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The *Brachyopoda* of Gabriola Island

by Nick Doe

A long time ago…, or as James Joyce would have said had he been Welsh, *amser maith yn ôl…*, whenever one came to an unfamiliar town, and one had time on one's hands, as one often did, one of the things one did was to seek out the secondhand bookshops.

The best shops were small, narrow, rather dark, with closely-packed shelves of hardback books. Lots of them. Back then, marketers hadn't mangled the simple notion that bookshops sold books, not covers.

The proprietor would look up from his reading as you unnecessarily jangled the door bell on the way in—he was always reading, usually by the window to catch the light, never aimlessly fiddling with a computer—and, trying hard to conceal his combination of surprise and annoyance at your entry, very politely, would ask if there was anything he could help you find. To which the answer was always, "No thanks, I'd just like to browse". Relieved, he would return to his book. "Just let me know then if there's anything I can do."

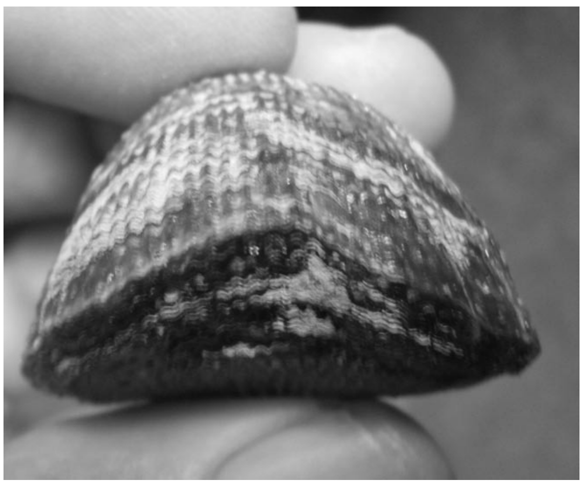
Methodically scanning the shelves, not too quickly, so it looked like you knew what you were doing and so as to warrant your declining his offer of help, you'd eventually come upon the only section that really interested you. Usually at floor level, at the back and out of sight, so that if it was getting late in the afternoon, you'd have to gently cough now and again to remind the proprietor that you were still there.

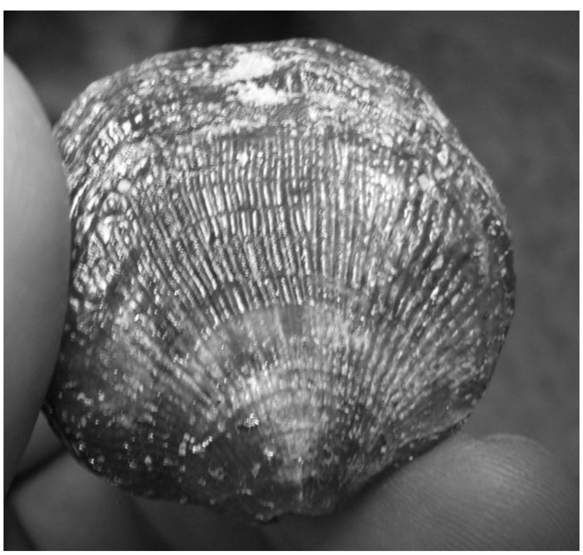
There they were. Well-written, useful books, but all very familiar and already sitting at home on your shelf. Books that should never have been written, yet alone published—every secondhand bookshop had a copy; most had two or three. Books that you knew, but would never buy because the author mentioned lots of things that you were interested in, but never wrote a single interesting detail about any of them. And then, the little section of books at the end of the shelf you had never seen before, easily recognizable because of their unfamiliar heterogeneous sizes and colours and the lack of readable titles on their spines.

One such book, I like to imagine, would have a worn, but not too-worn, faded forest-green cover, cloth of course, with title lettering in gold so that, because of the low contrast, it was hard to read and easily skimmed over by those who didn't care. It had a foreword and frontispiece; lots of finely-detailed, black-and-white drawings—no photographs—written in the 1930s or earlier; and a lovely soft comfortable feel to the pages. It would be entitled, "The *Brachyopoda* of Gabriola Island".

Nervously, I would take it to the front. "Found something, then have you?" "Yes, but I can't make out the price". So lightly pencilled on the title page that it was no longer readable. Was that $2, $20, or $200? I dare not ask. "Oh, I can't make it out either. I think it's $20, but how about $15 plus tax, it's been here a while." Carefully wrapped, in paper, no plastic bags in those days, the neatly handwritten receipt enclosed, the deal was done, and the visit to this town made memorable in a way little else could.

What then is wrong with all of this? The fantasy is, of course, that there aren't any *brachyopoda* on Gabriola Island. But there used to be—there used to be—and their remnants are plentiful.





