

Date: Fri, Jan 8, 2010 at 6:58 PM

Subject: Scholes cabin 5 (P): Antarctic fish blood

Dear Stirling,

It is snowing today, not very heavily, but enough to reduce the visibility to a few hundred metres and keep the helicopter in its hanger. The other one is stuck at SANAE IV, where today's weather report was quite brief - visibility: nil. The flakes are large, and as I stood on the deck guiding the CTD probe out, they settled on my dark wind jacket and I could see their perfect hexagonal shape, even without my specs on! Each one is supposed to be different from every other one. I suppose if you counted every molecule, that may be true: even then, I suspect there may have been more snowflakes in the history of the world than there are feasible combinations of water molecules in a flake! Anyway, Nancy has photographed zillions of snowflakes and is credited with finding two that certainly look the same - another myth busted!

You might not know that my first job in science was to do with ice. I was working for Nancy, catching hailstones so that she could cut them open and see how they formed. I was still a student and wouldn't have become a scientist if it was not for that experience. It did not occur to me that I **COULD** be a scientist, until Nancy suggested it. I thought that only super-smart people became scientists. I didn't know that you just had to be ordinary-smart and super-interested.

Ice is really quite wonderful stuff. Do you know that Charley is one of the world experts on ice? What I will tell you here is stuff I learned from him, and maybe got wrong - so if you have any questions, send him an email. He first studied to be a geologist, where they pay a lot of attention to the study of crystals. Then he spent a year on an ice floe, drifting around the North Pole, applying that knowledge to ice. A few decades ago he got interested in why fishes that live under the ice don't freeze, and came down to Antarctica several times to get samples. The fish he studied are quite big, and live for a long time. They catch the same ones year after year, take some blood, and throw them back!

By definition, pure water freezes at 0 degrees Celcius. When there is stuff dissolved in water, like the salt in seawater, it makes the freezing point a few degrees lower (seawater is supposed to freeze at about -2 degrees, which is the temperature below 50 m here, but the salinity is quite high here). But the fish blood is not as salty as the sea, so why does it not just freeze? If you remember that experiment Charley showed you, it is possible to super-cool water below 0 degrees without it freezing, provided it is perfectly clean. Put in one speck of something else and it instantly turns solid. Blood is full of cells, so that can't be the mechanism.

The antifreeze you put in car radiators in winter contains a type of alcohol. That would not work in a fish either, because the alcohol would poison the fish. And anyway, both salt and alcohol have to be present in quite a high concentration to push the freezing point down by several degrees. The antifreeze in the fish blood was found to be a protein, present in tiny amounts. It must work in a totally different way, and that is what Charley set out to explain. It is to do with how crystals grow.

As you know, crystals are very highly ordered forms of matter. They are put together a bit like a Lego set - everything has to click together just so, or you have a mess. The crystal can only grow along the edge, where there are vacant spaces waiting to be filled by the right molecule, pointing the right way. Turns out, that is what the fish-blood protein was doing. It was pretending to be a water molecule, all perfectly lined up to join the ice crystal. When it did, it blocked all further growth, because it did not have the right attachments on the other side. That way, just a few protein molecules could keep an army of ice from forming. Very clever!

Bye now. The weather is supposed to get a bit better from tomorrow.

Love,

Dad

PS: you can put a footnote in for other people to explain who Nancy and Charley Knight are. They are distinguished scientists at the National Centre for Atmospheric Research in the United States of America.