MARS MISSION

The Red Planet is one of Earth’s closest neighbours, yet we have barely scratched the surface of what we know about it.

Rachel Sullivan indulges her curiosity.

NEW MISSION TO MARS

The room resounds with cheers as the Mars Science Laboratory Team receives confirmation that Curiosity has safely landed on the surface of Mars and images start to return to Earth.

PHOTOS: nasa/bill ingalls (Mars Science Laboratory Team); Getty Images (surface of Mars)
The discovery follows an eight-month journey across more than 567 million kilometres of space, with Curiosity landing on Mars on August 6. That was when mission controllers at the Jet Propulsion Laboratory (JPL) near Los Angeles, in the United States, received confirmation that it had survived its tense seven-minute, 20,000-kilometres-an-hour descent to the planet’s surface. The nuclear-powered, six-wheeled, car-sized rover landed within a minute of schedule, in the target area (an ellipse of roughly 20 by 25 kilometres) near the foot of Mount Sharp, a mountain which rises 5.5 kilometres from the floor of Gale Crater in Mars’ southern hemisphere. (Gale Crater was not necessarily the inner white matter, clockwise from this image: daydreaming isn’t always a bad shown here in dark pink; molecular layer (pink) and the cerebellum’s outer there is now thought to be a dried up green men”. His novel, A Princess On Mars, was greeted with cheers and applause. A Princess On Mars, formed naturally from a series of open workshops. “Gale Crater was not necessarily everyone’s favourite, but was high on everyone’s list,” explains Sumner. “Its walls have many layers of rocks of different types, which contain minerals that usually form in the presence of water. These layers are like interesting pages in Mars’ history book.” Different instrumentation teams could clearly envision the investigations they could undertake at the site, such as determining the amount of water present, looking for organic, carbon-based compounds, and examining the morphology of the landing site,” she notes. Gale Crater had another point in its favour. Satellite imaging from an orbiter had indicated the presence of a cut in the crater wall that appeared to be a dried river or streambed. Named Peace Vallis, the channel continues into the crater and spouts out in a fan shape. “Water is a key aspect of habitability,” says Sumner, adding that the chance...
to identify gravels transported by streamflows on the alluvial fan was a important reason underpinning the researchers’ choice of Gale Crater.

The decision paid off in September. Only part way into its mission, Curiosity examined two outcrops, known as Hottah and Link, and sent back images of conglomerate rock containing ancient stranded gravels. The sizes and shapes of pebbles embedded in the conglomerate, which forms when gravel and sediment is gradually cemented together once they have come to rest in a stream bed, offer important clues about the speed and distance of the long-gone stream’s flow.

The components of the rock, known as clasts, range in size from a grain of sand to a golf ball, and vary in shape from angular to rounded. Their size indicates it is unlikely they were transported by wind, while the rounded clasts suggest long-distance transport by water from above the crater rim. The large number of channels in the fan between the rim and conglomerate finds also suggest flows continued or repeated over a long time.

“We don’t know how long the water flows we’re seeing persisted,” notes Sumner, “but there are similar analogues in Death Valley and the Mojave Desert, where water flows down the same channels multiple times (in response to wet weather events) over many years.”

“From the size of gravels it carried, we can interpret the water was moving about three feet per second (0.9 metres per second), with a depth somewhere between ankle- and hip-deep,” Curiosity science co-investigator William Dietrich of the University of California, Berkeley explained when announcing the find. “Plenty of papers have been written about channels on Mars, with many different hypotheses about the flows in them. This is the first time we’re actually seeing water–transported gravel on Mars.”

[It’s a] transition from speculation about the size of streambed material to direct observation of it,” he said. Unlike a geological expedition on Earth where finds are taken back to the lab for later study, Mars scientists need to be picky about what they decide to analyse in the onboard lab. The science team may use Curiosity’s instruments to learn the elemental composition of the material that holds the conglomerate together, revealing more characteristics of the wet environment that formed these deposits. The clasts in the conglomerate also provide a sample of the rocky terrain above the crater rim, and the team may examine them to learn about the region’s geology.

A long-flowing stream can provide a habitat for life. However, it is not ideal for preserving organic materials, and the slope of Mount Sharp remains the rover’s main destination, because clay, salt, and sulphate minerals detected there may have preserved the organic chemicals that are potential ingredients for life.

SCIENCE PAYLOAD

At three metres in length, Curiosity is about twice as long and five times as heavy as NASA’s twin Mars Exploration Rovers, Spirit and Opportunity, which launched in 2003. It inherited several design elements from them, including a six-wheel drive and a rocker-bogie suspension system to help it drive smoothly over rough ground. In addition, JPL engineers designed the rover to go over obstacles up to 65 centimetres high and to travel up to 200 metres per day on Martian terrain.

Curiosity is powered by a radioisotope thermoelectric power generator, which produces electricity from the heat given off by the decay of radioactive plutonium-238 fuel rods. This long-lived power supply gives the mission an operating lifespan on Mars’ surface of a full Mars year (687 Earth days) or more. Fluids warmed by the generator’s excess heat are circulated throughout the rover to keep electronics and other systems at acceptable operating temperatures in the harsh weather conditions. In late winter, temperatures ranged from minus 70 degrees Celsius at night to a comparatively balmy six degrees Celsius during the day.

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The GCMS can detect more than 140 gases and volatile compounds that may indicate the presence of organic material, which could be a potential ingredient for life. The tunable laser spectrometer can detect carbonates, sulfates, and other minerals that may have formed in wet environments.

