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Abstract: An article is presented that reports on human exploration of the planet Mars. The article discusses Mars' environment, distance from Earth, and the duration of any journey there, noting challenges faced by scientists and specialists as they begin planning. Information is also provided on the Mars500 study, a program where six men are simulating a long-term space travel for researchers to examine its mental and physical effects.

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DESTINATION MARS

Human explorers will set foot on the red planet one day. And it might be sooner than most of us realize

Viewed through a telescope on a clear night, the planet Mars glows a soft, dullish red. It seems foreign and strange, but familiar, too: like Earth, Mars has polar ice caps, clouds drifting in its thin atmosphere (even snow), and changing seasons. Its day is just 40 minutes longer than our own. And even though it's now a freeze-dried wasteland, a growing body of evidence suggests Mars was once wet and warm, and might have harboured life around the same time life sprung up here. Human explorers are bound to set foot on Mars one day. And it might be sooner than most of us think.

But our neighbouring planet, fourth from the sun, is also unimaginably remote: at its closest point in orbit to Earth, which happens only once every 26 months or so, Mars is still about 200 times farther away than the moon. At best, it would take a manned spacecraft roughly six months to reach it. By comparison, "the moon

is three days away," says Bret Drake, who leads mission planning and analysis for the Constellation Program at NASA's Johnson Space Center. "You can go any time, and if things go wrong, you can return any time." Once a spaceship left Earth's orbit for Mars, there'd be no turning back.

On the surface, astronauts might have to contend with everything from swirling dust storms to blasts of radiation from powerful cosmic rays. Their research would be a scientific bonanza, teaching us about our solar system, about the genesis of life on Earth and maybe even whether life exists on Mars, or ever did. Observing how the crew's bodies change in reduced Martian gravity could tell us if it's really possible to survive for years on end in space. They'd have to wait over a year until the planets lined up to come back, making it a 2 year trip, all told. If something went seriously wrong, there'd be little to no hope of rescue.

Teams of scientists and specialists from around the world are already working on projects that tackle some of the biggest challenges of a Mars mission, changing the way we think about space travel, about human endurance and about how we might live someday beyond the bonds of Earth. At the Kennedy Space Center in April, U.S. President Barack Obama delivered a historic speech on space exploration. "We'll start by sending astronauts to an asteroid for the first time in history," he said. "By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow. And I expect to be around to see it."

Space-age luminaries like Buzz Aldrin--who, along with Neil Armstrong, was the first human to set foot on the moon, in 1969--call it our next frontier. "Mars is the only other place that approaches conditions here," Aldrin, 80, told Maclean's. "It's much closer to Earth than Venus or Mercury," the only other rocky planets in our solar system. Unlike other destinations, "you can imagine astronauts on the surface of Mars, moving and working," says Richard Zurek, chief scientist for the Mars Program Office at NASA's Jet Propulsion Laboratory. "I truly believe the Mars astronauts are alive today," says Canadian astronaut Robert Thirsk. "They're probably in elementary school right now."

In June, six men entered a sealed isolation chamber in the outskirts of Moscow, to remain there for 520 days. The Mars500 study, a joint effort of the European Space Agency and the Russian Institute for Biomedical Problems, is an attempt to recreate the mental and physical stresses of long-duration space travel, and the effects of extreme isolation. (These lessons also come in handy on Earth: NASA is lending its expertise to help 33 Chilean miners now trapped below ground, expected to be there for up to four months until rescuers can reach them.)

On their simulated mission to Mars, the men--three Russians, two Europeans and one Chinese--only have personal contact with each other. A 20-minute delay is built into communications with the control centre, the same length of time it takes for messages to travel one way between Mars and Earth. The habitat's main living quarters, where each man has his own tiny bunk, is just 3.6 by 20 m.

