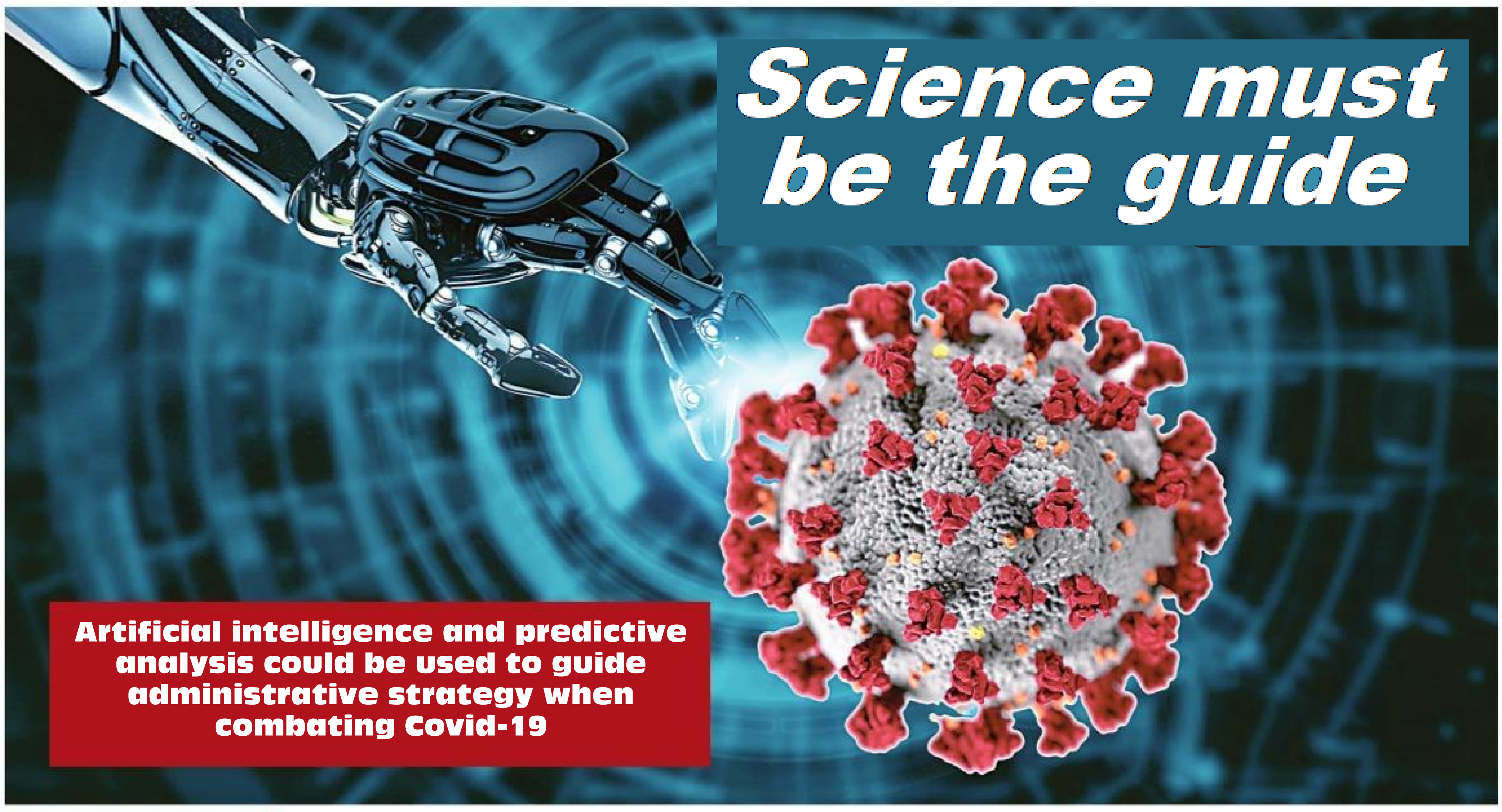

Science must be the guide

Artificial intelligence and predictive analysis could be used to guide administrative strategy when combating Covid-19

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Measures taken in the first six months of the pandemic have kept us from the catastrophic spread of Covid-19 that some had predicted. But we are by no means in control, as the numbers are showing an alarming increase.

