Curiosity Will Open a New Chapter In Man's Understanding of Mars

by Marsha Freeman

Aug. 10—The successful landing of the Mars Curiosity rover early on Aug. 6 opens a new chapter in what has been a continually re-written history of Mars. Curiosity's current mission builds upon a 50-year legacy of breakthroughs in planetary exploration.

Mars has undergone dramatic changes over billions of years, in its geology, chemistry, topography, hydrology, and atmosphere. But in the past few decades, Mars has experienced *revolutionary* changes, in the mind of man. Through a carefully crafted series of unmanned missions to the Red Planet that began nearly a decade ago, man has sent increasingly complex representatives of his extended sensorium, to observe and probe a planet that might have once supported life. It is we who have "changed" the planet Mars.

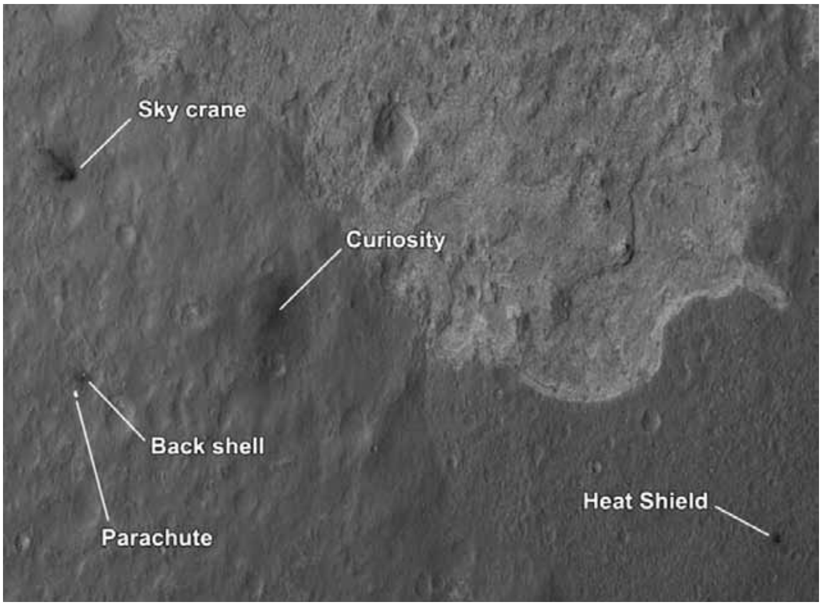
From Earth-based telescope observations, Mars was thought by Italian astronomer Giovanni Schiaparelli in 1877 to have "channels," then mistranslated as "canals," which were thought to have been built by intelligent beings. But man's first preliminary look at Mars, from quick fly-bys of the planet in the mid-1960s, revealed what looked, disappointingly, like the lifeless Moon—barren, dry, cold, bombarded for millennia by asteroids and comets, devoid of any possibility that there could have been life.

NASA/JPL-Caltech

Gale Crater was chosen as Curiosity's landing site, because the 3.4-mile high Mount Sharp is located at its center. The aim is to drive the rover to investigate the history of Mars, through the lower layers of the mountain, which would be oldest. If the rover can negotiate up Mount Sharp, we will see changes that have taken place more recently on the planet, as well. This photo was taken the day Curiosity landed on Aug. 6, with the Hazard-Avoidance camera. The rover's shadow can be seen in the center-ground.

Then, in 1971, Mariner 9 orbited the planet for the first time, and for almost a year, took a closer look. It showed us a new Mars, one that has the largest volcano in the Solar System; channels and dry lake beds, most likely formed by liquid water; indications of a warmer

Curiosity's Landing Site Seen from Orbit



NASA/JPL-Caltech/Univ. of Arizona

NASA's Mars Reconnaissance Orbiter (MRO) captured this photograph of the major elements used in the complex landing sequence of the rover. With the rover near-center, the Sky Crane, which lowered the rover gently down to the surface, is visible. The back shell and heat shield were jettisoned before the Sky Crane was deployed. The parachute was the largest planetary parachute ever built. MRO took this photo about 24 hours after landing.

past, and an environment that might have been hospitable to life. From the Mariner 9 results, an ambitious Viking mission was planned, to land spacecraft, for the first time, on the surface of Mars, and carry out an *in situ* investigation of this increasingly mysterious place.

