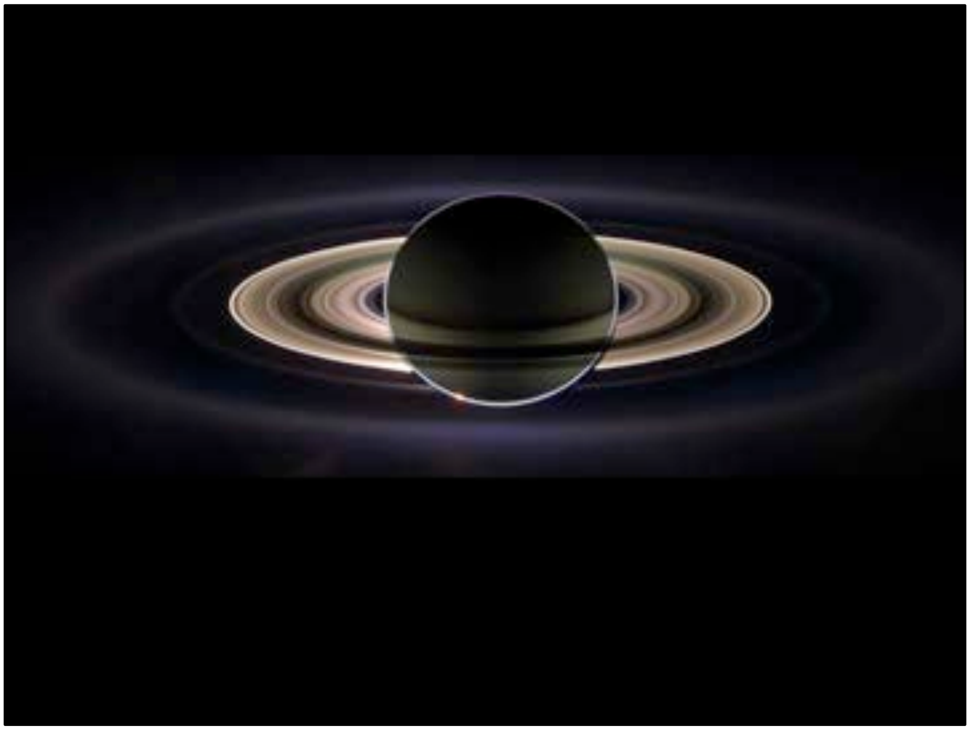
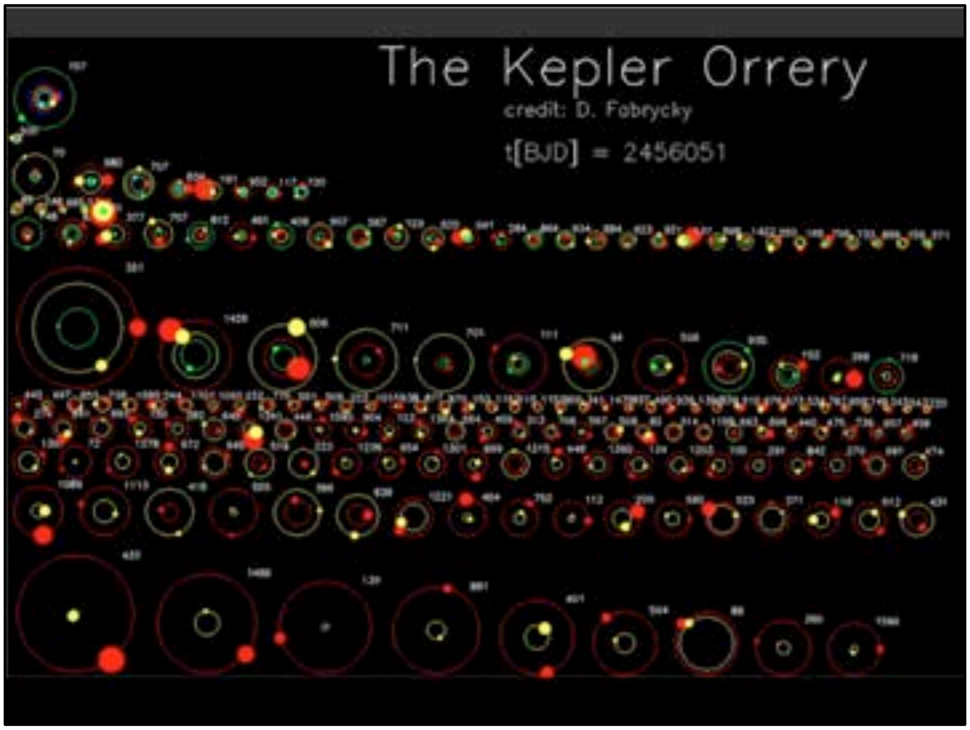
Astronomy Picture of the Day for January 19, 2011.



