CM Krane
Lay Abstract for 2013 STARS

“Frozen Alive”

Preservation of biological tissues by freezing has application in fields ranging from reproductive technology to conservation of endangered species. However, while scientists are able to cryopreserve small living structures like eggs and embryos, application of those strategies to larger structures remains challenging. The natural world provides models that can provide insights into overcoming those challenges. Many “cold-blooded” animals encounter sub-freezing temperatures in their natural environment and, among the vertebrates, a few species have evolved physiological and biochemical strategies to survive freezing. We study one of those species, Cope’s gray treefrog, which can survive ~60% of its body water turning to ice.

Freezing imposes daunting challenges for an animal. Physical damage from ice crystals could be lethal. Blood flow ceases as the circulatory system freezes, and so tissue oxygenation is reduced. Cold temperatures suppress metabolism. And molecular and cellular structures are disrupted as liquid water freezes and body fluid concentrations change. A key element to surviving these challenges is regulation of the distribution of water and dissolved solutes. Ice formation must be restricted to fluids outside of cells (ice crystals within cells would be too damaging), and so water must be able to leave cells rapidly when freezing begins. In addition, some solutes—such as glycerol—are “cryoprotective” and help to stabilize molecular structures and thereby preserve physiological integrity during freezing.

Gray treefrogs “know” about these strategies. During the cooling autumn months they accumulate glycerol. They also regulate the expression of proteins (“aquaporins”) that facilitate movement of water and glycerol across cell membranes. Aquaporins are water channels or pores that function in a number of different physiological processes, including urine formation, sweat production, tear and salivary secretion. Aquaporins were first discovered in 1991 by Dr. Peter Agre and colleagues, a discovery for which Dr. Agre was recognized as the co-recipient of the 2003 Nobel Prize in Chemistry. The research in our lab is focused on understanding the role of aquaporins in the process of freeze tolerance. In gray treefrogs, we hypothesize that aquaporins are the reason for cell survival during the process of ice formation and subsequent thawing. We seek to understand how these processes are regulated, and how they contribute to freeze tolerance. Gray treefrogs present a natural model for unraveling the secrets to remaining frozen alive.