# ANTIFREEZE GENES CONVERGE

**WASHINGTON, DC (April 18, 1997)** In a remarkable example of convergent evolution, two groups of fish at opposite poles of the Earth have evolved an identical anti-freeze compound necessary for survival.

Researchers have identified the parent of the Antarctic antifreeze gene: a digestive enzyme called trypsinogen. The researchers also suggest that the gene arose five to 14 million years ago, providing a new line of evidence to confirm when the Southern Ocean froze. The researchers describe a rare, direct link between the evolution of a protein, the diversification of an animal and environmental change.

The authors, supported by National Science Foundation (NSF) grants, are Liangbiao Chen, Arthur DeVries, and Chi-Hing C. Cheng, all from the University of Illinois.

Millions of years ago, fish in both northern and southern polar waters adapted to a cooling climate by evolving antifreeze proteins that kept them from freezing in frigid oceans, and let them exploit new ecological niches. The new research traces for the first time the genetic process by which a novel protein evolved to enable this adaptation.

The researchers show that the gene for antifreeze glycoprotein (AFGP), found in the Antarctic family of notothenioid fishes, evolved in a unique way: arising from trypsinogen, an enzyme produced by the pancreas. New genes are usually created through recycling of existing protein genes.

"This is the first clear example of how an old protein gene spawned a gene for an entirely new protein with a new function," said Chi-Hing C. Cheng. It is also one of very few newly-minted genes whose evolution can be so clearly traced.

"Demonstrations of this sort at the molecular level are rare and noteworthy," write John Logsdon and W. Ford Doolittle in a commentary on the paper. The antifreeze gene differs very little from its parent -- only 4 percent to 7 percent in the inherited gene segments -- so in evolutionary terms, its molecular clock began ticking quite recently. Segments at both ends of the gene are nearly identical to the parent trypsinogen gene.

Applying the known rate at which DNA changes in salmon mitochondria to the amount the antifreeze gene has changed from trypsinogen, the authors have pegged the gene's origin at five to 14 million years ago, close in time to the estimated freezing of the Antarctic Ocean. The freezing date was deduced independently, through studies of changing temperature as recorded in plankton in ocean sediments.

Some biologists had argued that Arctic cod, which produce very similar antifreeze proteins, evolved from the same stock as the Antarctic fish. But DeVries, who discovered the first antifreeze gene in Antarctic fish thirty years ago, says the new molecular evidence shows that the two polar fishes, the Arctic cod and the Antarctic notothenioid, developed their antifreeze genes separately.

By sequencing and analyzing -- essentially working out the architecture -- of the Arctic antifreeze gene, the authors show that it does not resemble the gene for trypsinogen, and differs from Antarctic antifreeze gene in gene structure and coding sequences as well.

The similar antifreeze genes in two unrelated fishes exemplify convergent evolution -the development of a similar protein from different parents under similar environmental pressure. The notothenioid family now dominates Antarctica's continental shelf, comprising more than half of the species and 95% of the biomass, or weight, of fish there. The fish arose in the deep ocean, but underwent a burst of evolutionary radiation into different ecological niches as the Southern Ocean cooled. In an evolutionary pattern like Darwin's finches, they are the only example of an oceanic fish to show this adaptive radiation. The antifreeze protein was evidently a key mechanism that let them colonize different depths of water.

## Questions

1) What is convergent evolution?

2) Explain how the evolution of the antifreeze gene is an example of convergent evolution.

3) What is trypsinogen? Why is it important to the study of the antifreeze gene in Antarctic fish?

4) Describe how natural selection may have led to the modern day population of Antarctic notothenioids, over half of which carry the antifreeze gene.

5) Do the Arctic cod and the Antarctic notothenionoid have the exact same antifreeze gene? Does this mean that these fish developed from the same population of fishes or different populations? Explain