This panorama of Saturn and its rings was the winner in 2007 for the “favorite Cassini image.” It is a combination of 165 images taken when the spacecraft was in Saturn’s shadow.

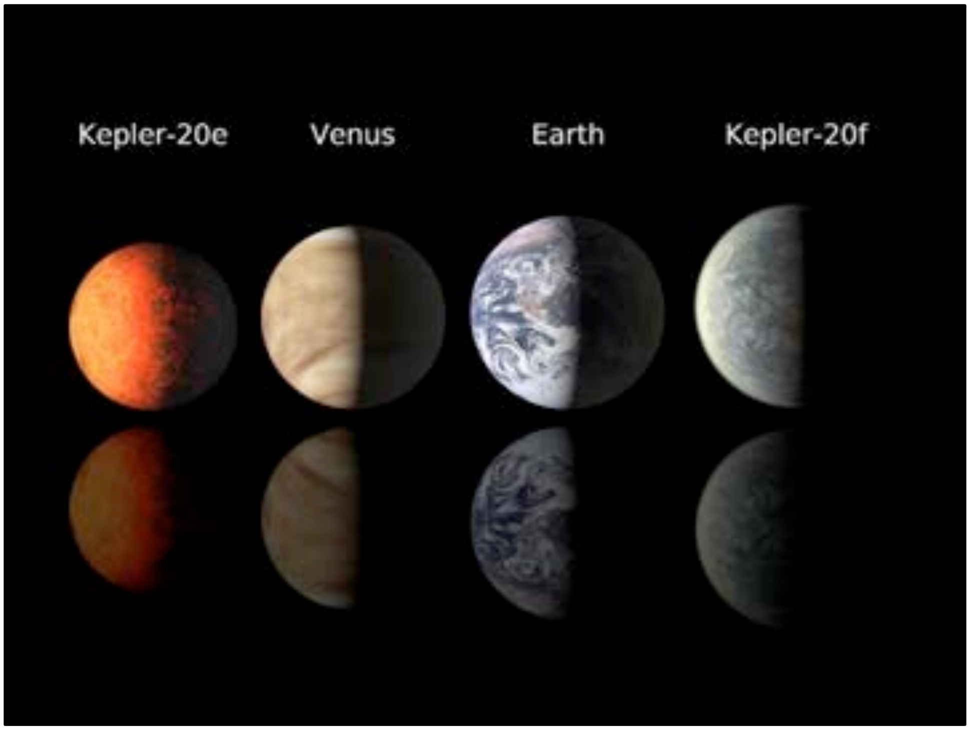
Finally in our tour of NASA's planetary missions, the New Horizons spacecraft will arrive at Pluto and its moon Charon (karen), in 2015 after a nine year flight. You can see these missions take many years to plan and carry out and might dominate a scientist's entire career. So the only way to carry out space exploration is by stable, long-term funding.



Looking beyond our solar system now, we are using the Kepler space observatory, a kind of telescopic camera, to search for planets around other stars.
As of last year (Dec 2011) there are over 2,300 candidates.
Over 200 are similar in size to Earth, but the majority of those we have found are the size of Neptune or larger because it's easier to spot large planets around small stars.

