Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

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To see more of Brunning's work, go to **compoundchem.com.** To see all of C&EN's Periodic Graphics, visit **cenm.ag/periodicgraphics.**

HOW ANIMALS SURVIVE FREEZING

Many animals, including some species of fish and frogs, can tolerate subzero temperatures. Here we look at the biochemical adaptations that help them stay alive.

TYPES OF FREEZE SURVIVAL

If the liquid in an animal freezes, ice crystals can damage cells and tissues. Animals avoid this in one of two ways.

Freeze avoidance

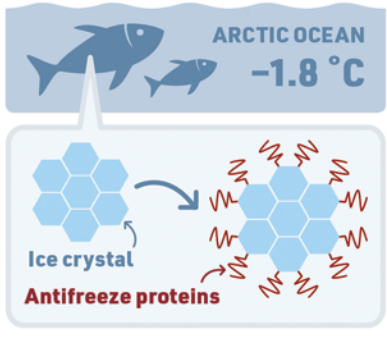
Many fish and arthropods use freeze-avoidance approaches, which keep their bodily fluids liquid below 0 °C.

Freeze tolerance

Freeze tolerance helps some frogs, intertidal marine invertebrates, and lizards keep ice formation outside cells.

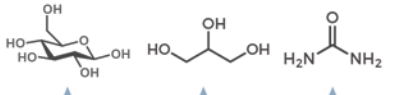
FREEZE AVOIDANCE

Some species use antifreeze proteins to limit ice formation in their bodily fluids. The proteins bind to small ice crystals and stop them from growing.



Many species also rely on cryoprotectant compounds in their blood. These compounds dissolve in the water in cells and lower the temperature at which it freezes.

Common cryoprotectants



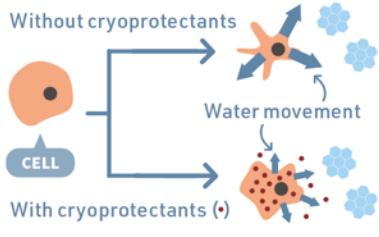
Glucose and urea are common cryoprotectants in frogs, while insects commonly use glycerol or other polyols.

FREEZE TOLERANCE

Freeze-tolerant species pack their cells and organs with cryoprotectants to prevent ice formation inside them. Meanwhile, ice-nucleating proteins help freeze water in the blood, where ice crystals do less harm.

WOOD FROGS
Up to 65% of their body water can freeze for up to 7 months.

Cryoprotectants stabilize the animals' cell membranes and minimize cell shrinkage due to water loss as ice forms outside the cells.



PERIODIC GRAPHICS