The Martian: Truth vs hype

So, how Martian is *The Martian*, Matt Damon's latest thriller? Turns out, the science fiction movie is, in fact, a lot of science. Based on Andy Weir's bestseller, which narrates the story of Mark Watney, a man stranded on Mars, *The Martian* is being heralded for its scientific accuracy by none other than NASA, which was also a consultant in its making. A few errors though have managed to creep into the movie, giving a field day to science websites separating fact from fiction in the film

THE STORM

THE OPENING scene, a ravaging dust storm, said *IFLScience.com*, is inaccurate. The thin atmosphere of the Red Planet won't give that much heft to wind power. "Dust storms certainly do occur on Mars, they get winds in excess of 100 mph. But a 100 mph wind on Mars, because the atmosphere is so thin, has the same inertia and dynamic pressure down at the surface as about an 11 mph (18 km/h) wind on Earth. It's not going to have the sort of energy to move large objects the way it is portrayed in the book and the film," Dave Lavery, NASA's Program Executive for Solar System Exploration said.

GRAVITY

Watney walks on Mars just the way he would have on Earth. That's off the mark, as the Red Planet has about 30 per cent of the gravity Earth has. "NASA envisages that the most efficient way to walk on Mars will be a gait somewhere between a shuffle and a hop," said *IFLScience.com*.

GROWING POTATO

Watney grows potato on Mars, using a mix of Martian soil, his excrement and water. Scientists said the task is possible given the chemical composition of the Martian soil. The addition of human poop helps as Martian soil doesn't have nitrogen but human excreta does.

MAKING WATER.

Watney produces H_2O by burning oxygen from the life support system in his habitat with hydrogen gas from leftover spaceship tanks. "In theory, it works. But to do it in a closed habitat like that would be tricky," said Doug Ming, chief scientist for NASA's Astromaterials Research and Science division.

THE LANDSCAPE

The cliffs of red rock and vast expanse of rocky sand, created from a mix of digital effects and location shooting in Jordan, do match the Martian landscape, said *Discovery.com*, quoting Ming. "Well, we actually do have cameras on Mars... We've taken an enormous number of images... They did a pretty good job of what we would really see on Mars — the boulders, the soil, those kinds of things," he said.

TORNADOS

Furious tornadoes emerge frequently in the movie, but given Mars' thin atmosphere, are such massive storms likely? Surprisingly, yes. "There have been some major dust storms on Mars over the past 20 years. They pretty much engulf the planet. It happens fairly fast, but it does take some time to develop," Ming told *Discovery.com*. But they do come with warnings, he added, unlike in the movie. "We do have some predictive capabilities to say, hey, there's a dust storm heading your way. That's one of the scenes where I'd say that's pushing the reality a little bit," he said.

Graphic : Sanjay Tambe

Scrubbed Red

Mars is pretty clean. The job of Catharine A Conley, 'planetary protection officer' at NASA, is to keep it that way

KENNETH CHANG

AT THE NATIONAL Aeronautics and Space Administration, Catharine A Conley has a lofty job title: planetary protection officer.

That conjures to mind shades-wearing Will Smith and Tommy Lee Jones in the *Men in Black* movies. Indeed, on her first day on the job, nine years ago, she was presented with a pair of sunglasses.

But with no extraterrestrial invasions on the horizon, Conley's job is not so much protecting Earth from aliens as protecting other planets from Earth.

Mars, in particular.

"If we're going to look for life on Mars, it would be really kind of lame to bring Earth life and find that instead," Conley said.

With the news that scientists had identified areas of flowing water on the Martian surface — some possibly reachable by NASA's Curiosity rover — that concern has taken on new urgency.

Thousands, millions, sometimes many times more, bacteria travel across the solar system on spacecraft. Earth has been invading Mars since November 1971, when the Soviet Mars 2 lander crashed. Certainly life exists on Mars today — the microbes that have hitchhiked from Earth. Even in the harsh environs of Mars — cold, dry, bombarded by ultraviolet light — it takes many years for all of them to be killed off.

The concern is that some of them might not only survive but thrive.