We detect planets as they cross a star and affect its light. Here you see a simulation of how Venus will appear transiting the Sun on June 5. We will be able to see it here in CA at sunset.

It is relatively easy to detect giant planets orbiting smaller stars--- because they block more of the star's light. For larger stars like our Sun and smaller planets like Venus and Earth, the effect of the planet's crossing is of course less and more difficult to detect. So we have to compare more photographs over several years. Seeing this animation you can see what an incredible accomplishment it is to detect an earth-like planet from light years away!



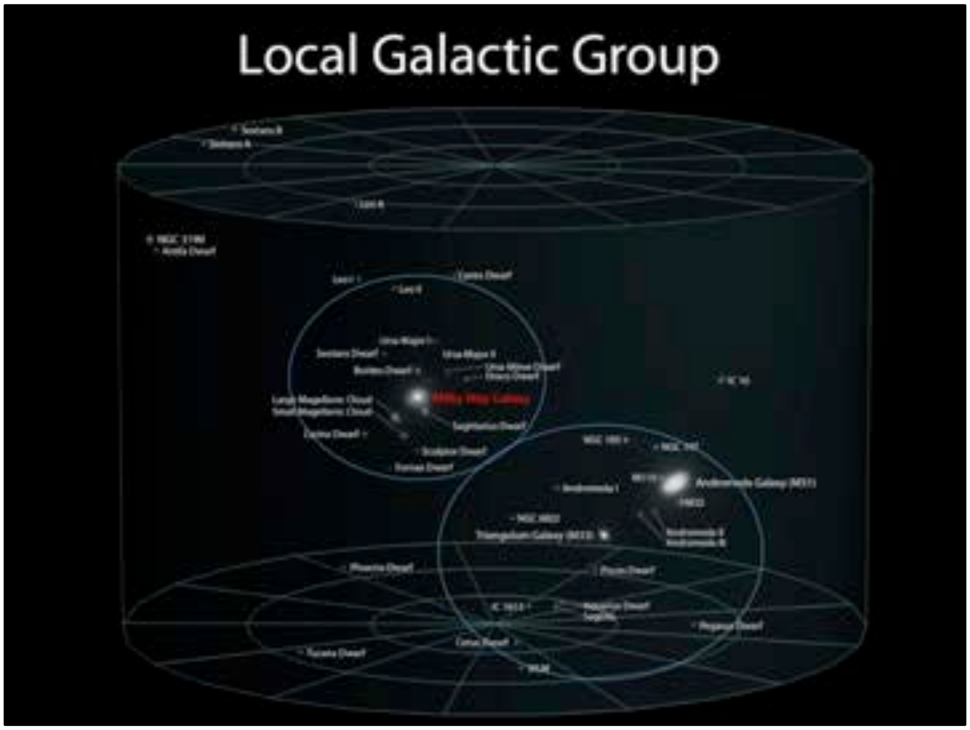
Last December (2011), the Kepler team announced the discovery of the first Earth-size planets found around a sun-like star; but they are too close to their stars to have life.

Based on data we have so far, scientists estimate that more that half of the stars like our Sun have at least one planet.
Stars come in a wide range of sizes and temperatures. Our sun is especially beneficial to life because it is not a variable star, it's light is stable.
Given that there are about 100 billion stars in the Milky Way Galaxy, then there may be on the order of 2 to 8 billion Earth-size planets around stars like our Sun.

Astronomer Seth Shostak estimated in 2011 that "within a thousand light-years of Earth," there are "at least 30,000" planets in habitable zones where life might exist. So far we've found 48.

All of this is statistical because Kepler's telescopic camera is examining only a tiny part of our galaxy. It's the largest camera we've sent into space, with 42 imaging elements (shown by the 21 squares in this graphic) and a total resolution of 95 megapixels. In the sector of space Kepler is examining there are about 150,000 stars of interest. Because we only detect planets when they cross in front of a star, we are only detecting planets that cross on our line of sight. We have to extrapolate to estimate how many more planets we might be missing because their orbits are lined up differently.

