Bacteria gauge cold with molecular measuring stick

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Some bacteria react to the cold by subtly changing the chemistry of their outer wall so that it remains pliable as temperatures drop. Scientists identified a key protein in this response mechanism a few years ago, but the question of how bacteria sense cold in the first place remained a mystery. Based on a study by scientists at Rice University and Argentina's National University of Rosario, the answer is: They use a measuring stick.

The study, published in the September issue of Current Biology, involved a series of intricate experiments on the bacteria Bacillus subtilis. The researchers found a specialized protein that protrudes through the bacteria's outer cell wall acts as a measuring stick that's tuned to give a signal when temperatures outside the cell drop.

Scientists have long known that cells use specialized proteins called "transmembrane" proteins to sense and react to the outside world. Transmembrane proteins protrude through the cell's outer wall, or membrane.

"All living cells have the ability to respond to external stimuli, but in most cases that we are aware of, signal recognition -- the event that triggers the response -- occurs when a transmembrane protein binds physically to another chemical outside the cell," said study co-author Ariel Fernandez, research professor at Rice.

Fernandez said the *Bacillus subtilis* study is one of the first to determine how a transmembrane protein can respond indirectly to a physical stimulus outside the cell. The research was highlighted in review articles in both *Current Biology* and *Nature Reviews* Microbiology.

He and colleagues examined a transmembrane protein called DesK (pronounced des-KAY). In previous studies, scientists had found that DesK responded to cold temperatures by causing the cell to make a special compound that keeps the membrane pliable. Without the compound, the fatty acids inside the cell wall become more rigid as temperatures fall.

Fernandez and colleagues found that the part of the DesK protein that protrudes outside the cell contains a sensitized tip. As long as the tip remains in contact with water molecules outside the cell, DesK remains switched off. As temperatures fall and the cell membrane becomes more rigid, the membrane also becomes thicker. As it thickens, it engulfs the sensitized end of the temperature probe, cutting off contact with water molecules outside the cell. This, in turn, activates DesK and sends the signal to release the cold-protecting chemicals. This mechanism, which Fernandez named the buried buoy trigger, was proposed by Fernandez and probed experimentally by the Argentinean team.

The molecular biology and experimental probes were conducted in the laboratory of Diego de Mendoza at the National University of Rosario in Rosario, Argentina. To confirm the findings, the group constructed versions of DesK proteins of varying lengths. Using these as longer or shorter measuring sticks, the researchers confirmed that the signaling mechanism was triggered based upon whether the tip of the transmembrane sensor remained in contact with water molecules outside the membrane.

Provided by Rice University