Bacterial response to oxidation studied as toxin barometer

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Common bacteria with an overt reaction to toxins that cause oxidative stress show promise as a biosensor to predict public health threats.

At the 233rd American Chemical Society national meeting in Chicago March 25-29, researchers from Virginia Tech and the Edward Via Virginia College of Osteopathic Medicine (VCOM) will report their work on a bacteria biosensor prototype and correlations to brain tissue damage.

Many environmental toxins in water, such as pesticides, heavy metals, and PCBs, kill through oxidative stress mechanisms, said Bev Rzigalinski, a pharmacologist with VCOM. Oxidative stress is caused by unbalanced molecules called free radicals and other oxidation-promoting molecules that damage cells and genetic material by removing electrons.

Gram negative heterotrophic bacteria "spit" potassium in the presence of oxidative stress, said Nancy Love, a professor in civil and environmental engineering and an adjunct in biology at Virginia Tech.

"More like 'sweat' potassium," said Kaoru Ikuma of Nishinomiya, Japan, an environmental engineering graduate student at Virginia Tech.

However you describe the process for the non-scientist, the bacteria's response of pushing potassium out of their cells in the presence of oxidative stress is called the glutathione-gated potassium efflux (GGKE) response. "Typical bacterial you find anywhere will have this response, but these particular bacteria really spew potassium," said Love.

And Rzigalinski was pleased to hear it. Perhaps the GGKE response could be used to predict potential damage to animal and human cells. "But bacteria are different from mammalian cells," said Rzigalinski, who is focused on neuroscience, particularly brain injury and aging, and nanotechnology.

"We wanted to see if the same type of marker would work with human cells, particularly brain cells. We used the bacteria to calibrate a sensor," she said. "The bacteria are easier to prepare and more robust than using mammalian cells, such as rat brain tissue. Brain tissue is the most sensitive to toxins. We wanted to relate the bacteria response to cell response, like a barometer."

"And we saw that it corresponds well," said Ikuma. "Something that sets the bacteria off also sets the cells off.

Using the toxin, N-ethylmaleimide, as a constant, Ikuma and Rzigalinski are taking measurements and seeing correlations of GGKE response to mitochondrial damage in cell cultures.

"If we can create a library of cellular response, we might have either a generic or a specific predictor," said Brian Love, professor of materials science and engineering at Virginia Tech. "We don't know yet because we haven't tested other cell types."

Brian Love has been assisting with the research team's attempts to immobilize the sentinel bacteria as part of a biosensor design strategy.

Nancy Love began her work with microbes by finding organisms that could be used to digest waste in wastewater treatment plants. When she noticed that the useful organisms were being put out of commission by various toxins in the water, she and a student went to a conference of microbiologists who work with stress systems. “We saw a connection between what they were seeing in food processing and what we were seeing in wastewater systems.”

She discovered that the ubiquitous Gram negative heterotrophic bacteria were being used to monitor food processing systems – so why not wastewater?

After doing work to develop what Brian Love describes as “bacterial canaries” as an early warning system to protect the microbes in wastewater systems, Nancy Love began to look for other applications, from water monitoring in general to specific health monitoring in other biological systems in the environment, and met Rzigalinski, who is focused on neuroscience, particularly brain injury and aging, and nanotechnology.

“It is a good sensor because it measures biological effect rather than concentrations,” Rzigalinski said. “So we can measure oxidative damage when we stick the sensor in the water, not individual concentrations of individual chemicals. It also announces the presence of an oxidative toxin you haven’t identified.”

“We don’t have to have 20 sensors for 20 toxins. We can sense the presence of any oxidative toxin,” Love said.

Ikuma, who was an undergraduate biology student at Virginia Tech when she began working with Love, has now come full circle from a biology student working on a civil engineering research project to an engineering student working on a biology project.

Source: Virginia Tech