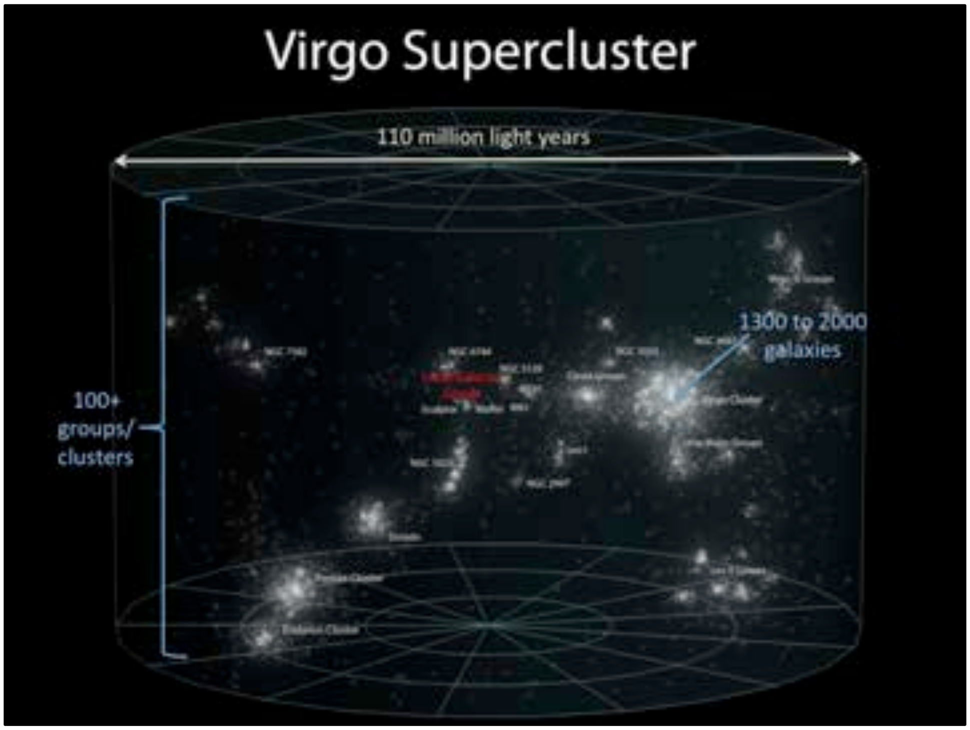
The Kepler spacecraft is in orbit around the sun, trailing the Earth, so it won't be influenced by light from Earth. This graphic shows Kepler's field of view as a kind of search beacon pointing at a particular region of our galaxy, the Milky Way. We are interested in stars in this region because they are about the same distance from the galactic center as the Earth, and that may be important for the development of life. So you see, ultimately we're not just searching for planets, we're searching for planets that might have life or even beings with their own telescopes pointing at us.



