

How Glycoproteins in Fish are Nature's Antifreeze

Scientific Example

Fish living in sub-zero waters have evolved a remarkable adaptation to keep themselves from freezing: anti-freezing glycoproteins (AFGPs), a form of anti-freezing proteins (ATPs). AFGPs are a combination of sugars and proteins in the cell membrane that help increase the freezing point in polar fish. AFGPs in fish are produced by the exocrine pancreas and secreted into the intestines where they are then absorbed into the blood, thus filling the internal environment with AFGPs¹. When ice crystals form, they start as a small seed and grow as the ice expands outward. AFGPs bind to the ice crystals and form a sort of net around the crystal, preventing the ice from growing further by increasing the gap between the liquid state of blood and the freezing point (thermal hysteresis)². These proteins' structures can be analyzed through a variety of techniques such as nuclear magnetic resonance (NMR) spectroscopy, next-generation sequencing (NGS) of genes, and Northern blots to analyze sequencing of RNA.

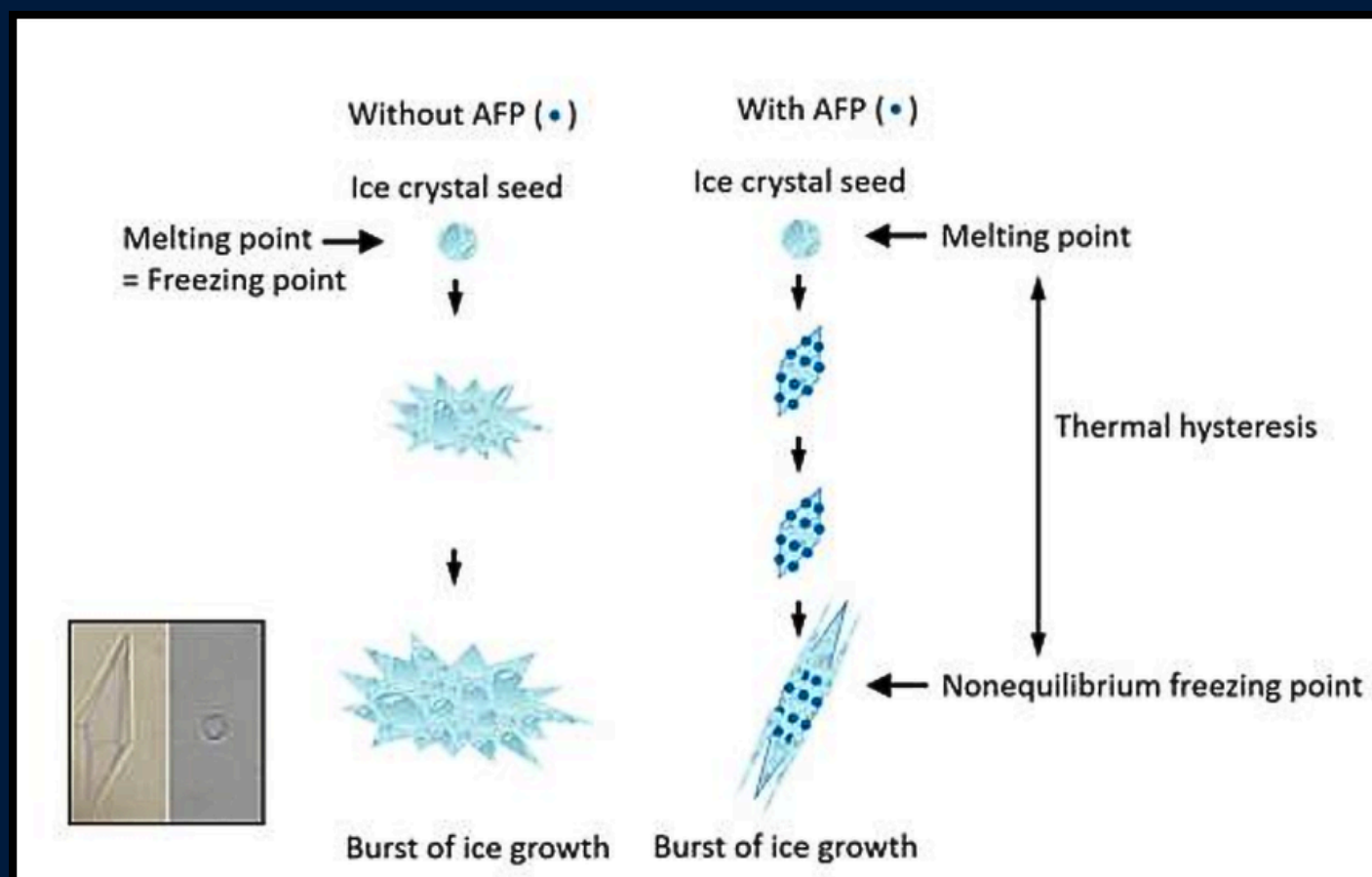


Figure 1. The differences in ice growth with AFP binding to inhibit growth compared to ice growth without AFP².

Nature of Science Connection

The analysis of different AFGPs and their concentrations within fish provides the evidence to expand our knowledge about AFGPs and how they operate within organisms. NMR spectroscopy is used to identify the molecular structures of proteins and carbohydrates present by using magnetic fields²; NGS of genes is used to identify which genes are responsible for AFGPs production, as well as Northern blots, which are also used to identify which genes code for AFGPs but on a smaller, focused scale^{1,2}. These techniques are just a few of the ways scientists can visualize and identify AFGPs.

Why This Matters

Collecting evidence through scientific techniques and technologies is vital to substantiating claims and furthering research. Having techniques such as NMR and NGS allows for identification of molecules (like glycoproteins) and provides a point where scientists can connect form to function. This begins the discussion for future uses of AFGPs such as with cryopreservation of organs and tissues as science expands in this field. Evidence is the starting point of every scientific breakthrough and leads to greater and more advanced research on the uses of AFGPs.

Classroom Use

This page could be used by instructors to generate discussions about how discovery and evidence leads to more complex scientific questions, such as how AFGPs could be used in other organisms, food, medicine, or biotechnologies.

References

1. Barlow, J. (2006, June 21). Researchers discover which organs in Antarctic fish produce antifreeze. University of Illinois Urbana-Champaign. <https://news.illinois.edu/researchers-discover-which-organs-in-antarctic-fish-produce-antifreeze/>
2. Kim, H. J., Lee, J. H., Hur, Y. B., Lee, C. W., Park, S. H., & Koo, B. W. (2017). Marine antifreeze proteins: Structure, function, and application to cryopreservation as a potential cryoprotectant. *Marine drugs*, 15(2), 27. <https://doi.org/10.3390/md15020027>