Brachipods live only in the ocean, and like bivalve molluscs—clams and mussels—they have two hard valves (a shell) that can be tightly closed together; at least, most of them do. Unlike the valves of bivalves however, the two halves of the shell are seldom mirror images. One species of brachiopod has one valve humped, and the other flat so that together they look like a tortoise shell. The internal structure of brachiopods is also different from that of bivalves, and they have a different evolutionary history. Bivalves and brachiopods are only distantly related despite their surficial similarities.[1]

Brachiopods are rare these days. There are some in the Strait of Georgia living deep down on the walls of the mainland fjords, but your chances of finding a contemporary brachipod shell on a beach on Gabriola are virtually zero.[2] But finding an ancient brachiopod shell…? The odds are fairly good. Brachiopods used to greatly outnumber bivalves, and, though it may not

Brachiopods have shells like clams and mussels. They are easily distinguished from bivalves however because, if you divide the shell, the two halves usually, but not always, look different.

Brachiopods are common fossils, but modern species "cling and hide in a few relic habitats scattered across the world". The photographs are of a pyritized specimen I bought at a rock-and-fossil shop in Nanaimo that no longer exists. It's very old, from Ohio or Indiana. It was alive long before Gabriola and adjacent Vancouver Island existed.

[1] *Bivalvia* are a class in the *Mollusca* phylum: brachiopods are in the *Brachiopoda* phylum. These two phyla have been distinct since at least the early-Cambrian period, 550-million years ago.

[2] Brachiopods now live mainly in cold and low-light conditions and avoid locations with strong currents or waves. Brachiopods suffered greatly in the great Permian-Triassic extinction event, 251-million years ago, and never recovered their former diversity.

Brachipod fossils in the late-Cretaceous mudrock of the Northumberland Formation (Nanaimo Group) on Gabriola. Most have been so heavily weathered chemically—suggesting to me that they may have been buried alive in an underwater mudslide—they are no longer instantly recognizable for what they are. Those are the toes of my size 9 boots at the bottom.

seem so, brachiopod fossils in the shale on Gabriola are common. At least that's the good news. The bad news is that common though they are, they are so chemically weathered that they now form small (<100 mm) hard, rusty, black nodules in the shale, sometimes containing bright-orange or drab-green clay, and with dark purplish, black, or chocolate-coloured centres laden with iron and manganese compounds.[3] Without their valves, they are virtually unrecognizable as being what they once were.

When I first came across what I now think are brachiopod fossils, I didn't know what they were. I described them in a previous *SHALE* article as Type S nodules.[4] There were at the time, clues that these seemingly formless fossils were actually the remains of brachiopods, but I didn't recognize that then.

One important clue as to what they were was the high phosphorus content of these nodules. I'll give the (corrected) data from the earlier *SHALE* article, which gave the relative numbers of different atoms present:

[3] The result of secondary permineralization, possibly during the Pleistocene.

[4] Doe, N.A., *SHALE* 9, *Curious nodules*, pp.41–52, August 2004.

Nodule **Type A** (now known to be the remains of an inoceramid bivalve Sample 02, ACME File: A305008):
<u>cations</u>: calcium 44; iron 28; aluminum 11; magnesium 8; manganese 6; sodium 2; potassium 1
<u>anions</u>: carbon 65, silicon 25, phosphorus 10; sulphur 1

Nodule **Type S** (now known to be a brachiopod Sample 27, ACME File: A403430):
<u>cations</u>: calcium 29; iron 20; aluminum 18; magnesium 5; manganese 19; sodium 6; potassium 3
<u>anions</u>: carbon 11, silicon 65, phosphorus 23; sulphur 1.

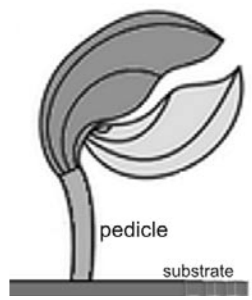
A lot of data. So what did I miss?

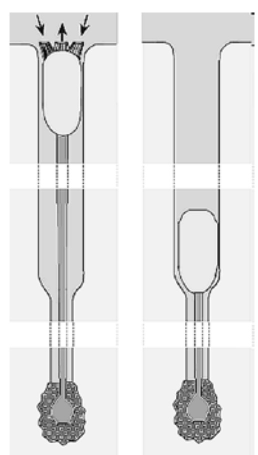
What I missed was that in the Type A nodule, the remains of a bivalve, there was 6.5 times as much carbon as phosphorus; but in the Type S nodule, despite being the remains of shellfish, there was 2.1 times as much <u>phosphorus</u> as carbon!

The Type A fossil was loaded with calcium carbonate (*calcite*; the stuff seashells are made of), but the Type S fossil had very little and must instead have contained significant amounts of calcium phosphate (*apatite*; the stuff your teeth are made of). And one of the strange characteristics of one class of brachiopod, the *Lingulata*, is that their shells are composed of a combination of chitin (the stuff shrimp and crab shells are made of), protein, and calcium phosphate. This is, to quote Wikipedia, "…unlike most other shelled marine animals, whose shells are made of calcium carbonate".