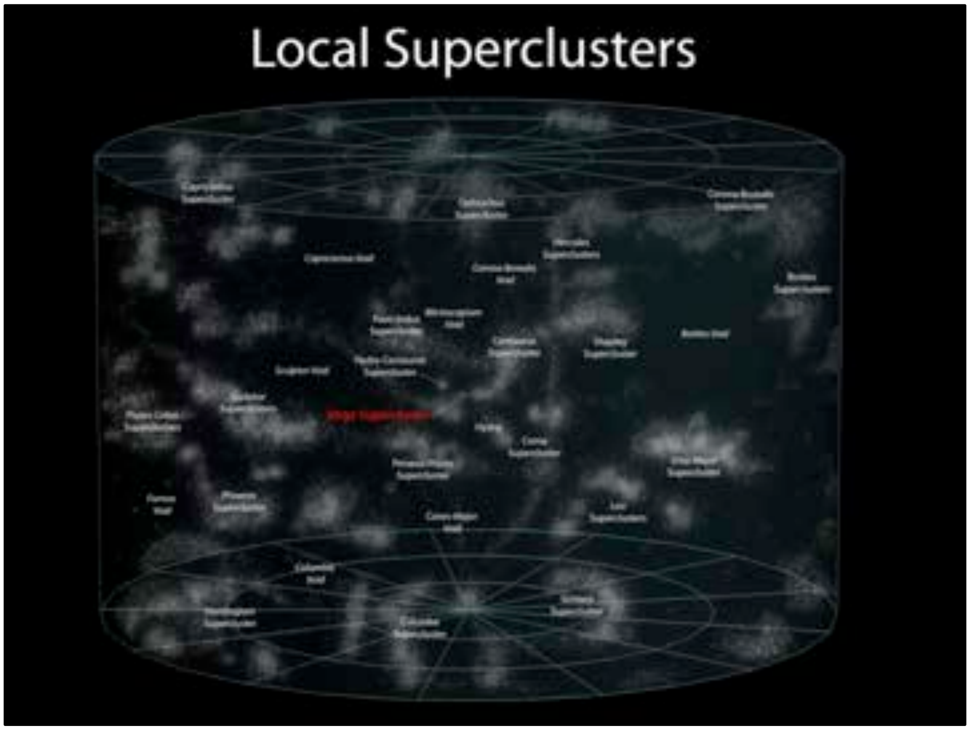
I would like to conclude my presentation by putting our scouting of the solar system and nearby stars in perspective.

Our galaxy, the Milky Way, has about 100 billion stars. The Milky Way is part of a collection of more than 54 galaxies called the Local Galactic Group.

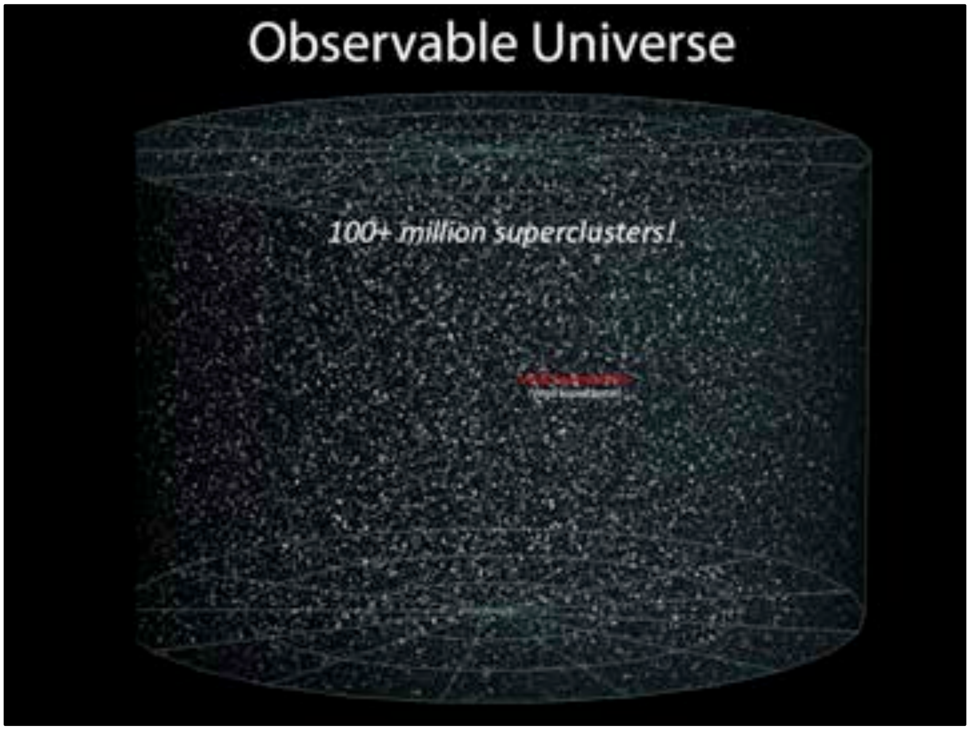
“The two most massive members of the group are the Milky Way and the Andromeda Galaxy, which is 2 million light years away. Both the Milky Way and Andromeda have satellite galaxies around them.” (advance) So you see galaxies are not scattered, but occur in groups.