In one diary entry in July, French engineer Romain Charles wrote about spending his 32nd birthday in isolation. On his last visit home, "I received some presents for my first birthday in the modules, for [Christmas] and also for my next birthday in 2011," he writes. "Now here I am with a lot of gifts just under my bed and nothing to stop me from opening them." Entering the living room, he found his crewmate, Italian-Colombian engineer Diego Urbina. As a surprise, Charles recounts, Urbina had taken a photo of an astronaut, "changed his face to mine and the flag for the French one," and asked all the crew to sign it. "He

knew that since I was nine or 10 years old I wanted to go to space and he made this dream come true in a way."

Like the Mars500 group, the first team to go to Mars might have four to six members, Drake says, and a complementary set of skills: a commander, an engineer, a geologist and a doctor is a likely mix. They'd almost certainly be multinational and include both men and women. And we can only hope they get along as well as the Mars500 team apparently does. "It's going to be a very isolated spacecraft, away from family and friends," says Thirsk, who spent six months aboard the International Space Station last year, becoming the first Canadian to fly a long-duration mission there. Thirsk could often speak to his family back home, a luxury they won't have.

If there's friction among the crew, reaching a mediator might not be possible either. Even when psychologists are available, astronauts "often try to hide emotional problems, out of fear they'll be grounded," Mary Roach writes in her new book, Packing for Mars, and stressed-out astronauts have been known to vent their frustrations at mission control. Conflict resolution software, in which "the computer acts as a therapist," might be helpful, says Dr. Jeffrey Sutton, director of the National Space Biomedical Research Institute. It would give astronauts the chance to play out conflicts--hypothetical or real--and explore outcomes with a machine, instead of on a crewmate.

When Thirsk was on the ISS, he spent long moments gazing down at Earth. "I was amazed by its beauty," he says. "The oceans are blue, but they're 100 shades of blue. You see incredible patterns in the desert: 100 shades of brown, gold and red. It's so heartwarming to see such a beautiful planet, and all the signs of life down there." This is common among astronauts, who tend to say that seeing Earth is the greatest benefit of their time in space, says Dr. Nick Kanas, a professor at the University of California, San Francisco and an expert in astronaut psychology. It can be calming and restorative, he says, imparting "a sense of history, of a lack of boundaries, and of the beauty of Earth as a homeland."

Astronauts going to Mars won't have that benefit. They'll be the first humans to see their home planet fade away, until it disappears into the blackness of space. (As they zoom toward Mars through permanent sunlight, they won't even see any stars, Roach reports, just black.) "Nobody in the history of our existence has ever perceived Earth as an insignificant dot. We've either seen it as a beautiful ball, or we're standing on it," Kanas says. Nobody knows what the impact of "Earth out-of-view phenomenon" will be. "It might be nothing," he says, "but it might be profound."

Watching their home planet disappear out the rear-view window is just one of the mental and physical challenges these astronauts will face. Microgravity, stress and radiation all wreak havoc on the human body; in space, immune systems become weaker and wounds take longer to heal, Sutton says. Radiation can make medication less effective, and in reduced gravity, muscle and bone tissue wither away. Astronauts might lose bone at up to 1.5 per cent per month on average, a loss that "can be as high as 10 times that of post-menopausal women," he says. After months in space, an astronaut returning from Mars might step back into Earth's gravity and snap a bone. Researchers are looking at drugs to help combat bone loss (Thirsk was part of a drug trial on the ISS). Others talk about designing a spinning spacecraft, to create artificial gravity. For now, "the main countermeasure," Thirsk says, "is exercise." On the ISS, astronauts do resistance training and work out on stationary bikes or treadmills, with a bungee cord to keep them from floating away.

In May, astronaut Chris Hadfield, who'll be the first Canadian to command the ISS when he takes over in 2012, spent two weeks in a pod under water off the Florida coast. On that NASA mission, NEEMO 14, he and three crewmates simulated activities that might be performed on Mars or the moon, including emergency procedures like rescuing a wounded colleague (played by a dummy) from the hostile environment of the ocean floor. They also charted how their bodies reacted to the confined space. "It's very evocative of being on another planet," Hadfield told Maclean's in a video chat from the pod. "When you walk outside, you're weighed down like on another planet. You bounce when you walk, and you hear every breath."

