

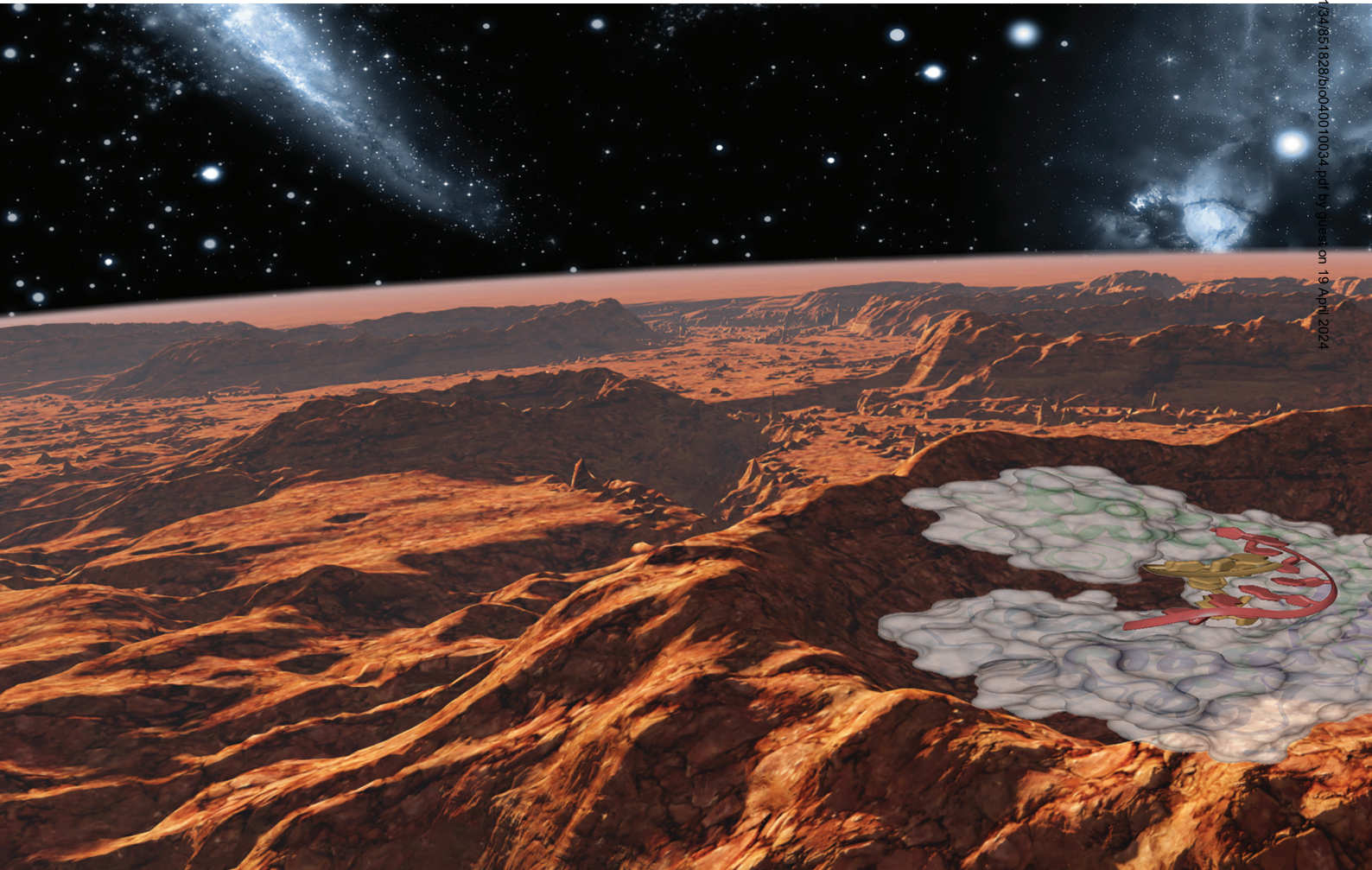
Science Communication Competition

The Science Communication Competition is now in its seventh year. As in previous years, it aims to find young talented science writers and give them the opportunity to have their work published in *The Biochemist*. In 2015, a new branch of the competition was launched to include video entries. Overall this year's competition attracted 82 entries and these were reviewed by our external panel of expert judges. The third prize in the written category was awarded to **Catherine Baker**, University of Glasgow, whose article is presented here; the third prize in the video category was **Inés Dawson**, University of Oxford. Inés' video can be viewed at bit.ly/scicomm3.

Bacteria are out of this world! Could they help us clean up our act?

Catherine Baker
(University of Glasgow, UK)

Bacteria are everywhere, in your hair, your clothes, your body, your food, your pets, your house, your garden and even in the air surrounding you! They can survive almost anywhere on the planet. Some even survived a trip into space on the International Space Station. So how is it that something so small can live a happy life in conditions where humans don't stand a chance?



