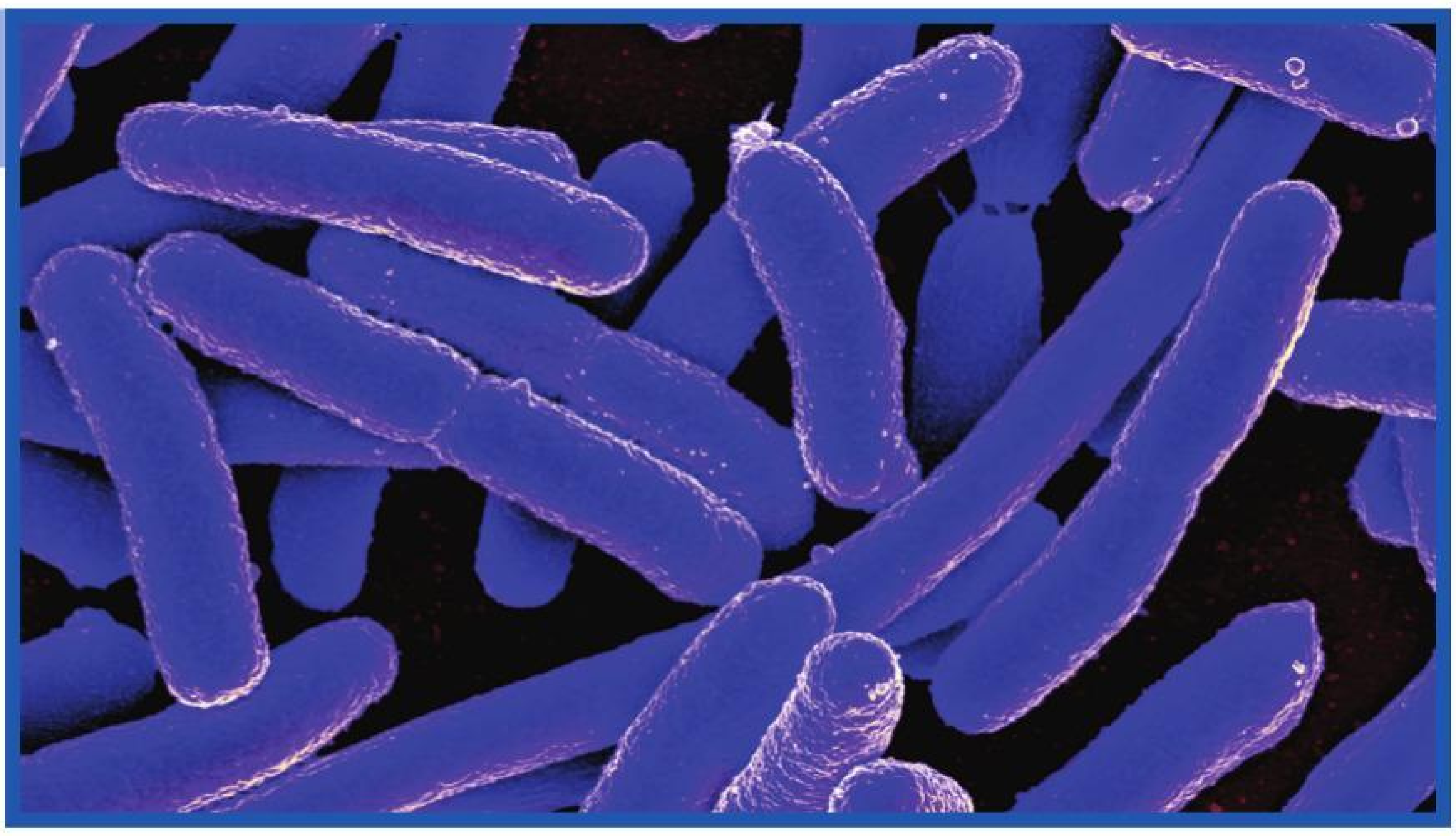
Bacteria strike back

Metals that target the microbe get affected too

S ANANTHANARAYANAN



Copper and silver are known bactericides. The existence of microbes, like bacteria, was not realised till improvements in the microscope in the 17th century. But it was known since ancient times that water stored in copper containers does not develop slime or show signs of fouling.