In principle, the pandemic will die out if new infections are prevented for just three weeks. It can be possible when there is "herd immunity", which can come about with the help of a vaccine, or when everybody stays disciplined. Discipline seems out of question, as many are yet to understand what we are facing. As for the vaccine, it is, so far, not a reality. The toll, while we await herd immunity, is what we would like to keep down.

Philippe Carmona and Sylvain Gandon, from Université de Nantes and the nuclear research centre at Univ Montpellier, in France, undertook a study, completed in October 2019 before Sars-CoV-2 raised its head, of how observing the behaviour of a pathogen could help optimise the intervention to contain its spread. The study, just published in the journal, *PLOS Computational Biology*, identifies ups and downs, or seasonality, in how an infection flourishes, and identifies a period, which is called "the winter" when conditions for the pathogen are not favourable.

The study defines a value, "λ" (the Greek letter lambda), called the "birth rate", the rate at which the infection grows, which depends on the rate of transmission and how many susceptible persons surround an infected person. And then, there is a value, "μ" (the Greek letter mu), called the "death rate", which is the rate at which the number of infected persons reduces, when infected persons get well, or die. The ratio of the two rates, λ/μ, is the now well-known R_0, or the reproduction rate.

The simplest understanding is that the infection will spread if R_0 is greater than one, and will go extinct if it is less than one. This understanding, however, the paper points out, is true provided the number of infections to start with is reasonably high. How the population of pathogens rises or falls, the paper says, is sensitive to the conditions in the environment of the infection and could be driven to extinction, during patches when the conditions are right, even when the value of R_0 is above one.

The paper cites studies that show how the pathogen that causes malaria, or the viruses that cause dengue, West Nile fever, tick-borne brain inflammation, hepatitis, shingles, chicken pox, influenza, all have their "seasonal window of occurrence" and are affected by the temperature and humidity. The factors, λ and μ are then considered to be variable with seasons, and the paper develops a procedure to work out the probability of the emergence of epidemics.

The working shows that even if infection occurs in a community at a time when it could flourish, if a period of low survival (of the infection) were to follow within a short time, the infection would not be able to spread. Such low survival spells are called "winter" for the pathogen and the effect on outbreaks that occur just before such a spell is called the "winter is coming" effect. The effect is perceptible, the study says, when the time span over which the environment changes is large, compared to the time the infection lasts, that is the time it takes for a person to get well.

"Understanding this effect allows us to identify the optimal deployment of control strategies minimising the average probability of pathogen emergence in seasonal environments," the paper says. The paper, which was written before Covid-19 broke, has been tested with the emergence of Zika, which, unlike Covid-19, is spread by mosquitoes, apart from contact. The paper also speaks of timing "pulse vaccination", to reduce emergence, and measures of using drugs to accelerate recovery. Such avenues are not available with Covid-19. The only strategic action we can take is to detect seasonal effects on the transmission of Sars-CoV-2 and tailor behaviour patterns – like allowing and restricting travel and economic activity.

In the short months that Covid-19 has been with us, it has not been possible, so far, to discern seasonal variation, and the only effect popularly seen is rapid spread. Nevertheless, there is now considerable data, of the prevailing conditions, behavioural as well as climatic, day-to-day and in different parts of the world. Analysis of this data can reveal patterns –ones that could guide administrative strategy, to gain footholds and create the "demographic traps" where the pandemic could be blocked. These are the same methods – artificial intelligence and predictive analysis – that are routinely used by marketing consultants, and web services like *Google*, to optimise different objectives.

It is clear that the current pandemic will stay for a considerable period – even if a vaccine emerges, it would be many months before a significant number are protected. In 1918, the viral, influenza pandemic infected 500 million people and caused 50 million deaths. The present tally is 16 million cases and over half a million dead. However, and at a rate of doubling every 30 days, we could reach 500 million by the year-end. The difference is that we now know the virus causing the pandemic and understand its transmission in detail that was unthinkable in 1918. This is the difference that we need to leverage to do significantly better.

Reports about the outbreak of 1918 (it started in the United States) contain instances where local administrations permitted unfettered commercial activity. "...the broader pattern that emerged was dismissal, dissemblance and outright deception on the part of public officials who either did not perceive the severity of the threat or who would not acknowledge it, for fear of political consequence. What mayor or governor, after all, wanted to go to war with local businesses, which in every city vocally opposed forced shutdowns?" says a report about what went wrong in 1918.