Near our local galactic group is the much larger Virgo Cluster, which contains 1300 to 2000 galaxies. (advance)
Our local galactic group with its 54 galaxies and the Virgo Cluster are part of the Virgo Supercluster which contains at least 100 galaxy groups and clusters.(advance)
The Virgo Supercluster is more than 100 million light years in diameter, which is a thousand times bigger than the Milky Way.



Also, rather than being scattered randomly, superclusters are arranged in the Universe as kinds of filaments. All of the white areas here are superclusters of galaxies. Our galaxy of 100 billion stars is one of the thousands of galaxies in the Virgo Supercluster.

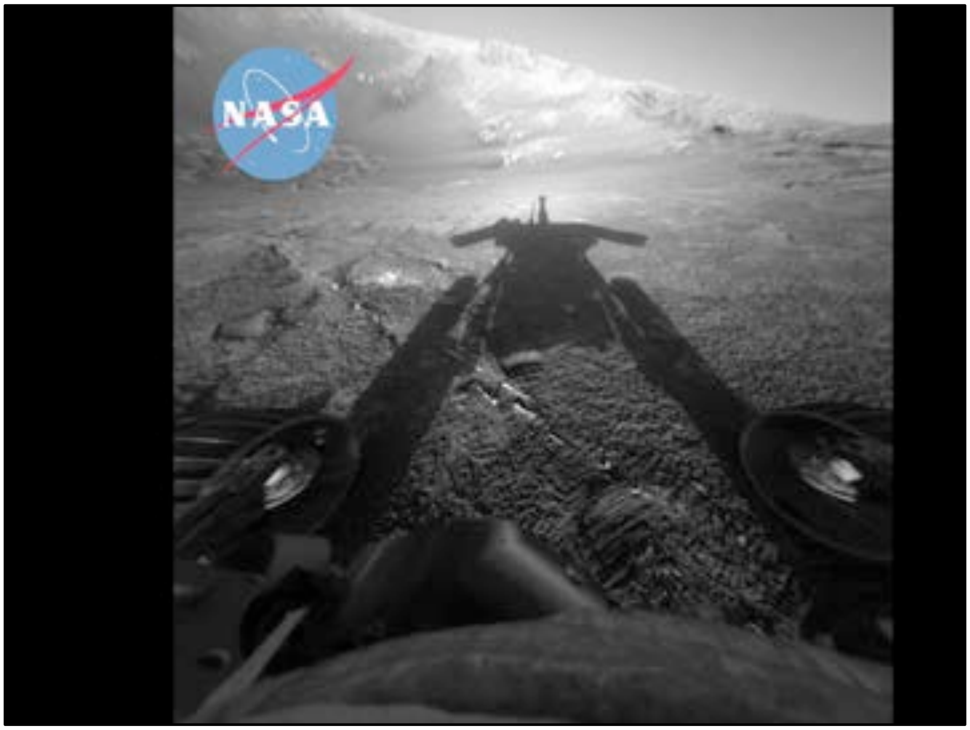


There are tens of MILLIONS of superclusters in the observable universe.

And yet people ask, “Are we alone? Are there other beings like us in the universe?”

I think the universe is saying to us, “Take a guess. The answer should be obvious.” That could mean the Universe is an unimaginably large space full of a diversity of life and cultures -- in the memorable words of Carl Sagan, there are billions and biilions of planets like Earth.

Everyday I remind myself of where I am and how we are part of this incredible hum and vibrancy of life. And I feel an immense privilege to be alive now, knowing and enjoying this gift.



So to end, I return you to sunset in a land nearby …. Maybe now Mars is beginning to feel like home?

Spirit and Opportunity are our first forrays on a world where people will explore, raise children, and enjoy. These missions are part of our hopes and dreams that Humanity will Live Long and Prosper.

And yes, someday young adult scouts will be camping on Mars.

Thank you.

(END)