While we now understand that metals can be selectively toxic to bacteria, a question is what effect the bacteria may have on those metals. Giuseppe M Paternò, Aaron M Ross, Silvia M Pietralunga, Simone Normani, Nicholas Dalla Vedova, Jakkarin Limwongyut, Gaia Bondelli, Liliana Moscardi, Guillermo C Bazan, Francesco Scotognella and Guglielmo Lanzani, from Istituto Italiano di Technologia, Politecnico di Milano, and Consiglio Nazionale delle Ricerche, at Milan, the University of California at St Barbara and the University of Singapore, describe in the journal, *Chemical Physics Reviews*, their work on the effect on silver or its interaction with bacteria. This understanding could even become the basis of imaging the interior of the bacteria.

Metals like copper, silver, gold and platinum are different from others like sodium, potassium, even iron, zinc or aluminum, on a scale of electrical activity. Thus, an electric cell with one electrode as copper and the other as zinc develops a voltage equal to the large difference in electric potential of the two metals. Metals at the copper or silver end of the scale are also less reactive, and form weak bonds with other elements, like chlorine or oxygen. They are thus easily found in nature in the metallic state, without having formed compounds. That is why gold, silver and copper were the first metals to be extracted from their ores.

Metallic copper or silver can hence stay as atoms of the free metal, and if they enter living cells, or the bodies of microbes, they can be toxic. Copper and silver are hence known to be bactericides, as they are more toxic to bacteria than to humans. Copper containers have been considered naturally disinfecting and silver coins were dropped into casks of water or wine, on sea voyages, to keep the contents fresh. Knobs or railings of copper alloys or silver do not harbor microbes and silver is used in medical devices, like breathing tubes and catheters, for the same reason. Silver nitrate swabs have been used to prevent infection and battlefield wounds were wrapped in silver foil or sutured with silver thread.

As the effect of the metal on bacteria comes from individual atoms, which exist as charged ions of the element, the effect is marked when the metal is in the form of nanoparticles, which present the largest surface area. Nanoparticles of silver also display well-known optical features, changes in which have been used to monitor release of charged silver ions in different conditions and surroundings. Atoms of the metal release their outermost electrons, and these electrons move, relatively free, over the surface of the metal. Being charged particles, and influenced by the charge of the mother atoms, they move in waves, which are characteristic. As disturbance of the electrons by a light source modifies the electron wave, there are optical effects, with frequencies of light getting absorbed.

Such effects were known to Roman glassmakers, who embedded silver or gold in the glass, to make goblets that would change colours when the source of light was altered. The effect was studied by the English scientist Michael Faraday in 1857 and an explanation based on scattering of light waves was developed.

The current understanding, however, based on absorption by oscillation modes of free electrons, turns the property into an instrument to study how the electron cloud is affected by surrounding influences. They could be the shape of the nanoparticle, other particles in the vicinity, chemicals, or, as in the present study, microbes and bacteria.

The team writing in *Chemical Physics Review* carried out the study with films of silver, just eight nanometres thick, deposited on a glass slab. A colony of the bacterium, E. Coli was grown and poured on to a base that had been treated with a nutrient. The plates with the silver film were then placed face down on the base that had the E. Coli, as well as on a base without E. Coli, as a control, and left in contact with the bacteria, or the base, for 24 hours.

The silver nanoparticles were then studied, using a high resolution, scanning electron microscope and with scattering of X-rays, to look for changes in shape. And then, with a spectroscope, to look for changes in the colours of light that the nanoparticles absorbed. And yet again, where the sample is excited by a laser pulse and probed by another pulse that rapidly follows.

The images of the silver film, before exposure, show irregular nanoparticles with average thickness of eight nm, the paper says. They stay unchanged by contact with the nutrient-enriched, control medium. Exposure to E. Coli, however, "causes dramatic changes," the paper says. These changes were, first, of the size and shaping of the nanoparticles, with rounding of edges, and clumping together nearer the bacterial membrane and within the bacteria. And then, in the nature of the electron cloud at the surface of the nanoparticles.

