proteinspotlight
> ONE MONTH, ONE PROTEIN <

Issue 112, December 2009

www.proteinspotlight.org

String of intrusion

Vivienne Baillie Gerritsen

When I was little, I used to wear little cotton shirts that were knitted by my grandmother. So? Well, onto them she sewed tiny nacre buttons you could never get hold of and which mesmerized me because of the different colours that shone off them depending on how you oriented them in the light. You can still find these buttons today but plastic ones have almost completely replaced them – and some even try to copy the lustre which is so particular to mother of pearl. What is it that makes pearl what it is known for? Aragonite. Aragonite is a calcium carbonate mineral and, very recently, scientists discovered a complex of three proteins in the pearl oyster *Pinctada fucata*, which seems to be at the heart of aragonite formation and orientation, and hence the famous sheen.

"The girl with a pearl earring" by Vermeer

Source: Wikipedia

The use of pearls is not particular to the 20th century and aristocracy. Because of their singular shine, pearl beads have been hunted – insofar as one can hunt a mollusc… – for thousands of years in many different seas and appear in as many sacred rites. Hindu scriptures suggest powdered mother of pearl as a stimulant of digestion or to treat mental ailments. And Marco Polo recounted that the King of Malabar – a region in southern India – wore 108 rubies and as many precious pearls around his neck. This singular necklace was transmitted from generation to generation. Why 108? Because the King of Malabar had to say 108 prayers at dawn, and another 108 at dusk.

Before the 20th century, it took a long time to find the perfect pearl. Over the centuries, millions of molluscs have been pried open and subsequently killed by divers eager to find the precious gem and gain as much money as possible. The bigger and rounder, the better. But such pearls are very rare – because they are natural and the result of a benign accident. Indeed, the origin of a natural pearl is an irritant which has ended up in the soft tissue of a mollusc – a grain of sand, a small organism or even part of the mollusc's own shell which has broken off. As a means of defence, the mollusc traps the foreign body in a shell of aragonite – a slow process but a process which ultimately leads to the formation of a pearl. So what some like to decorate their necks with is in fact the result of an intrusion. There's a thought.

It wasn't until the very early 1900s, that Thomas Henry Huxley – the man who dealt with the promotion of Darwin's theory of evolution – sent William Saville Kent, an English marine biologist, to Australia. The marine biologist promptly devised a way of cultivating pearls by introducing an irritant into

the soft tissue of molluscs, and he passed the information onto Japanese fellow workers. Pearl culture has prospered ever since, to become almost commonplace, yet it is still a difficult task to make a perfectly round pearl.

But how is the stuff of pearl made? Shell and nacre are made out of organic matter, mainly chitin, and two different forms of calcium carbonate. The outer shell of a mollusc is made out of the mineral calcite which grows in prisms; it is very strong and stable. Nacre is made out of the mineral aragonite, an alternate form of calcium carbonate, very tough but less stable than calcite; it grows in platelets and lines the inner side of the mollusc's shell and has this singular lustre. How the switch from the prisms to the platelets occurs remains a mystery to date. But a newly discovered protein complex is at the heart of the formation of the aragonite platelets, and hence the stuff we call "pearl".

The complex is made out of three proteins, known as the Pif complex in which is found pearlin, Pif80 and Pif97. Pif80 and 97 are part of the same sequence which is subsequently cleaved into two. A complex of both is then formed in the soft tissue epithelial cells and secreted where Pif97 seems to bind to chitin microfibrils – the organic part of pearl – and pearlin, thus forming a larger aggregate which, in turn, binds to other proteins. All this contributes to the lamellar sheeting of aragonite. Within such sheets, Pif80 – by way of its many asparagine residues – binds to calcium carbonate and not only elicits aragonite crystal formation but also has a role in the orientation of the aragonite crystals. This leads to the nacreous layer we all admire when opening an oyster. Some of you may even have come across the lone natural pearl… Usually deceptively small.

Many organisms know how to make inorganic material – bone, teeth, exoskeletons, shells – which is, in itself, amazing. No stone could make anything organic… It is all in the name of keeping our parts together or protecting them. And it is something materials engineers envy. A greater knowledge of how biomineralization occurs would enable the synthesis of high performance composite materials. Yet again, Nature shows its varied activities and power. And is it not an intriguing thought to realise that a pearl only exists because an oyster is inconvenienced one way or another? And that such an inconvenience can become something so becoming on the end of an ear lobe?

Cross-references to UniProt

Pearlin, *Pinctada fucata* (Pearl oyster) : O97048
Pif80, *Pinctada fucata* (Pearl oyster) : C7G0B5
Pif97, *Pinctada fucata* (Pearl oyster) : C7G0B5

References

1. Suzuki M., Saruwatari K., Kogure T., Yamamoto Y., Nishimura T., Kato T., Nagasawa H.
   An acidic matrix protein, Pif, is a key macromolecule for nacre formation
   Science 325:1388-1390(2009)
   PMID: 19679772

2. Kröger N.
   The molecular basis of nacre formation
   Science 325:1351-1352(2009)

Protein Spotlight (ISSN 1424-4721), http://www.proteinspotlight.org, is published by the Swiss-Prot group at the Swiss Institute of Bioinformatics (SIB).