That these brachiopods were some kind of *Lingulata* makes perfect ecology sense. We know from the abundant "giant clam" fossils (the inoceramids)[5] found in the 74-odd-million year old Northumberland Formation shale on Gabriola, that these mudrocks must have been formed fairly deep down in dark, semi-tropical, stagnant, and quiet water. And one of the characteristics of brachiopods that is different from bivalves is that brachiopods have low metabolic rates and weak respiratory systems; they need very little oxygen and hence their modern ecological niches in out-of-the-way places where tidal current is weak.[6]

Another of the clues as to the identity of these "Type S" fossils is their "feet". Many species of brachiopod had (and have) a "foot" or "stalk", which, to save us from embarrasment in the company of biologists, we should call a *pedicle*.





Pedicles were used to secure the brachiopods to a substrate (a rock or coral); however, this wouldn't work for us because the supposition is that our brachiopods (I'm getting quite fond of them you'll notice) lived in soft mud where there was nothing to anchor themselves to. But again, *Lingulata* come to mind.

Quoting form Wikipedia, "…*Lingulata* [particularly the…

[5] Doe, N.A., *SHALE* 4, *Inoceramus vancouverensis—big clams*, pp.9–15, June 2002.

[6] Which prompts the alert reader to ask, how come the inoceramids lived along with the brachiopods then?...to which the answer is that it is thought that the inoceramids you find on Gabriola had a symbiotic relationship with bacteria living within their mantles that used sulphur rather than oxygen for metabolism.

…*Lingulida*][7] have…a long fleshy pedicle, with which the animal burrows into sandy or muddy sediments. They inhabit vertical burrows in these soft sediments [into which they can withdraw] with the anterior end facing up and slightly exposed at the sediment surface [diagram opposite]"

And you can still find the fossilized remains of these pedicles on Gabriola. In fact, they are common. Every so often, somebody will excitedly tell me that they've found on the beach what they think is a vertebra. And, of course, since all our bedrock dates back to Mesozoic times,[8] what else could it be but the vertebra of a dinosaur!

These "vertebrae" usually have an axial core[9] that has sometimes weathered away leaving a hole. What they actually are, are the remains of pedicles that after fozzilization have been fractured into segments. The pedicles, which were once mainly muscles contained in a hose-like tube, have been infilled with fine sediment rich in *chlorite* (a clay mineral), possibly lightly cemented with *calcite*.

Under a petrographic microscope, the conspicuous axial core is seen as being coarse sub-radiating *calcite* crystals—indicating that it was originally a hollow duct. Geologists might call such a feature *amygdular*, meaning it is the result of infilling by crystals coming out of solution during the final stage of fossilization.

[7] *Lingulida* is an order of brachiopods in the hierarchical classification: kingdom (*Animalia*)–phylum (*Brachiopoda*)–class (*Ligulata*)–order (*Ligulida*)–family (*Lingulidae* or Linguloid)–genus (*Lingula*)–species. *Ligulida* have been around since the Ordovician period, 443–488 million years ago. Wikipedia lists 11 extant species of *Lingula*.

[8] The Nanaimo Group on Gabriola is late Campanian to late? Maastrichtian in age.

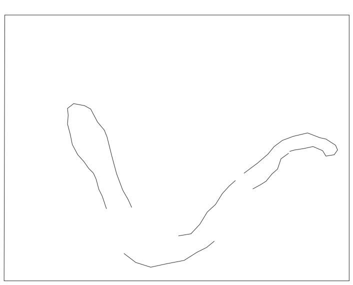
[9] Very occasionally, you see two such features side-by-side in the same nodule.

Another test passed. *Lingula* is Latin for "small tongue", and this brachiopod concretion from near the Community Cemetery Beach on Gabriola has that shape. It also has a pedicle scar, complete with central core, at the top.

While it is possible that these ubiquitous axial features are fluid escape pipes used for dewatering during compaction, I doubt it.

Since they all look so similiar, there has to be a suspicion that they are biological in origin. They are perhaps the remains of part of the brachiopods' coeloms (body cavities). These would have been filled with coelomic fluid—the nearest thing invertebrates have to blood. Some invertebrates, earthworms and sipunculids (peanut worms) for example, wriggle, move, and dig using muscles to vary the hydraulic pressure of the coelomic fluid in a central duct. *Lingulida*, which are among the earliest creatures ever known to burrow, probably did (and do) the same with their pedicles.[10]

[10] Although observations of modern specimens show pedicles being used as props while valves do the excavating. Emig, C.C., *Ecology of the inarticulated brachiopods*, in Kaesler, R.L. (ed.), *Treatise on Invertebrate Paleontology*, Part H, *Brachiopodia revised*, 1, p.477, GSA & Univ.of Kansas, 1997.