The use of silver nanoparticles as a bactericide has gained importance with the emergence of bacteria that are resistant to antibiotics. Knowing the mechanism of interaction of metal particles and microbes would help understand the reasons behind the nanoparticles acting on the organisms but not on human cells. It would help devise new applications and therapeutic strategies.

It is challenging to study the internals of microbes while the microbes are alive. Nanoparticles that have been exposed to the microbes, however, can be examined and studied in detail. Nanoparticles could thus serve as proxies, for the study of things like bacteria, and also to detect their presence.

The writer can be contacted at response@simplescience.in

PLUS POINTS

Gifted for tax bills

A vast collection of personal belongings and landmark papers belonging to professor Stephen Hawking have been gifted to the United Kingdom.

The contents of the late British physicist's office have been handed by his family to London's Science Museum, while an archive of scientific and personal papers have been given to the University Library in Cambridge, where he lived. Among the "treasure trove" of items include Hawking's personalised wheelchairs, voice synthesisers and his original PhD thesis.

The acquisition, announced on last Wednesday, was made through the government's acceptance in lieu scheme, which allows people to pay their inheritance tax bill by donating important cultural, scientific and historical objects to public collection. The office contents to the Science Museum settles £1.4m tax and his archive to Cambridge University Library settles £2.8m tax.

Described as a "once-in-a-lifetime" acquisition, it includes a "treasure trove" of research papers, personal letters and mementoes of the great scientist's life. His children, Lucy, Tim and Robert, said they were "very pleased" to see their father's work preserved "for the benefit of generations to come".

"Our father strongly believed that everyone should have the chance to engage with science so he would be delighted that his legacy will be upheld by the Science Museum and Cambridge University Library," they said.

The renowned scientist died at his Cambridge home on 14 March 2018 at the age of 76. Diagnosed with motor neurone disease in his twenties, he went on to become known as one of the greatest scientific minds in the history of the world.

Hawking shot to international fame after the 1988 publication of his book *A Brief History of Time*, and he would also embrace areas of popular culture, appearing several times in the TV show *The Simpsons*. His work ranged from the origins of the universe itself, through the possibility of time travel to the mysteries of space's all-consuming black holes. His most famous theoretical breakthrough was the idea that black holes are not really black but can produce thermal radiation and potentially "evaporate". Scientists refer to such potential emanations as "Hawking radiation".

The Science Museum plans to display selected highlights of the acquisition early next year, including his custom-built Permobil F3 Corpus wheelchair. Also, on display will be his glasses, which contained an infrared sensor that he operated by moving his cheek, and other innovative communications devices that generated his famous voice. The museum will also show documented bets the professor made with fellow scientists, using his thumbprint as authentication.

The Cambridge archive contains letters dating from 1944 to 2008, a first draft of *A Brief History Of Time*, and letters he wrote to popes, United States presidents and leading scientists of our time. Cambridge University Library said the 10,000-page archive joins those of Sir Issac Newton and Charles Darwin, bringing "together three of the most important scientific archives in history under one roof".

Hawking's son, Tim, said his family were "delighted" that his father's body of work and memories were being safeguarded. He said, "Our father would be really pleased. It was really important during his lifetime that science be opened up to the widest possible number of people and be democratised and not be the preserve of the elite few."

"So I think this body of work will help – hopefully inspire – the next generation to come."

–The independent

ESCAPE TO SURVIVE

Is the Covid-19 pandemic a prelude to space colonisation?

BIJU DHARMAPALAN

Every year, 12 April is celebrated as the International Day of Human Space Flight under the auspices of the United Nations. It commemorates the anniversary of the first human space flight on 12 April 1961 by Soviet Union astronaut, Yuri Gagarin. Since then, citizens from 41 countries have flown to space, including India's Rakesh Sharma, who did so aboard the Soviet rocket Soyuz T-11 launched from Baikonur Cosmodrome on 3 April 1984.