Looking for Life

Viking's mission, launched in 1975, was an extremely ambitious one: to look for evidence of life on Mars. Based on a very preliminary understanding of the complex chemistry and other features of the planet, Viking's scientific instruments, investigating Mars' surface, only provided contradictory results as to whether or not organic material, which could indicate the presence of past or present life, were found. The "consensus" in the scientific community, that no indication of life was found by Viking, put on the back burner plans for any future missions to pursue the direct detection of life.

But interest in understanding the Red Planet—the one most similar to Earth in our Solar System—suffered only a temporary hiatus. If life never existed on Mars, "Why not?" would be as important a question to answer as, "How did it?" Scientists stepped back from the "life" question, to begin an effort to gain a more comprehensive understanding of Mars. "Follow the water," based on the proposition that liquid water is prerequisite for life, became the theme for the next two decades.

Mars Global Surveyor, launched in November 1996, arrived at the Red Planet in September of the following year. Just four days after being inserted into orbit around Mars, the spacecraft discovered a remnant magnetic field there, possibly a requirement for life. Over its nine-year mission, the orbiter discovered extensive layers in the planet's crust, ancient deltas, channels which appear to exhibit relatively recent activity, and minerals that form under wet conditions. It also served as a communications relay for the Mars Exploration rovers, Spirit and Opportunity.

Just a few months before Global Surveyor began its journey, on Aug. 7, 1996, scientists had announced a stunning observation. They had been given a gift—a piece of Mars that had been ejected from the planet billions of years ago, eventually to land in Antarctica. Meteorite ALH84001 (a piece of which can be seen in the National Museum of Natural History, in Washington, D.C.) was found to contain carbonates, and tiny structures, evocative of minuscule worm-like creatures on Earth. Although, still today, the debate continues over whether ALH84001 contains fossil evidence of life on Mars, the meteorite helped to spur the next series of Mars missions that were being planned.

The First Mars Rover

On July 4, 1997 the first lander on Mars in two decades, and the first-ever rover, made it to the surface of the planet. The Pathfinder mission, and its diminutive, 25-pound rover Sojourner, were designed mainly as a technology test-bed for more complex future missions, but contributed our first up-close look at the surface since Viking. Pathfinder sent back extensive data on wind and weather on Mars, more than 17,000 images, and more than 15 chemical analyses of rocks and soil.

After two mission failures in 1998 and 1999, the next U.S. craft to arrive at Mars, in 2001, is the one that,

The Rim on the Horizon

NASA/JPL-Caltech

This full-scale resolution image taken by Curiosity's navigation cameras, show the rover on a flat, pebbley plain, inside Gale Crater. What looks like a mountain range in the distance is the rim of the crater. The foreground shows two distinct zones of disturbed soil, which were most likely carved out by the blasts from the rover's descent thrusters. Part of the rover is visible in the foreground.

today, is the prime communications relay satellite for Curiosity data to be sent to Earth—Mars Odyssey. Early on, its gamma-ray spectrometer provided strong evidence for large quantities of frozen water, mixed in to the top layer of soil, near the North and South poles. Later, a site in this region was chosen as the target for the near-polar Phoenix Mars Lander.

Odyssey's cameras have identified minerals in Martian rocks and soils, and compiled the highest-resolution global map of Mars. Its observations helped to identify potential landing sites for the Spirit and Opportunity rovers, the Phoenix lander, and Curiosity. For over a decade, Odyssey has monitored the atmosphere of Mars, which data was critical for predicting the possible range of weather conditions during Curiosity's highly-complex landing.

Spirit and Opportunity, Mars' first mobile field geologists, landed in early 2004, and confirmed the past presence of liquid water on Mars. During its investigation of the Columbia Hills, Spirit discovered rocks and soils bearing minerals providing evidence of extensive exposure to water.