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Imagine going to the beach on a hot day. Everyone around you is crisping up in the midday sun, sticky with sweat, hunched in the shade to keep cool. But you don't notice the heat, you can't feel it at all and your body remains a comfortable temperature. So whilst others endure hot sand and rapidly melting ice-creams, you're quite happy pottering about, enjoying the warmth, the heat simply doesn't affect you.

As well as feeling content in the sunshine you don't have to park yourself in front of a fan to cool off; you can make use of the sun. You can fix up your garden, cut the grass, and hang clothes outside to dry. The warmth allows a whole new sense of productivity as everyone around you struggles. This is how it works for thermophilic bacteria which don't just endure, but thrive in temperatures above 50°C. The special powers of these bacteria can be harnessed and exploited by us for a wide range of industries.

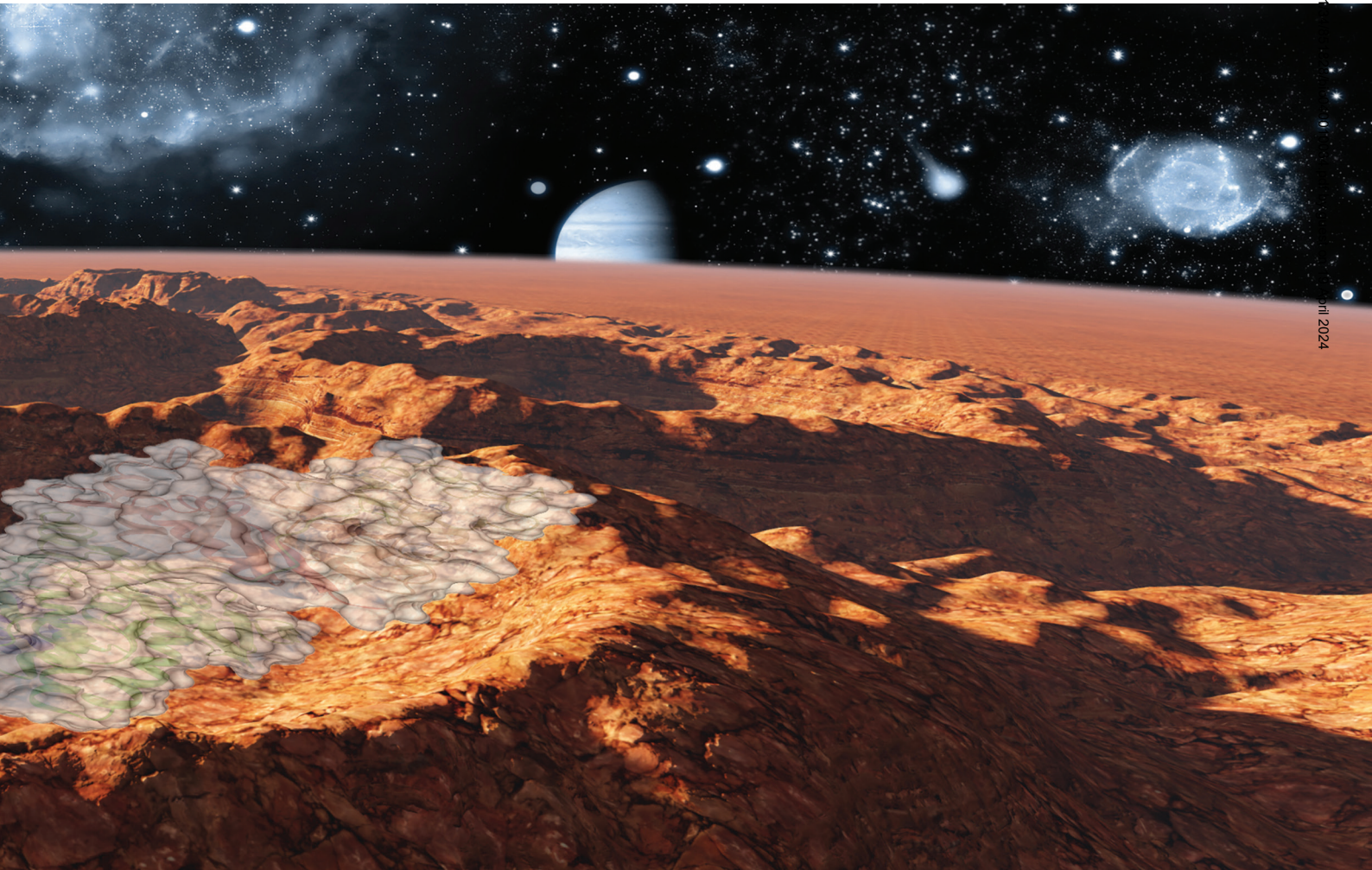
Thermus aquaticus, which is happiest at 70°C, is one such example. *T. aquaticus* was found in hot springs in Yellowstone national park, thriving where few bacteria could survive. It produces an enzyme called Taq polymerase. This enzyme helps in the making of new DNA by adding to it at one end. Many enzymes only function within a small range of temperatures which are specific to the organism that they work in. Taq polymerase, however, can work at a wide range of

temperatures. Most enzymes with this function have a proofreading mechanism to prevent mistakes but Taq polymerase does not.