This time round we need to manage the crisis, not just its consequences. We know that some trade and business must continue. But we need to put the scientist, statistician and manager in charge, and ensure that the conditions needed to minimise risk are objectively discovered and then implemented. The analysis by counts of *Susceptible, Exposed, Infected, Recovered (the SEIR scheme)* has been found to be a reliable guide of when to loosen and tighten social controls. We now have sophisticated information gathering and processing tools. We need to bring those into play, share information with the populace, ensure participation and acceptance. Create an awareness that, for some time, at any rate, self interest lies in thinking of the common good.

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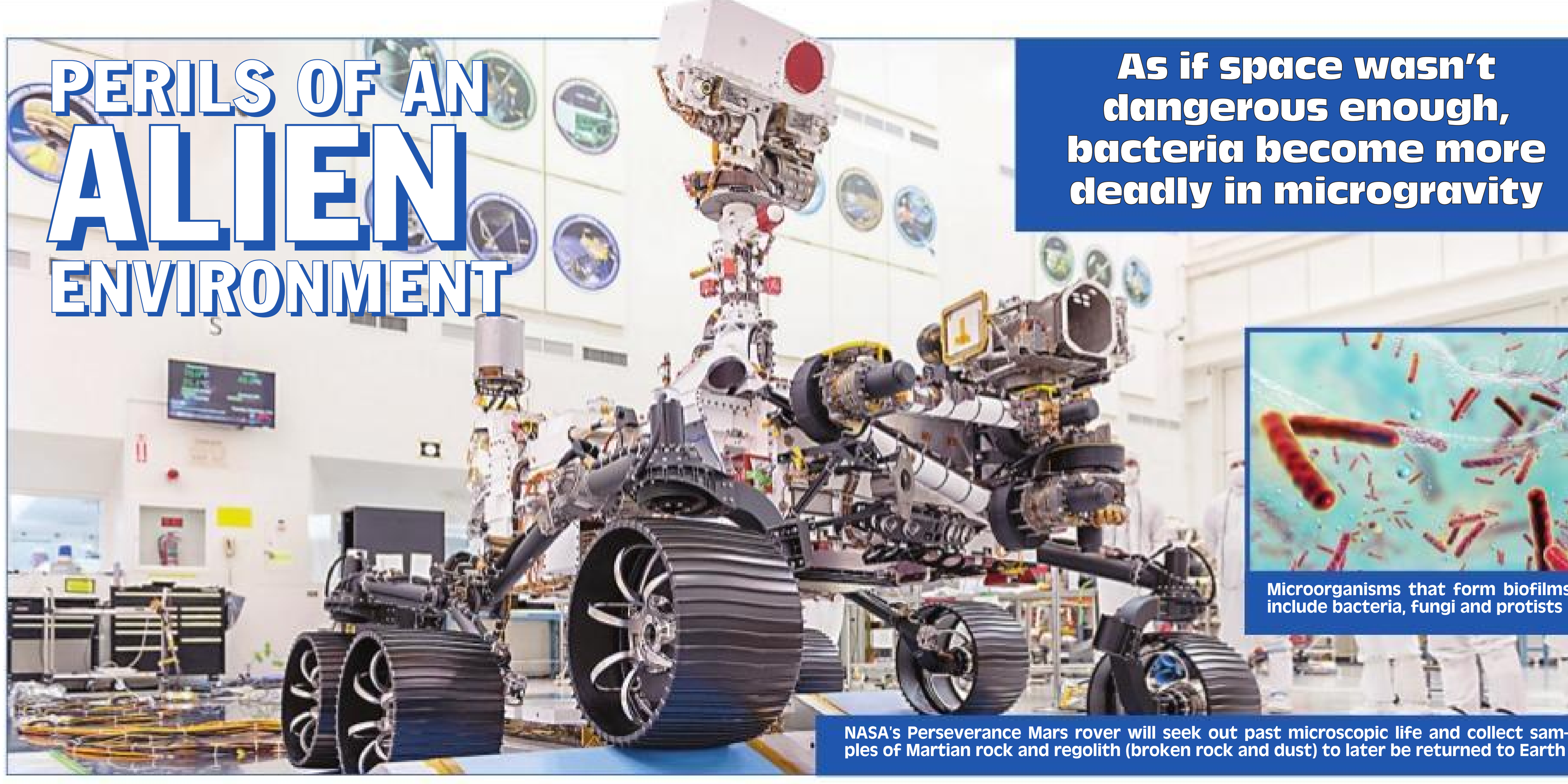

