MECHANISMS OF CRYOPROTECTION

A handful of species have learned how to survive in freezing climates. To do so, the animals must counteract the damaging effects of ice crystal formation, or keep from freezing altogether. Here are a few ways they do it.

ANTIFREEZE PROTEINS

Antifreeze proteins (AFPs) ❶, first identified in the blood of Antarctic fishes, have repeating structures that bind to the surface of ice crystals and prevent them from growing into larger crystals ❷. AFPs isolated from the blood of these fishes have been used successfully to preserve rat and pig hearts at below-freezing temperatures for up to 24 hours.

CRYOPROTECTANTS

As the temperature drops, extracellular water begins to freeze, leaving behind a slush of concentrated solutes. In an attempt to dilute those solutes, water rushes out of the cell ❸, causing significant cell shrinkage and death. But cryoprotective compounds such as glycerol, glucose, urea, and trehalose accumulate inside cells to help equalize the imbalance of solutes, preventing water loss and cell damage ❹. Scientists have found that during the fall, wood frogs accumulate urea, and later glucose, to preserve their organs when the frogs freeze solid during the winter.

AQUAPORINS

Water can make its way through a cell membrane unaided through the process of osmosis, but a quicker way into or out of a cell is through an aquaporin—a membrane protein that regulates the flow of water into and out of cells ❺. Scientists have found that aquaporins help some freeze-tolerant frogs move not only water but glycerol into cells in preparation for freezing. Aquaporins also help freeze-avoiding insects move water out of cells during cryoprotective dehydration.