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This view of the lower front and immediately areas of curiosity combines nine images taken by the rover’s mars hand lens imager. The camera can focus on any target at distances of about 2.1 centimeters to infinity. Panoramic images by the rover uses, such as views of the rover itself from different angles.

**Mars Mission**

**1971**
- **USA** Mariner 8, Mariner 9
  - Mariner 9 was in orbit around Mars for almost a full year
  - Returned 7,329 photos

**1971**
- **USSR** Kosmos 419, Mars 2 and 3
  - Mars 2 and 3 successfully obtained orbit around Mars
  - Measured the surface temperature of the planet and managed to capture some photos

**1973**
- **USA** Mars 4 to 7
  - Mars 5 took about 40 photos and collected some atmospheric data
  - Mars 6 delivered its lander, which collected information on the atmosphere as it descended

**1975**
- **USA** Viking 1 and 2
  - Each comprised an orbiter and a lander
  - Returned over 50,000 images, including the first panoramic image of the surface
  - Viking 2 stopped transmitting in 1980, Viking 1 in 1982

**1988**
- **USSR** Phobos 1 and 2
  - Aimed to explore Phobos, one of Mars’ two moons
  - Neither reached Phobos

**1996**
- **USA** Mars Global Surveyor
  - Transmitted information until November 2006
  - Returned over 215,000 photos and 266 million spectrometer measurements
  - Also sent back 671 million laser-altimeter images, which helped produce detailed topographic maps

**The Rocky Road to Mars**

- **SUCCESSFUL**
  - 1971 Mariner 8, Mariner 9
  - 1973 Mars 4 to 7
  - 1975 Viking 1 and 2
  - 1988 Phobos 1 and 2
  - 1996 Mars Global Surveyor

- **PARTIAL SUCCESS**
  - 1971 Mars 2 and 3
  - 1973 Mars 5

- **FAILED**
  - 1973 Mars 6
  - 1975 Mars 7

**Photos:** NASA/JPL-Caltech; NASA (Mariner Mars)
Acquisition/Sample Preparation and Handling System. This includes tools to remove dust from rock surfaces, scoop up soil, drill into rocks and collect powdered samples from the interiors, sort samples by particle size with sieves — and deliver samples to the onboard laboratory.

A suite of instruments named Sample Analysis at Mars (SAM) analyses samples of material collected by the rover’s arm, as well as samples collected from the atmosphere. SAM includes a gas chromatograph, a mass spectrometer and a tunable laser spectrometer, all of which allow for the identification of a wide range of organic compounds and the determination of the ratios of different elemental isotopes. This will provide clues to understanding Mars’ atmospheric and water history.

An X-ray diffraction and fluorescence instrument called CheMin also examines samples gathered by the robotic arm, identifying and quantifying their mineral content, while the arm-mounted Alpha Particle X-ray Spectrometer determines the relative abundances of different elements. A mast-mounted instrument named ChemCam uses laser pulses to vaporise thin layers of material from rocks or soil targets up to seven metres away. It includes both a spectrometer to identify the types of atoms excited by the beam — and a telescope to capture detailed images of the area illuminated by the beam.

Then there is Curiosity’s Radiation Assessment Detector, which examines radiation levels on the planet’s surface. This allows researchers to assess Mars’ ability to harbour life, and helps further plans for human exploration of the Red Planet.

Probably most familiar to earthbound followers of the Mars mission is the Mars Science Laboratory Mast Cameras. Mounted at about human-eye height, the cameras record images of the rover’s surroundings in high-resolution stereo and colour, and can also take and store high-definition video sequences.

Supported by a Hand Lens Imager that captures extreme close-up pictures of rocks, soil and ice (to prowess the Mast Cameras are used for viewing materials collected or treated by the arm, and help the team on Earth select targets for further exploration, as well as choosing driving routes. Rounding out a total of 17 sex-cameras, Curiosity is also outfitted with low-slung, stereo hazard-aversion cameras, similar to earlier Mars rovers.

**LONG WAY TO GO**

“So far the longest drive has been around 50 metres, which is related to engineering,” says Summer. Currently the engineers drive the rover, take stereo images, then convert these into a 3D model, before picking where to go, she notes, adding that the engineers are “still working on letting the rover choose its own path and to go further towards Mount Sharp — as long as there are no obstacles in the way.”

Meanwhile, information captured by the rover is correlated with high-resolution imagery obtained by the orbiters. “Panoramic ground images look different to those taken from the orbiters,” she explains. “Even though we have not gone far yet, we’re able to map out different rock types and interpret more information because of the combination of data sources.”

“We have discovered more than we expected at the beginning,” Summer notes. “When I think back on what we’ve already learned, it’s amazing.” And there are still 20 months to go.

**AN INSTRUMENT EXAMINES RADIATION LEVELS TO ASSESS MARS’ ABILITY TO HARBOUR LIFE, AND TO HELP FUTURE PLANS FOR HUMAN EXPLORATION OF THE PLANET**

**SHINY!**

In early October, Curiosity took a break from its everyday sample-harvesting routine to check out a strange bright object that was spotted — via the ChemCam — in the sand near its wheels. According to the rover’s official Twitter feed (@MarsCuriosity), at the point of writing, the scientific team “continues to assess a small object on ground, likely a shred of benign plastic.” It’s probably not an item left behind by a careless Martian hastily hiding from human eyes, but if it’s an object from an older rover, it might mean that some samples must be discarded due to contamination.