PERILS OF AN ALIEN ENVIRONMENT

As if space wasn't dangerous enough, bacteria become more deadly in microgravity

Microorganisms that form biofilms include bacteria, fungi and protists

NASA's Perseverance Mars rover will seek out past microscopic life and collect samples of Martian rock and regolith (broken rock and dust) to later be returned to Earth

VIKRANT MINHAS

China has launched its Tianwen-1 mission to Mars. A rocket holding an orbiter, lander and rover took flight from the country's Hainan province last week, with hopes to deploy the rover on Mars's surface by early next year.

Similarly, the launch of the Emirates Mars Mission on 19 July marked the Arab world's foray into interplanetary space travel. And on 30 July, we expect to see Nasa's Mars Perseverance rover finally take off from Florida.

For many nations and their people, space is becoming the ultimate frontier. But although we're gaining the ability to travel smarter and faster into space, much remains unknown about its effects on biological substances, including us.

While the possibilities of space exploration seem endless, so are its dangers. And one particular danger comes from the smallest life forms on Earth – bacteria. Bacteria live within us and all around us. So whether we like it or not, these microscopic organisms tag along wherever we go – including into space. Just as space's unique environment has an impact on us, so too does it impact bacteria.

We don't yet know the gravity of the problem

All life on Earth evolved with gravity as an ever-present force. Thus, Earth's life has not adapted to spend time in space. When gravity is removed or greatly reduced, processes influenced by gravity behave differently as well. In space, where there is minimal gravity, sedimentation (when solids in a liquid settle to the bottom), convection (the transfer of heat energy) and buoyancy (the force that makes certain objects float) are minimised.

Similarly, forces such as liquid surface tension and capillary forces (when a liquid flows to fill a narrow space) become more intense. It's not yet fully understood how such changes impact life forms.

How bacteria become more deadly in space

Worryingly, research from space flight missions has shown bacteria become more deadly and resilient when exposed to microgravity (when only tiny gravitational forces are present). In space, bacteria seem to become more resistant to antibiotics and more lethal. They also stay this way for a short time after returning to Earth, compared with bacteria that never left Earth.

Adding to that, bacteria also seem to mutate quicker in space. However, these mutations are predominately for the bacteria to adapt to the new environment – not to become super deadly. More research is needed to examine whether such adaptations do, in fact, allow the bacteria to cause more disease.

Bacterial team work is bad news for space stations

Research has shown space's microgravity promotes biofilm formation of bacteria.

Biofilms are densely-packed cell colonies that produce a matrix of polymeric substances allowing bacteria to stick to each other, and to stationary surfaces.

Biofilms increase bacteria's resistance to antibiotics, promote their survival and improve their ability to cause infection. We have seen biofilms grow and attach to equipment on space stations, causing it to biodegrade.

For example, biofilms have affected the Mir space station's navigation window, air conditioning, oxygen electrolysis block, water recycling unit and thermal control system. The prolonged exposure of such equipment to biofilms can lead to malfunction, which can have devastating effects. Another effect of microgravity on bacteria involves their structural distortion. Certain bacteria have shown reductions in cell size and increases in cell numbers when grown in microgravity. In the case of the former, bacterial cells with smaller surface area have fewer molecule-cell interactions, and this reduces the effectiveness of antibiotics against them.

Moreover, the absence of effects produced by gravity, such as sedimentation and buoyancy, could alter the way bacteria take in nutrients or drugs intended to attack them. This could result in the increased drug resistance and infectiousness of bacteria in space. All of this has serious implications, especially when it comes to long-haul space flights where gravity would not be present. Experiencing a bacterial infection that cannot be treated in these circumstances would be catastrophic.

