Interview: Nothing but the tooth

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As well as working as a dentist in Sharon, Connecticut, Martin Nweeia is a clinical instructor at Harvard University's School of Dental Medicine and a research associate in the department of zoology at the Smithsonian Institution's National Museum of Natural History in Washington DC. He is the principal investigator of the Narwhal Tooth Expedition and Research Investigation, a multidisciplinary research project he began five years ago (www.narwhal.org). He is also an accomplished musician and author of *The Whole Tooth* (Randall Morita Design, 1999)

What was it like the first time you saw a narwhal?

It was a bit of a haunting experience. I was alone on polar bear watch on an ice floe off the northern tip of Baffin Island. It was very early in the morning. The water was like glass. There were up to 10 narwhals, and they were doing this heavy breathing. It felt like they were breathing in my ear, that's how intense the sound was. And yet, when I listened to my tape at home it was so faint I could hardly hear it. It's one of the few times when the reality is more incredible than the fable - I have more difficulty believing a whale has a tusk like this than I do a unicorn.

Why are you so interested in the narwhal's tusk?

It is, without question, the most extraordinary and unique tooth in nature. It defies evolution and modern-day explanation. It is the only known straight tusk, the only spiral tooth in nature today. And it is a dramatic example of sexual dimorphism in teeth: the male almost always has the tusk, the female often does not. The narwhal actually has two teeth, but the other one is embedded in its jaw. So you've got one tooth that stretches out almost 2.5 metres, while the other one rarely grows more than 30 centimetres. As a dentist, naturally I was motivated to solve this puzzle of nature that has baffled scientists for hundreds of years.

What are the popular theories?

The one that keeps popping up is that the tooth is for aggressive behaviour - that males use their tusks for jousting. We have observed narwhals gently rubbing tusks during the summer months, but nothing I would ever document as aggressive. Then there's the hypothesis that the tusk is a temperature gauge. Another theory was that it was an ice-breaking tool, but later it was found that the whales break the ice with the back of their head. One commonly quoted theory is that the tusk is a secondary sexual characteristic. It always amuses me when people identify anything as a secondary sexual characteristic because it doesn't really tell you anything about what it does. They use the analogy of a lion mane or a peacock feather.

What do you think?

I think the tusk is a sensor of some kind. It could be used for detecting sound, temperature or salinity. I also think there may be a voltage potential across the tooth. Most bones and teeth have what is known as a piezo effect: they contain crystals that generate a voltage when a mechanical force is applied to them. So when a twisted crystal like the narwhal's tooth is moving with a tremendous force through water, there's probably some kind of voltage across it.

How would narwhals use this electrical charge?

I don't know. But it could have something to do with detecting their prey. Studies show that some species of fish elicit their own electric charge that other animals are sensitive to. Adolescent paddlefish are so sensitive to this force around the prey they're eating that it actually stimulates their jaw to open as they swim through schools of fish.

How did you get from researching human teeth to whale teeth?

I was invited to give lectures in different parts of the world to talk about my work in dental anthropology. I never liked to repeat myself, so I started adding examples of unusual teeth from nature: the elephant, the walrus, the narwhal. The more I looked at the narwhal's tooth, the more I realised that what I was reading in the literature did not make sense. No one fully addressed the purpose of the tooth, and a lot of what was written was more speculation than science. So I proposed a long-term scientific study of the narwhal tooth. I have assembled a team of experts from many different disciplines, so I would say the depth and breadth of this investigation is unprecedented. We are looking at the tooth in ways that no one has before, creating mathematical models of the spiral, using computerised infrared mapping microscopy to examine tusk tissue, and doing CAT scans of male and female narwhal heads - all to help us construct a map of the tusk's chemical, structural and mechanical properties.

What is the greatest danger you face doing research in the Arctic?

The best time to go is May and June, when the ice is breaking and the first narwhal start coming into the inlets off Baffin Island. The danger is that a couple of weeks after we leave, that ice is completely melted. So we are there during a very fragile time, and you need someone who is very knowledgeable about breaking-ice conditions. If the ice breaks around you and you start drifting out, there is no rescue team handy to come and get you. I have been fortunate enough to have one of the best Inuit hunters as my guide.

Have you involved the local Inuit in your research in other ways?

I developed a six-page questionnaire about the narwhal and had it translated into Inuktitut, the native language. So far I have conducted interviews with five Inuit elders. I have gained a tremendous amount of information this way, particularly about narwhal behaviour and anatomy. I have always found in any research that the most important thing is to tie yourself to the community that lives with whatever it is you are studying. It is one of the most important ways of gathering data, and most scientists overlook it.

Last summer was your third expedition to the Arctic. What were you doing?

I attached a portable sensor to the narwhal's tusk to measure sound, vibration and position over time. Collecting this information while the whale is swimming and active might give us a glimpse into what the tusk is being used for. I also used hydrophones to compare sound from the whale's head with sound from the tusk, to see if there was a separate sound field produced in and around the area of the tusk. All of this data is being analysed now. I brought a portable electroencephalogram with me to the Arctic to measure brain activity when sensory information was introduced to the tusk - for example, when pouring fresh water on it. I spent a year learning how to use the EEG: I trained on the equipment at a hospital, I visited the company that made it, and I talked to neurologists to learn how to interpret the data. But I never got to use it because of high surf conditions. Things like that can make you lose your sense of humour unless you're completely devoted to what you're doing.

How do you attach a sensor to the tusk of a live whale?

First we have to catch the whale. When this happens, someone shouts, "Whale in the net!" and everyone has five or ten minutes to do their job. We pull it in to shore, holding it with a hoop net on its head and a rope to stabilise the tail. So I'd be in a dry suit in near-freezing water trying to attach a sensor to the tusk while the surf is going and the wind's blowing, probably at 3 am in the morning.

Do whale teeth reveal anything about human teeth?

Fred Eichmiller, director of the Paffenbarger Research Center of the National Institute of Standards and Technology in Washington DC, did stress tests on the narwhal tooth and said he had never seen a material as flexible and strong. That's remarkable because, in tooth structure, when something is very strong, it's usually also very brittle. So they are quite interested in finding out its secrets, as it may provide insights into developing a dental restorative material for humans.

What do your dentist colleagues think of your narwhal research?

They are somewhere between amazed and a little befuddled that someone would actually do this. If I were studying whales in the tropics, that would probably be easier for them to identify with. But the fact that I'm sitting out on an ice floe with an Inuit hunter in 110-kilometre-an-hour winds, and the ice that I'm camped on could break off into the ocean, and I'm doing this with the hope of seeing a whale that might not appear - I think most people would say that's definitely not me.

What do you find so fascinating about teeth?

Teeth offer great insight into so many things. The morphology of teeth - their shape, form and size - can tell you all sorts of things about an organism. In our modern world, teeth are the best link for forensic work because they are such permanent records. There is a rare metabolic disease called

congenital porphyria, and if you shine an ultraviolet light on someone with this disease, their teeth show up fluorescent red. You can even determine cause of death this way up to 100 years after the event. Imagine that.

Why did you go into dentistry?

I think dentistry is a great combination of both art and science. The only other career I contemplated was facial reconstruction. Dentistry has so many different fields within it. I could be making a crown one day, and doing shade analysis for porcelain teeth the next day. I know how the light refracts against porcelain - that's the art of making it look alive. Then another day you could be helping someone with gum disease or diagnosing oral cancer. We also do radiology every day. That is why you'll find that dentists have a lot of outside interests.