If there were an emergency and surgery were required, a robot might be the one to do it. McMaster University's Dr. Mehran Anvari is an expert in telerobotic surgery, remotely controlling robotic arms that perform operations hundreds of kilometres away. The system was designed for use in remote communities, but Anvari's worked with the Canadian Space Agency and NASA--including mock-ups on NEEMO missions--to see if it could be done in space. Because of the long delay in communications to Mars, "you'll need a system with some degree of artificial intelligence," says Anvari, who directs the Centre for Minimal Access Surgery. "I'll be very surprised if the next long-term manned mission includes a surgeon," he says. "It's not necessary."

A robotic surgeon would certainly be an asset on a mission to Mars, but we still don't have a ship that can take us there. With current technology, a trip would require a heavy-lift rocket (one that could blast at least 70 metric tonnes off Earth's surface) and several launches to get all the necessary equipment off the ground. The giant ship would then be assembled in orbit before blasting off to Mars.

Lifting hundreds of thousands of pounds into Earth's orbit is no small feat. Paul Spudis, senior staff scientist at the Lunar and Planetary Institute, suggests it might be possible to reduce weight--and, critically, launch costs--by making rocket fuel on the moon instead of bringing it all from home. "The moon's poles have significant amounts of water ice," he says. This could be broken down into hydrogen and oxygen, "the most powerful rocket propellants we know of." (Obama has said he hopes to choose a heavy-lift rocket design by 2015.)

Former NASA astronaut Franklin Chang Díaz thinks it's time to move on from chemical rockets. After retiring from NASA in 2005, he founded Ad Astra Rocket Company, which is developing a plasma rocket called VASIMR. Powered by solar arrays or nuclear electric power to produce a superheated gas (plasma), "we can do the same work with about one-twentieth the fuel," he says. "It completely changes the equation of space travel." With energy close to what's generated in a nuclear sub, he believes, VASIMR could bring humans to Mars in 39 days. After that, "We won't stop at Mars," he says. "We'll keep going."

After months of travelling through space, the ship will park itself in orbit around Mars. A lander will detach, ferrying the crew down to the planet's surface, where--if the most commonly expected scenario plays out--they'll find rovers, supplies and a habitat waiting, delivered robotically on earlier missions.

Astronauts will spend days at a time inside a rover, exploring the surface and collecting samples, says Kriss Kennedy, a space architect at NASA. (The pressurized rover, which might be the size of a Winnebago, would be what astronauts call a "shirt-sleeve environment.") In reduced Martian gravity, which is three-eighths of our own, they won't need to be strapped to their beds when they're sleeping; but they will feel like

they have superhuman strength, jumping higher and lifting more than they ever could on Earth.

When not in the field, astronauts will come back to a habitat, which might be buried in the ground for protection against radiation that bombards the planet. Its size will depend on the specifics of the mission, but each crew member would probably have his own private quarters, with shared space for exercise, lab work and socializing. (The Mars500 crew kills time playing Guitar Hero.) The air they breathe could be brought along in canisters, or made from waste water split into oxygen and hydrogen, a process used on the space station.

It's impossible to really imagine setting foot on another planet, but luckily we can practise at home. The spot on Earth that most closely resembles Mars is here in Canada: Devon Island, in Nunavut, which was struck by a meteorite about 39 million years ago, leaving a massive scar called the Haughton Crater. Today, it's "an almost perfect place to learn how to explore Mars," says Pascal Lee, a planetary scientist at NASA Ames Research Center and chairman of the Mars Institute, which runs the Haughton-Mars Project, a scientific study of the crater and how it relates to Mars. "Mars is a cold, windy, dusty, barren and impact-scarred place," he says. "So is Devon Island."