After the "space race" ended, many countries collaborated to build the International Space Station. The ISS was constructed with contributions from 15 nations and their space agencies of whom the National Aeronautics and Space Administration (United States), Roscosmos State Corporation for Space Activities (Russia) and the European Space Agency are major funding partners. As of January 2018, 230 individuals from 18 countries have visited the ISS. The long-term habitation of the ISS by teams of astronauts, scientists and medical professionals has provided a wealth of data to establish the parameters for keeping humans alive and healthy for long periods in the harsh environment of space.

Once in the realm of science fiction, space travel and space colonisation could soon become a reality. The urgency to establish humanity as a multi-planet species has been revalidated by the emergence of the Covid-19 pandemic. It has taught us to live in an enclosed area wearing extra equipment – in a way, quite like astronauts travelling to space.

Need for space colonisation

Every part of Earth, be it mountains or oceans, has become a repository of harmful pollutants and the planet is slowly transforming into an inhospitable region, thanks to us. The grand history of life on Earth shows that faced with a hostile environment, organisms inevitably meet one of one fates – they can leave, adapt or die out. Going by the present, it can be said that we will eventually face a disaster so great in future that adaptation will be virtually impossible.

Global disasters have happened many times in the past and they will inevitably happen again. Earth has already witnessed five major extinction cycles in which up to 90 per cent of all life forms vanished. It's imminent that extinction will happen and to tide over that, we must establish ourselves as a multi-planet species. Elon Musk, the entrepreneur behind space tourism company SpaceX, said recently, "I think there is a strong argument for making life multi-planetary in order to safeguard the existence of humanity in the event that something catastrophic were to happen." We must leave Earth, or we will perish.

Hopping across to Mars

The successful landing of the Mars Perseverance Rover on 18 February this year is a scientific and technological landmark. At an average distance of 140 million miles, Mars is one of Earth's closest habitable neighbours and many people are interested in colonising the Red Planet in the immediate future, as soon as 2050.

Mars is about halfway between the Sun and Earth and therefore, has decent sunlight. It is a little cold, but we can warm it up. Gravity on Mars is about 38 per cent of that on Earth, so you would be able to lift heavy things and bound around! Furthermore, the diurnal cycle is remarkably close to that of Earth. Its atmosphere is primarily carbon dioxide with some nitrogen, argon and a few other trace elements, which means that we can grow plants on Mars just by compressing the atmosphere.

Recently Nasa astronauts successfully grew "Amara" mustard (*Iberis amara*) and "Extra Dwarf" pak choi (*Brassica rapa*) on the ISS. They were grown for 64 days – the longest leafy greens have grown on the station. The plants were cultivated for the "veggie study" that is exploring space agriculture to sustain astronauts on future missions to the Moon or Mars.

The scientific community is already discussing how homes should be built for space colonisers. Many architects have come up with designs for making homes using the resources available in the Martian environment. Nasa is also conducting competitions to select the best designs that could be adopted in their missions.

Musk wants to build a city on Mars by 2050. His company has already developed the Dragon spacecraft that can carry up to seven passengers to and from Earth orbit and beyond. It is the only spacecraft in operation that can return significant amounts of cargo to Earth and is the first private spacecraft to take humans to the space station.

Taking people and settling them in specialised housing structures may be possible, but if we want to preserve or save our species, we need to produce our next generation in space itself. On the other hand, when long-term space missions to outer planets become a common phenomenon, people will start interplanetary business ventures like mining of minerals or even the water from the Moon that could be used as fuel for rockets. You start your journey from Earth; take a break on the Moon for refuelling and then move on to Mars!

During this year, three countries – U S, China and the United Arab Emirates – have successfully sent rovers to Mars. Several countries will follow suit soon, apart from private players. The ultimate objective is to establish one's own space colony with one's own people. Would we compete with each other as we do on Earth or start a new culture of cooperation and unity for the sake of saving our species?

Science diplomats should come up with an International Treaty regarding the sharing of resources and maintaining the environment in Mars and other planets humans are expected to inhabit in future. Otherwise we would be creating another Earth-like culture on Mars – one where humans fight over religion, class, politics and race.

The writer is a science communicator and can be contacted at bijudharmapalan@gmail.com