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To Beat the Heat, Personal Cooling That You Can Take With You

Saharan ants, camels inspire scientists looking for new technologies to keep people cool without air conditioners

By Mark Harris

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Some office workers in Tokyo and Hong Kong have a hidden weapon against blistering summer temperatures.

Slipped discreetly into a pocket in the collar of special business shirts, Sony's Reon Pocket 4 device rests a cool metal pad against the back of the neck. The gadget, about the size of a small television remote, relies on a thermoelectric phenomenon called the Peltier effect. When electric current flows through the junction of two different conductors, it causes one to heat and one to cool—effectively pumping heat away from the wearer.

Even though the Reon provides only a modest chill, a predecessor device with a smaller battery swiftly sold out last year. Sony says it sees interest in personal-cooling tech increasing, and anticipates a growing market.

The prospect of a warming world is propelling efforts to find new options for personal cooling—a challenging pursuit that some see going far beyond

questions of comfort. Whether exploring ways to take thermoelectrics to new levels or looking to desert ants and camels for inspiration, researchers and scientists are seeking innovative solutions, not just for sweaty executives, but farmers, factory workers, first responders and others who lack access to traditional air conditioning.

Sony's Reon Pocket 4 device for personal cooling and heating.

PHOTO: SONY GROUP CORPORATION

"You can't just bring an AC unit with you in the field," says Sheng Xu, a professor of nanoengineering at University of California San Diego who is working on the next generation of thermoelectric devices, aimed at providing respite for farmworkers and others who labor outside when temperatures rise. "It's too costly, and too heavy for people working long, strenuous hours."

Xu has incorporated flexible prototype thermoelectric patches into an undershirt, with the hot side of the thermoelectric device separated from the skin by a small air gap. This prevents heat from flowing back to the wearer. He says he has demonstrated a local temperature drop of about 10 degrees Celsius (18 degrees Fahrenheit) and envisions a cellphone-size battery pack powering his system for up to eight hours.

"We should have a product ready to deploy within about two years," he says. "Right now, everything is made manually by my students, and except for the manufacturing, it isn't rocket science."

Others are skeptical that thermoelectrics are the answer for personal cooling. "They're not super efficient, so to power them on a person who's moving around and not tied to a power source is quite challenging," says Jarad Mason, a chemistry professor at Harvard University. His research in air conditioning, rather than personal cooling, focuses on replacing liquid refrigerants with so-called barocaloric materials—solids that heat up or cool down when squeezed. These stationary cooling devices would be similar to the window units and heat pumps in use today, he says, but smaller, simpler and greener.

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Heat has been worrying the Department of Homeland Security for years, says David Alexander, senior science adviser for resilience in its Office of Science & Engineering: “Extreme heat events are occurring more frequently, all over the U.S. They are the most significant and growing cause of weather-related deaths.”

As part of its mission to protect first responders and outdoor workers, as well as people displaced during emergencies, the DHS in 2021 launched a $195,000 Cooling Solutions Challenge prize competition to kick-start the development of cooling solutions—efficient and lightweight technologies that people could sit inside, carry or even wear.

An entrepreneur inspired by the Saharan silver ant is among last summer’s winners. Surviving in a searing desert, the silver ant is the world’s fastest ant, darting out swiftly from the shade to scavenge for food in the full heat of the African sun.

Saharan silver ants have characteristics that enable them to withstand high temperatures, which have inspired some researchers developing cooling technologies.

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Looking into how the natural world deals with high temperatures, Don Chernoff, a materials scientist from North Carolina, read research about the Saharan silver ant led by the University of Zurich. For many years, naturalists had assumed that the ant's silvery hue simply reflected enough sunlight to maintain a safe temperature. But a team of scientists in the U.S. and Switzerland discovered that was only part of the story.

Examining the ant under powerful microscopes, they found that its body hairs had evolved into an unusual triangular shape, like tiny, hollow Toblerone chocolates. This structure is very effective at scattering most

radiation, including sunlight. But it is also almost transparent to a narrow band of infrared radiation corresponding to the temperature of the ant itself, allowing it to beam out its body heat, even on the sunniest day.

In 2020, researchers at Ningbo University in China showed that the ant's cooling system can work at a human scale, too. They covered a smartwatch with tiny silicone fibers containing triangular air gaps, modeled after the ant's hair, that reduced the watch's temperature by 4.5 degrees Celsius (8 degrees Fahrenheit). With his $25,000 DHS prize, Chernoff has recruited textile engineers at North Carolina State University to develop a hairlike clothing material that would actively cool anyone wearing it. He admits that any cooling garments are a long way from shelves. "So far it is all challenge and no success, but I'm hoping to have fabrics to test this year," he says.

The camel provided a guide for Zhengmao Lu, a materials scientist at the École Polytechnique Fédérale de Lausanne in Switzerland and part of a team that won a runners-up prize in the DHS challenge.

Camels' thick fur helps insulate them from the heat while allowing water vapor from their sweat to escape.

PHOTO: DOMINIKA ZARZYCKA/NURPHOTO/GETTY IMAGES

"If you shave a camel, its water consumption doubles," Lu says. "Very heavy fur in a hot desert might seem a counterintuitive dress code, but it's necessary for the camel's survival."

Like humans, camels have sweat glands to cool themselves using evaporation. Under the desert sun, their thick fur insulates them from their hot surroundings, while allowing water vapor from their sweat to escape.

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What do you see as the most useful applications of personal cooling technologies in coming years? Join the conversation below.

Lu's version reimagines the camel's cooling system as a multilayered material that could form a garment—or, for now, a packaging material to keep food and medicines cool in hot climates. The "sweat" comes from a skinlike hydrogel—a network of polymers similar to collagen or gelatin that is up to 99% water by weight. On top of that, Dr. Lu places an aerogel to act as the "fur." This tough and ultralight top structure is 90% air, making it both highly insulating and extremely porous to water vapor.

To make the composite material more effective, Lu uses a hydrogel that shares the silver ant's ability to emit infrared radiation, and an aerogel that lets that radiation through while still reflecting sunlight. In tests, the material was able to keep a container at least 9 degrees Celsius (16 degrees Fahrenheit) cooler than the ambient temperature, without using any power at all, Dr. Lu says.

While Lu thinks his technology could initially be used to keep packages cool, "the materials that we're developing are perfectly applicable to personal cooling," he says. "Adjusting the material's layers gives you a recipe you can use for different climates—which is really cool."

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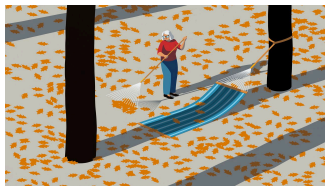

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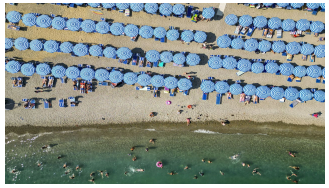

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