This summer, the Haughton-Mars Project team spent six weeks on site, its 14th consecutive season. Part of their research involved trying out a suitport, a system in which a spacesuit is fastened to the outside of the spacecraft (conventional suits are stored inside the ship and donned inside an airlock). When an astronaut wants to do a spacewalk, he swings open a port "like a thick refrigerator door," Lee says, climbs into the suit and "scoots through legs first." He then seals the port behind him, detaches from the vehicle and walks off wearing the suit. When the spacewalk is over, he re-docks, climbs out of the suit and right back into the ship. Suitports would have several advantages on Mars: they're quick to put on, and corrosive Martian dust is kept outside, although they do risk damage from exposure. Up in Nunavut, the team experimented with spacesuits dangling from a Humvee, which stood in for the type of rover that astronauts could drive on Mars. During the exercise, "almost the entire team tried going in and out," Lee says. "It was fantastic."

On Mars, astronauts will find mountains taller than Everest, canyons deeper than the Grand Canyon, and the biggest volcanoes in our solar system: the largest, says Zurek, is the size of the state of Arizona at its base. They might encounter massive winds and dust storms that can engulf the entire planet, and temperatures from -125° C at the poles in wintertime, up to 20° C at noon by the equator, according to NASA. And it might not always look so different from home. In 2008, aided by a Canadian-made weather station, NASA's Phoenix Mars lander found the first evidence of snow falling from Martian clouds.

Space agencies have been sending robotic missions to Mars since the 1960s, but human explorers would achieve more than robots ever could. Spirit and Opportunity, two NASA rovers, landed on Mars in 2004, and while Spirit eventually got stuck in a sand trap, Opportunity's still driving around. But their work is excruciatingly slow: it's been said humans could learn as much in one week on the ground. Getting samples into scientists' hands will be invaluable. Unlike Earth, the Martian surface seems to be one solid crust; with no plate tectonics to melt it down, ancient rock litters the ground, "preserving an early record of the planet," Zurek says. Beyond just teaching us about how Mars has evolved, this record might teach us about the origin of life.

Today, the pressure on Mars is so low that liquid water boils off almost immediately. But scientists have

found evidence the planet was once wet and warm, with lakes, oceans, maybe even an atmosphere dense enough to support rain. Where there's water, there can be life, and new clues suggest that maybe it's still there. We now know there's methane in the Martian atmosphere, which, in Earth's atmosphere, "is largely produced by biological matter, like plants and algae," says Victoria Hipkin, senior planetary scientist at the CSA. "Methane in the Martian atmosphere could mean there's a surface source," maybe even methane-producing microbes, "some of the most primitive microbes that exist on Earth."

On Axel Heiberg Island, in Canada's Far North, a team of scientists has been exploring the remote Lost Hammer spring. Its water pushes up through 600 m of permafrost, says McGill University microbiologist Lyle Whyte, but it's so salty it doesn't freeze. The water lacks any consumable oxygen, but Whyte has found microbes living there, surviving off methane that bubbles to the surface.

Images from NASA's Mars Orbiter have shown new gullies forming on Mars. No one knows why, but the presence of springs like Lost Hammer could explain it. If microbes can live in the Lost Hammer spring, maybe they can live on Mars. And if there's life on Mars--no matter how small, or primitive--chances seem much better that, one day, we'll find life on other planets, too.

Mars has been called a spacecraft graveyard; it's littered with the orbiters, landers and unmanned rovers we've sent over the years--we've never been able to bring any of them home. How we'd bring our astronauts home is another question. The technology to launch a rocket off a foreign planet, with its own gravity and atmosphere, doesn't yet exist. So maybe, some say, we should just leave them there.

