QnAs with John P. Grotzinger

In late November 2011, the National Aeronautics and Space Administration (NASA) plans to launch its robotic explorer to scour Mars for signs of the planet's ability to support life. The Mars Science Laboratory (MSL) spacecraft is scheduled to lift off from Cape Canaveral Air Force Station in Florida, shuttling *Curiosity*, an SUV-sized rover with a hefty scientific payload, to the red planet's surface. John Grotzinger, a member of the National Academy of Sciences and professor of geology at the California Institute of Technology, helps oversee the mission. He became involved in the quest after studying how changes in the Earth's environment helped influence animal diversity in some parts of our planet. Here, Grotzinger discusses the MSL with PNAS.

John P. Grotzinger.

PNAS: What is the goal of the MSL?

Grotzinger: The MSL mission's primary goal is to explore the landing sites on the planet as a potential habitat for ancient microbial life. A habitat for microbes must contain water, a source of energy for metabolism, and carbon for building organic structures. Previous explorations have found evidence for the extensive existence of water on the planet's surface billions of years ago. In addition to other goals, the MSL will assess the potential for preservation of large organic molecules. The 3-week window for the launch opens on Thanksgiving Day. The laboratory will land on Mars near the Gale crater in August 2012.

PNAS: Why did you choose to land near Gale crater?

Grotzinger: Gale crater sits within a deep depression on the surface of Mars. We chose the spot based on the logic that water flows downhill and on the evidence for an abundance of hydrated minerals, such as clay and sulfates, there. But the main draw was a 5-km-high stack of sedimentary rocks shaped like Hawaii, possibly one of the most significant sedimentary outcroppings in the entire solar system.

PNAS: How is the scientific payload of MSL different from those of the earlier rovers *Spirit* and *Opportunity*?

Grotzinger: The MSL will have full-color, HD-resolution cameras with telephoto imaging that can also capture video. That will enable us to get a sense of the textures and colors of rocks. To analyze the composition of the rocks, the MSL will carry a laser that will ignite a tiny spark on rocks as far away as 7 m whose emission spectra will reveal their elemental signatures. To explore rocks further, the rover will drill the rocks into powder, which will be fed into the rover's belly. The belly houses an X-ray diffraction setup, a mass spectrometer, and a gas chromatograph. Together, they will help study the rocks' mineral and isotopic composition and directly help detect any large organic molecules.

PNAS: How challenging is it to land such a hefty payload?

Grotzinger: The MSL is more than fivefold heavier than both *Spirit* and *Opportunity*, so it has a very different landing system from that of the earlier rovers, which landed on Mars by soft crash landing. MSL is too massive for a soft crash landing, so we will use an active propulsion system called a sky crane, propelled by rockets and hovering above the surface. *Curiosity* will be reeled out on cables to the surface. Once the rover lands, the system will cut the cables and unmoor the crane, which will then crash at a distance.

PNAS: Do you hope to find microbial life on Mars?

Grotzinger: The MSL cannot tell whether anything is alive on Mars; its goal is not life detection. But if we find a large organic molecule that, say, represents a fragment of a long-dead microbe, the composition of the biomarkers might help us deduce how the microbe may have lived. That said, finding such molecules must be considered a remote possibility, given what we know about preservation in ancient rocks on Earth. The most likely outcome from our studies would be an understanding of the planet's current environmental evolution. We know that Mars went from being a wet to a dry planet, so we're trying to find places with vestiges of the wetter period, when it may have been more Earth-like. With MSL we can analyze dozens, hundreds, and possibly, thousands of layers of sedimentary rock, looking to see how the surface might have changed over time. That could help explain how Mars became so different from Earth.

PNAS: What are some of the challenges tied to the mission?

Grotzinger: By far the biggest challenges are launching and landing successfully; there's a 5% chance of failure. Also, the rover will have a long drive—15 to 20 km—from our landing site to a site suited for geological analysis. That means we're taking the risk that something bad could happen to the rover, like a wheel breaking, on the way to the promised land. Finally, we have our fingers crossed that the most complicated suite of instruments ever delivered to the surface of another planet will actually work. For some of the instruments to work successfully, over 50 valves must open and close without a hitch; and that's just one of many hurdles.

PNAS: Do you expect to learn anything that might help prepare for human spaceflight to Mars?

Grotzinger: A radiation detector on the rover will be turned on for about 15 minutes daily to measure the background solar and cosmic radiation. The detector will help characterize the environment of Mars, providing information about the kind of radiation flux that future astronauts to the planet might have to deal with. Also, the mission will search for sources of water on Mars that could be used by astronauts. If there's water locked up in the minerals, perhaps there is a way to tap into it for future generations of astronauts.

PNAS: With the shuttle program ended, can we hope to see boot prints on Mars in the next couple decades?

Grotzinger: MSL is a precursor mission to another called Mars Sample Return, an essential step toward human travel to Mars. Mars Sample Return, a three-step mission, would be proof that you can return something from Mars. But it's complicated: first, rovers will land on Mars, collect rocks, and store them in a cache. Then, a separately landed rover will fetch the cache and deliver it to an ascent vehicle, which will launch the cache into orbit around Mars. Finally, a separate mission will help retrieve the orbiting cache and return it to Earth. Unlike the moon, Mars has significant gravity, posing serious challenges to returning even rock samples to Earth. So it's unlikely that NASA will send astronauts to Mars anytime before 2030.

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