Because of the residual microbes, NASA's Opportunity and Curiosity rovers are prohibited from visiting what are known as "special regions" — places that Earth bacteria might happily call home. (InSight, NASA's next Mars lander, to be launched in March, and the next rover, to be launched in 2020, will also not be sterilised. In considering landing sites for the 2020 rover, NASA has crossed off those in special regions.)

The thinking is that some Earth microbes have been jostled to the surface of the inhospitable parts of Mars, but they would remain dormant and not proliferate. "So far, Mars is still pretty clean," Conley said.

Areas treated as special regions include the periodic dark streaks known as recurrent slope lineae — RSLs for short — spotted on the sides of craters, canyons and mountains. Scientists last fortnight said they were generated by the percolating of liquid water, one of the essentials for life.

The caution brings up a Catch-22. NASA at present cannot explore the places with the greatest potential for life — one that could come into play for Curiosity, which is slowly climbing a mountain in Gale Crater.

Gale was selected as Curiosity's destination in part because it was the "driest and least likely to have special regions", Conley said. But some candidate RSLs have been unexpectedly spotted from orbit on the mountain within a couple of miles of Curiosity's planned path.

James L Green, the director of NASA's planetary science division, did not rule out that Curiosity might go to one of them.

If the streaks are confirmed as RSLs, Green said, NASA might then evaluate how many Earth microbes are likely to survive on the outside of Curiosity.

"That would tell us, if we can get approval from planetary protection, how close we could go," Green said.

Conley would be the one to make that call. She said that at launch, there were probably 20,000 to 40,000 heat-resistant bacterial spores on Curiosity, and perhaps 100 or 1,000 times more microbes not counted. Many of them would have since perished in the vacuum of space. Intense ultraviolet radiation on the Martian surface would have killed many more — but not all, and some drop in the soil as Curiosity trundles by and performs its science work.

"We are still having ongoing discussions," Conley said. "It depends on what the results of the calculations are."

This is not just a fastidious whim of NASA, but an international agreement. The Outer Space Treaty of 1967 dictates that nations should take care when exploring other planets "to avoid their harmful contamination".

The Committee on Space Research, part of the International Council of Science, develops planetary protection policies that Conley is responsible for carrying out. For most missions, like the Cassini orbiter at Saturn, the requirements are fairly simple — do not crash into a body where life might exist, and when done, dispose of the spacecraft. (Cassini will be sent on a death dive into Saturn, where heat and pressure will obliterate it and any remaining microbes.)

Similar care will be taken studying Europa, a moon of Jupiter, and Enceladus, a moon of Saturn, known to have oceans beneath the surface. But it will be many years before a lander sets down there. For now, the main concern is Mars.

"We're treading new ground," John M Grunsfeld, NASA's associate administrator for science, said of the discussions on Curiosity. "The issue of planetary protection has gone very much from one where we're just trying to be careful to one that has very real, near-term consideration."

With the two Viking landers in 1976 — NASA's first and so far only attempts at detecting life on another planet — the agency took extraordinary precautions sterilising the spacecraft, first cleaning it to fewer than 300 heat-resistant bacterial spores per square meter. Then it was packed up and baked for several days, reducing the number of spores by a factor of 10,000.

But most of the data from Viking pointed to Mars as a lifeless place. Since then, NASA has still cleaned its Mars spacecraft to the same standards — "better than a surgical suite", Conley said — but skipped the baking step. Sterilisation would add perhaps $100 million to the price of a mission.

Thus NASA has avoided the special regions, which include anywhere with water ice within a meter of the surface. (An exception was the Phoenix Mars lander, which dug into ice in the polar region. The arm — only the arm — was sterilised to Viking standards.)

The salts known as perchlorates that lower the freezing temperature of water at the RSLs, keeping it liquid, can also be consumed by some Earth microbes.

"The environment on Mars potentially is basically one giant dinner plate for Earth organisms," Conley said.

The first Earth settlers could be one of the lowliest of plants. "I worry about lichen," Conley said. "I worry about the stuff that grows on your roof. They basically eat rock and they breathe sunlight. And there's rocks and sunlight on Mars."

For some NASA critics, the concerns of planetary protection are just an expensive ball and chain that slow study of the solar system. Why the caution now if one day in a few decades, astronauts, carrying a slew of Earth microbes, arrive to colonise Mars?

