FEATURE

Crabs Give Blood for Space Travel

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Soon, astronauts onboard the ISS will test a high-tech medical device that uses primitive enzymes from horseshoe crabs to diagnose human illness.

Nov. 16, 2006: Picture this: You're on a mission to Mars, halfway there from Earth, and you're not feeling well. Your throat hurts when you swallow, your forehead is hot. You don't want to get sick or infect your crewmates. Should you take an antibiotic? If so, which kind?

With a new biological laboratory on a chip being developed at NASA's Marshall Space Flight Center in Huntsville, Alabama, in partnership with outside researchers, you may be able to get the answer in as little as five minutes.

The mini-lab goes by the maxi-acronym LOCAD-PTS, which stands for *L*ab-*O*n-a-*C*hip *A*pplication *D*evelopment–*P*ortable *T*est *S*ystem. The latest version is a handheld device slated for launch this December aboard shuttle mission STS-116 for testing on the International Space Station.

Right: LOCAD-PTS. Image credit: NASA.

On Earth, the most reliable method of diagnosing illness is to take a sample of bodily fluid (throat swab, or blood or urine sample) and culture them on Petri dishes with different growth media in a medical laboratory. Culturing decisively reveals whether an infection is viral (which will not respond to antibiotics) or bacterial or fungal (which will), Culturing also pinpoints the species and thus the most effective kind of antibiotic.

"So-called gram-negative bacteria, such as *E. coli* and Salmonella, respond to different antibiotics than gram-positive bacteria, such as Staphylococcus," explains Ginger N. Flores, LOCAD project manager at Marshall.

But cultures can be impractical, chiefly because growing them takes two or three days—by which time a person might be very ill, indeed. LOCAD-PTS, on the other hand, is fast: "It gives results in 5 to 15 minutes," says Norman Wainwright, the project's principal investigator and director of research and development at Charles River Laboratories in Charleston, SC. "And it's very sensitive—it can detect just a single bacterium."

The high-tech device relies on four enzymes extracted from the blood cells of one of Earth's most ancient living creatures: the horseshoe crab. "The horseshoe crab, a species that has survived some 300 million years, has a very primitive but sensitive immune system," Wainwright continues. A single bacterium can be enough to trigger enzymes in the crab's immune system, which clot the blood to seal off a wound.

The enzymes' extraordinary sensitivity and rapid response makes them widely useful in medical research to test the effectiveness of drugs and devices. (Withdrawing a bit of blood annually from horseshoe crabs, which are then returned to the wild, does not injure the creatures, and so far there is no acceptable synthetic substitute.)

It is these horseshoe crab enzymes that allow LOCAD-PTS to be so small, sensitive, and fast. First, a tiny amount of enzyme is inserted into tube-like channels and dried. Introducing any liquid sample to be tested into the channels rehydrates the enzymes. If the sample includes bacteria, their toxins trigger the enzymes, which change the liquid's color—the degree of color change depending on the number of germs.

Right: Horseshoe crabs on a beach. Photo credit: University of Delaware. [More]

The experiment package scheduled to fly in December will compare LOCAD-PTS to tried-and-true Petri-dish methods. Once a week for six weeks, astronauts will press a sticky, flexible patch onto an exposed surface, and then swab a short distance all around the patch. Any bacteria adhering to the swab will be introduced into LOCAD-PTS, whereas any bacteria adhering to the sticky patch will be cultured. A few days later, bacterial colonies will counted in the traditional manner.

Note: This procedure takes advantage of the fact that humans aren't the only astronauts in space: the surfaces of the space station, just like walls, floors, and kitchen counters here on Earth, are rich in bacteria ("one small step for a germ…").

Of course, Wainwright and Flores expect that LOCAD-PTS will prove to be fast--but what about *accurate*? A big unknown is how well LOCAD-PTS will compare in analyzing the type of bacteria, and how well its color changes can be calibrated to the number of bacterial colonies that grow. "We also want to see how easy and practical the device is for astronauts to manipulate in microgravity," Flores adds.

Although the initial LOCAD-PTS will test only for Gram-negative bacteria, "we plan later also to test for Gram-positive bacteria, yeast, mold, and certain chemicals."

Eventually, if all goes as planned, one sample from the throat of an ill-feeling astronaut could be sent flowing through parallel channels on a future generation of LOCAD-PTS, and could indeed, within minutes, come up with a diagnosis like "take two Amoxicillin and call me in the morning."