This means it can make new DNA faster, which makes it ideal for PCR (polymerase chain reaction). PCR is a technique used in labs across the world to make many copies of DNA. The process requires heating and cooling to treat the DNA.

In bacteria, the whole cell is affected by heat, not just the outer surface. Every part of the bacteria must be able to cope in high temperatures. Just like ice-cream on a hot day, DNA and protein melt, or denature, at high temperatures. In heat-loving bacteria their DNA is tightly packed and coiled up so it doesn't melt as easily. Some thermophiles also have helper proteins called chaperonins. These assist the bacteria by grabbing onto melted proteins and using chemical forces to fold them back to their functioning shape. Instead of dripping down your arm, your Mr Whippy sits nicely on its cone.

Charles Cockell and his team blasted bacteria samples up to the International Space Station to see if anything could survive in arguably the toughest environment for life. The extreme conditions on Earth seem relatively tame when you think about the conditions in space: extreme temperature changes, extreme dryness, little gravity and high levels of UV radiation.



UV radiation isn't just an issue in space; we've all stayed out a little too long in the sun and ended up looking slightly like a lobster. The danger of UV radiation is that it can cause mutations and break DNA. This means that cells can no longer make the correct proteins needed for survival.

Cockell and his team found that some bacteria lived for over a year in space while exposed to high levels of UV radiation. But how? When the samples returned to Earth, one sample had a group of charred looking cells on the surface of the colony, but underneath the other cells were fine. Imagine you're back on that beach. With no shade to protect you from the midday sun you would burn to a crisp. If your friends kindly huddled around to protect you, they would inevitably end up burnt but you, and the others in the middle of the group would be unscathed. Some samples were found to have thick outer surfaces to keep in moisture and protect them from the sun's power; it probably would be a bit sweaty inside that huddle. It is thought that these seemingly invincible bacteria could be used to establish life on the moon or even Mars by extracting minerals for us.

Although life on another planet seems appealing with all the political drama going on at the moment, for now, we have to stay put and clean up the messes we've made. Everybody has heard of the 1986 Chernobyl nuclear disaster. Even 30 years later, the 30km exclusion zone around the power plant remains. An eerie mix of nature thriving without humans, but entire towns left as they were on the day of the disaster; food still in kitchen cupboards, clothes still hanging in wardrobes and hospital beds still made as if waiting for the next patient.

Currently, radiation levels are too high to allow humans to return, but would it be possible to make that land safe again and retrieve it from the plants that have claimed it as their own? Bacteria could be the answer! *Deinococcus radiodurans* is a bacterium, related to *T. aquaticus*, which can survive in extremely high levels of radiation and could be used to breakdown the nuclear waste.

As with UV radiation, nuclear radiation is dangerous to us as it is absorbed by the body and can react with DNA, causing damage. In humans and animals this can result in a whole host of illnesses, including cancer, as the cells don't know when to stop dividing. How do the bacteria survive this radiation?

Think back to that beach on this seemingly never-ending sunny day. You have a nice cold drink in your hand but the ice in it has melted and its rapidly becoming a tepid mess. Now imagine someone chucks a handful of ice in there, and it becomes a tasty refreshment again. This is how *D. radiodurans* survives radiation; it has rapid DNA repair techniques. Using

special DNA repair proteins, it can reassemble pieces of DNA that have been shredded by radiation and stick them back together. High levels of an element called manganese are thought to protect the bacteria's DNA from becoming damaged in the first place as well as reducing damage during the repair process. This means it can quite happily live with radiation 1000 times stronger than us mere humans can survive in.

Changing the DNA of *D. radiodurans* may allow it to be used in the clean-up of nuclear waste. By taking DNA from *Salmonella enterica*, a bacterium which commonly causes food poisoning, and placing it in *D. radiodurans*, it can make use of *S. enterica*'s special skills. *S. enterica* produces a protein which can attach to dangerous metals such as uranium, a type of nuclear waste, and change their shape. This change means that the metal isn't as dangerous and can't move as freely in soil so can be extracted from contaminated land.

S. enterica itself can't survive radiation like *D. radiodurans*; it doesn't have the all singing, all dancing equipment, but it can lend a helping hand by donating its skills to *D. radiodurans*, which can steal the show. Hopefully *D. radiodurans* can help us out and clean up nuclear waste so we don't have to relocate elsewhere in the solar system!

So next time you're too hot, or too cold, or too thirsty, or stuck in the middle of a crowd, think about the tiny bacteria that would love to be in your situation - having a great time, making the most of the conditions which seem incredibly inconvenient to you. ■

Read more about extremophiles and how they survive in such tough conditions in the December 2017 issue of the magazine.

Further reading

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