With a changing picture of present-day Mars that is not quite as desolate as once thought, "we actually do need to be careful", Grunsfeld said, "because there could be life on Mars". **NYT**

Shedding light on changing properties of photons

KAMAL SINGH AND GOPAL VERMA,
IISER, MOHALI

FROM THE LAB

A WEEKLY UPDATE FROM INDIA'S FINEST RESEARCH INSTITUTES

THE RESEARCH

Finding out whether the momentum of light photons increases or decreases when it enters another medium like water or glass

LIGHT HAS many special properties, most of which are well understood. However, one unresolved issue, for over 100 years now, is how some of its properties change when it comes in contact with a different medium, like air, glass or water. Its momentum is known to change, even though the energy remains the same. There is difference of opinion on whether the momentum of light photons increases or decreases in such a case.

Hermann Minkowski, Albert Einstein's teacher, had proposed that the momentum of light photons increases while passing through another medium. However, German physicist Max Abraham measured a decrease in the momentum. Scientists have not been able to conclusively establish one over the other. Both suggestions could also be true under different conditions.

If there is a loss of momentum, for example, this loss needs to be absorbed by the medium. That is what the Law of Conservation of Momentum says. If a ball is thrown at a hanging cloth, the ball loses its momentum after hitting it and a depression is created in the cloth. Similarly, the light photons should create a depression on the surface of water when it strikes it. The nature of the dent in the surface will reveal whether the light photon has lost or gained momentum. The effect of momentum change is small and difficult to measure.

In the 1970s, some US researchers pointed a high-power light beam at water to examine the depression. Their experiments proved Minkowski's theory, that light photons gained momentum while crossing another medium. But some scientists were not convinced, as it was not very clear whether the depression observed was due to momentum change or heating by the beam.

During our own experiments, instead of using one medium, we used two. We put a drop of water on glass surface and directed a beam of light on it. Both are transparent mediums and most light crosses through it. But a small amount gets reflected by the water drop and forms a spectrum on a screen opposite it. A small amount of light gets reflected from the glass surface as well and another spectrum is created. The two reflections form an interference pattern, which is dependent on the shape and size of the water droplet. We also introduced some other changes, like bringing in a magnetic field, to see how the interference pattern changes. By doing this we noticed how a change in the water drop, changes the interference pattern.

The next step was to direct another beam of light at the water drop that was placed on the glass surface. This caused a change in interference pattern. Having studied these patterns earlier, we were able to tell what kind of depression in the water drop had led to these changes, and whether it was related to a loss or gain in momentum of photons.

Our observations showed that the light photons actually gained momentum while interacting with the water-glass interface. This might not be true in all circumstances, in all mediums. But at the same time, unlike the US research, in which the laser beam was pointed perpendicular to the water surface, our results were not dependent on the angle from which light is directed at water surface. The result holds true at all angles and shows that in the kind of medium and settings we used, Minkowski was right.

Our results might be useful in making reconfigurable fluid lenses and to trap tiny objects on fluids by using light forces.

For your research to be considered for this column, please write to Senior Editor Amitabh Sinha at amitabh.sinha@expressindia.com

SCIENCE IN 140 CHARACTERS

WHAT SCIENTISTS ARE TWEETING ABOUT
BY JAMIE MULLICK

Spice it up

@BENGOLDACRE
BEN GOLDACRE, PHYSICIAN

Goldacre tweeted a study published in the *British Medical Journal* which says chilli-laden diet is beneficial for us. Capsaicin, the chemical that makes chilli hot, is known to lower the risk of death from cancer, coronary heart disease and diabetes. Capsaicin patches are available with chemists for use as painkillers.

One small click

@BADASTRONOMER
PHIL PLAIT, ASTRONOMER

An archive of more than 12,000 photographs and transcripts from NASA's Apollo missions have landed on Flickr thanks to a major digitisation effort by the agency's librarians. Astronomer Phil Plait, shared his article for *Slate*, in which he said, "Most people will of course be entranced more by the photos of the astronauts themselves. I easily found my favourite Apollo photo of all time - Al Bean (pictured) standing on the Moon's surface during Apollo 12, holding a regolith sample container."