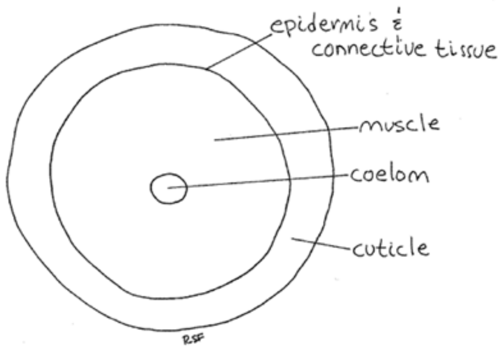
Left: A fossilized brachiopod pedicle standing vertically, as they usually do, like a sawn-off stump on a forest trail, embedded in the mudrock. You find them on the beach in False Narrows and also on Whalebone Beach. They nearly always have a small central core, which contains *calcite* (see text).

Middle: A modern brachiopod, *Lingula anatina*, with its pedicle (white) extended. The tip of the pedicle (on the *right*) is gelatinous and in this photograph covered with sand. The valves of *Lingula* spp. are uncharacteristically symmetrical and can be moved side-to-side like scissors.

Wikipedia: Andreas Altenburger; modified by Mark A. Wilson

Below left: A fossil in the mudrock in False Narrows with its pedicle in a rarely seen horizontal position. It looks remarkably like the modern brachiopod in the picture above it.

Below: A fragment of a pedicle fossil superficially resembling a vertebra. It has a small axial core that responds vigorously to dilute hydrochloric acid.



Top: Sketch of a cross-section of the pedicle of a modern *Lingula* species. The central coelom is an extension of the main coelom and is only present within the pedicles of inarticulate species of brachiopod.

Richard Fox, Lander University

Below: Roughly polished cross-section of a late-Cretaceous pedicle from Gabriola, about 74-million years old. The remarkable longevity of organophosphatic-shelled brachiopods in the fossil record—over 400-million years—was noted and discussed by Charles Darwin in his *On the Origin of Species*… published in 1859.

A coelomic duct would have had a thin wall (an epidermis), and this is consistent with there being no sign that I can see of progressive precipitation in the fossils from rim to core outside of the central core.[11]

[11] Hydrostatic pressure in the coelom of soft-bodied animals may also function as a skeleton by preventing crushing.

Above: Another fossil pedicle unusually lying horizontally. The segmentation of the pedicle is likely a result of fossilization.

These fossils are quite different from trace fossils—worm burrows and the like. Trace fossils (ichnofossils) in this shale are usually filled with very-fine sand-coloured sediment, and often have been crushed, unlike the brachipod nodules, which remain firm.

While I said earlier that the Type S fossils are very weathered chemically, there are nevetheless sometimes remnants of their internal structure to be seen. By which, I hasten to add, I mean variations in colour and texture, patches of lightly coloured clay being in noticeable contrast to black well-cemented mudrock—I don't mean anything that would even get me a pass mark in a zoology lab. session.

A living *Lingula adamsi* (Dall) with pedicle. Many of the Type S fossils are no longer attached to their pedicles, or never had them, making identification difficult.

Changhua Coast Conservation Action's Photostream

This internal "structure" is the way that I sometimes distinguish these fossils from the calcareous Type A nodules that are the remains of inoceramids—without testing with acid for *calcite*. The inoceramid nodules, which are plentiful in the shale, have a grey flint-like interior with invariably, no visible internal structure at all.[12]

A cross-section of a Type S fossil. My guess is that it is a lateral cut close to the pedicle end, looking toward the anterior; the brachial (dorsal) valve is uppermost. Near the top is the suspected (worm-like) intestine(?)
[Unfortunately if you are seeing this in black and white, this cross-section is highly coloured].

In one example of structure, I think I'm safe to say, the brachiopod's intestine is still visible. In another, I don't think I'm safe to say, you can see the brachiopod's gonads. "Gonads" (sex organs) is a suitably vague term here because I'm not sure if the brachiopod was male or female.

Now, by the time I get to talking about animals' gonads in a public forum, I know it's time for me to stop. I am after-all neither a biologist nor a palaeontologist. I'll just have to keep looking for that book, while you go on looking for that shell.[13] ◊

Unidentified white organ within the body cavity of a *Lingula* sp. fossil. Gonads?

[12] Perhaps because they were once gas bubbles in the decaying bodies of animals that had been buried alive in a mud slide. The brachiopods may have suffered the same fate as they tend to occur in thin strata as if they had all died at the same time.

[13] In the meantime, I'd recommend Peter Douglas Ward. *On Methuselah's Trail*, Chapter 2, *The Advent of Skeletons—the Brachiopods*, Freeman, 1992.