A one-way mission to Mars would cut costs significantly, since we wouldn't need to send fuel for a return trip, says Paul Davies, a cosmologist at Arizona State University. And the dangers of space travel, including exposure to radiation and the risks associated with takeoff and landing, would be reduced. "People conclude this is a suicide mission," but it's not, he says. On a foreign planet, life expectancy would be lower, he admits, but sending older colonizers (say, those in their fifties) might mean shaving only a few years off their lives. Once on Mars, any scientist would be "the proverbial kid in the candy store," Davies says. "The science would be stupendous. I'm sure plenty of volunteers would be willing." In her book, Roach cites several who say they'd happily do it. She quotes Valentina Tereshkova, the first woman in space: "I am ready to fly without coming back."

The first trip, as envisioned by Davies, would consist of roughly four astronauts. With refuelling missions sent every few years--and perhaps another group of explorers to join them, a decade or so later--they could "set the foundations for a permanent colony," he says. Eventually, they'd have to wean themselves off supplies from Earth, since restocking missions are expensive, so they'd learn to derive what they need from the planet itself; oxygen, Lee says, could be made by breaking down carbon dioxide in the Martian atmosphere. One day, they might even grow their own food in inflatable, radiation-proof greenhouses.

Mike Dixon at the University of Guelph has spent nearly two decades working out how to farm crops in space. In hypobaric chambers at Guelph's Controlled Environment Systems Research Facility, which he directs, his team is tinkering with pressure, lighting and other factors to determine what plants, and the microbes and pollinators that support them, can withstand. (One day in late July, the chambers were full of soybeans.) So far, "we can grow plants at one-tenth of the Earth's atmospheric pressure, with one-third of Earth's oxygen," says Dixon, who works with the CSA and NASA. "They're still perfectly edible." Up on

Devon Island, at the Arthur Clarke Mars Greenhouse, his team experiments with germinating and growing crops by remote control before the crew arrives on site, as might be done on a Mars base in the future, he says.

Farming crops in space would have all sorts of benefits, Dixon says, from filtering air to providing the calming effects that come from tending to plants. He hopes to eventually sprout a plant on the moon as proof it can be done.

Before humans ever set foot on Mars, robots will continue to pave the way. Several exploratory missions are planned, with Canadian components. Set to launch next year, NASA's Curiosity--the size of a minivan, it's the largest Mars rover yet--features a Canadian-made tool to measure rock composition. A Canadian team is developing an instrument called MATMOS, to be used on the 2016 ExoMars Trace Gas Orbiter mission (a joint NASA-ESA project) to measure methane in the Martian atmosphere. In 2018, space agencies hope to land a rover on Mars to collect samples. These will be picked up on a future mission and shot back to Earth, which has never yet been done. If successful, says the ESA's Jorge Vago, many of the technologies needed for a manned mission--precision landing, takeoff from Mars and the return to Earth--will be demonstrated on a small scale, for the first time.

When we finally do take off for Mars, it will be our greatest adventure yet. "Ask anyone what happened in the 15th century and they'll say, Columbus discovered the new world," says American planetary scientist Alan Stern. "In the same way, the first mission to Mars will go down in history, I think, in a way people in the 26th century will remember."

He and others permit themselves to dream of a future--maybe not so far away--where Mars is within reach. One day, Zurek muses, maybe we could have "little museums at the Viking and Mir landing sites."

A very distant neighbour

It would take a manned spacecraft six months to reach Mars from Earth. Astronauts would stay over a year, until the planets' next close alignment, to come back, making it a 2-year round trip.

FURTHEST APART

Jan 28, 2011

Earth to Mars distance: 355 million km

CLOSEST

Feb 27, 2012

Earth to Mars distance: 101 million km

MAP: FURTHEST APART

MAP: CLOSEST

PHOTO (COLOR): Under the sea: Chris Hadfield and crew use the ocean as a stand-in for another planet

PHOTO (COLOR): On the ground: A NASA rover sends images from Mars, which has seasons, polar ice caps

PHOTO (COLOR): Trial runs: With the suitport system, Martian dust stays outside

PHOTO (COLOR): Trial runs: Studying how to farm crops in space

PHOTO (COLOR): Life on Mars: Utah is one of several environments on Earth used to stimulate Mars

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By Kate Lunau

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