The benefits of performing research in space

On the other hand, the effects of space also result in a unique environment that can be positive for life on Earth. For example, molecular crystals in space's microgravity grow much larger and more symmetrically than on Earth. Having more uniform crystals allows the formulation of more effective drugs and treatments to combat various diseases including cancers and Parkinson's disease.

Also, the crystallisation of molecules helps determine their precise structures. Many molecules that cannot be crystallised on Earth can be in space. So, the structure of such molecules could be determined with the help of space research. This, too, would aid the development of higher quality drugs. Optical fibre cables can also be made to a much better standard in space, due to the optimal formation of crystals. This greatly increases data transmission capacity, making networking and telecommunications faster.

As humans spend more time in space, an environment riddled with known and unknown dangers, further research will help us thoroughly examine the risks – and potential benefits – of space's unique environment.

The writer is a PhD candidate, University of Adelaide, Australia. This article first appeared on www.theconversation.com

PLUS POINTS

Smoother rides

Researchers at the Indian Institute of Technology-Madras Researchers, working in the field of carbon nanotube Composites, have yielded promising results that can contribute greatly in reducing the vibration during car rides.

Polymer composites – materials formed by combining polymers with various additives – have been used for a long time in recorded history for various purposes. Many polymers, loaded with various types of reinforcing fillers, are the mainstay of daily use articles, from automobile parts to construction components.

Prathap Haridoss from the department of metallurgical and materials engineering, IIT-Madras, along with his co-scientists and research students at the institute, are working towards developing and testing interesting polymer composites. The results of their research have been recently published in the international journal *Nanoscale Advances*. The paper was co-authored by Anand Joy, Susy Varughese, Anand K Kanjarla, S Sankaran and Haridoss.

The research will lead to better understanding of the mechanisms of vibration damping in these types of polymers, which would, in turn lead to designs of better vibration dampers in automobiles. Haridoss said, "The outstanding properties of carbon nanotubes (CNTs) – nanometre-sized molecules made of rolled-up sheets of carbon atoms – can tremendously improve mechanical, thermal and electrical properties of polymers. Of the numerous attractive properties of CNT-polymer composites, their vibration damping properties make them useful in aerospace, automobile and construction industries."

Haridoss and his collaborators work with a special class of composites called polymer nanocomposites. The discovery that nanoparticles – particles a hundred thousand times smaller than the thickness of a sheet of paper – can afford extraordinary properties to polymers, is the basis of such composites. "Carbon nanotube-reinforced polymers combine the viscoelastic properties of the polymer with the interfacial properties of the CNT, resulting in enhanced vibration damping. Thus, CNT loaded polymers can conceivably give you a smoother ride on your car. The team decided to find out why," explained Haridoss.

Protein's journey

The mechanism of a protein which transports ammonium across cell membranes has been discovered, which could lay the foundations for preventing infection.

The transporting process is vital to all living things but in two distinct ways. Bacteria, fungi, and plants import ammonium as a major nutrient, using a protein called Amt, but in humans and animals, ammonium must be excreted from cells because of its toxicity; this is performed by another protein called Rh, or Rhesus antigen.

Rh is one of the proteins that is used to classify human blood groups and if the function of expelling ammonia goes wrong, it can lead to disease and death. The Rh and Amt proteins are very closely related and, despite their essential role, how they actually transport ammonium has remained elusive.

The new study, led by the University of Strathclyde in collaboration with the laboratory of Professor Ulrich Zachariae at the University of Dundee and the laboratory of Professor Anna-Maia Marini at the Université Libre de Bruxelles, has revealed the mechanism of Amt, from the bacterium E coli. The researchers found that Amt takes ammonium, which is naturally positively charged, from the environment and fragments into ammonia and the proton particle responsible for the positive charge. Remarkably the Amt protein from E coli transports ammonia and the proton separately, side by side, and the then proton re-joins the ammonia on the opposite side of the membrane to reform ammonium. The study has been published in the journal *eLife*.

The team is pursuing a number of follow-up projects and its next step is to understand the human ammonium transporters, the Rhesus proteins. Apart from their well-known role in blood-typing, malfunction of Rhesus proteins has also been associated with a range of diseases, from haemolytic anaemia to male infertility and early-onset depressive disorders. It is hoped that the results of this work could pave the way for the development of therapies.