Opportunity's findings were a clincher: inside a small crater, the roving geologist examined an outcrop of bedrock. Not only had the rocks been saturated with water, but they had been laid down under the surface of gently flowing water. The presence of the mineral hematite, which had been identified from orbit by Mars Global Surveyor, was verified by Opportunity. Some hematite presented itself in the form of nearly-perfect spherical shapes, termed "blueberries" by the scientists, likely formed in flowing water.

Intriguing Observations

Following the excitement of the "new" Mars that was emerging before our eyes, the European Space Agency (ESA) decided to embark on its own Mars exploration program, and in June 2003, ESA's Mars Express went into orbit around the planet. The spacecraft has been able to identify deposits of clay minerals, similar to what Curiosity will encounter at Gale Crater, indicating a past wet environment. One intriguing observation by Mars Express was the detection of methane in the atmosphere. Since methane from the past would break down too rapidly to be detectable in the atmosphere today, it is apparently still being produced there. Although there are various ways that methane can be produced on Mars, one is by life.

Since 2006, the Mars Reconnaissance Orbiter (MRO) has been on station. It is now beaming back data from Curiosity. MRO has shown us three distinctly different time periods of Mars, and that it is still a dynamic world. It has observed dust storms, new craters, and avalanches. MRO has tracked the cycling of water from Mars' poles through its atmosphere, shown the effect of cyclical variations in the tilt of its axis of rotation, and deep deposits of carbon-dioxide ice buried in the solar cap.

In 2008, the Mars Polar lander verified deposits of underground water ice, first detected by Mars Odyssey from orbit. But its groundbreaking surprise observation was the detection of perchlorate, which is food for some microbes, and a chemical that can lower the freezing point of liquid water, perhaps enough to allow liquid water to exist in otherwise below-freezing environments.

The team of more than 700 scientists around the world who conceived Curiosity have waited nearly a decade for the mission's realization. In April 2004, NASA announced an opportunity for researchers to propose science investigations for the mission. Eight months later, NASA announced the selection of eight experiments, and also scientific investigations, through international agreements, by Spain and Russia. Over the next few weeks, their wait will be over.

It is the past discoveries about Mars, and the infrastructure that has been built in orbit around the planet over decades, that have enabled the breakthroughs that Curiosity will make.

The Curiosity Mars Rover

Curiosity, weighing nearly 2,000 pounds, has a robotic arm with a reach of seven feet, and stands seven feet tall. Its mission is to investigate Gale Crater, to assess whether the area could have been a habitat for life.

Atop the mast is the Mastcam, two color cameras which will show the rover's surroundings in exquisite detail.

ChemCam, mounted on the mast, will investigate rocks, using a laser to create a glowing plasma, or ionized gas, from a small piece of the rock's surface. The light from the plasma will be studied by three spectrometers, to determine their elemental composition.

The **Rover Ultra High-Frequency Antenna (RUHF)** and the **High Gain Antenna** will send and receive data to and from orbiting spacecraft, and directly to Earth.

The **Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)** will allow the rover to operate its suite of 10 scientific instruments, over a two-year period. As the generator's 10.6 pounds of plutonium dioxide decays, the heat will be converted to 110 watts of electricity to power instruments and recharge the rover's batteries.

The **Dynamic Albedo of Neutrons (DAN)** investigation, contributed by Russia, will detect water bound in underground minerals, using neutrons to see how they scatter to identify hydrogen.

The **Radiation Assessment Detector (RAD)** has already measured galactic and solar radiation during the trip to Mars, and will provide a detailed profile of radiation on the surface.

The **Chemistry and Mineralogy (CheMin)** experiment will analyse powdered rock and soil samples that are delivered by the rover's robotic arm. It will identify the full range of minerals in the samples.

The **Sample Analysis at Mars (SAM)** investigation will use three analytical tools to study the chemical state of carbon compounds in the soil and the atmosphere.

The **Rover Environmental Monitoring Station (REMS)** is the Spanish-built weather station, recording wind, temperature, pressure, humidity, and ultraviolet radiation.