The Naze #1: ***Neptunea angulata / contraria,*** **The Left-Spiralling Shell**

Recently, I was lucky enough to make my very first trip ever, to The Naze. For those of you who are unfamiliar with the location, it's a beach on the North Sea-facing UK coastline, which is famous for its proliferation of fossils.

The Naze

The settings for a good many of Arthur Ransome's ***Swallows and Amazons*** stories were based around the Eastern English coast; notably the Norfolk Broads, Harwich, and Hamford Water (Secret Water), which I visited on the same day.

Hamford Water

I aim to expound more on these in future articles, but for the purposes of this one, will focus on one very interesting fossil found at The Naze, namely ***Neptunea angulata*** (formerly called ***Neptunea contraria,*** and not to be confused with its modern cousin of the same name), with an unusually left-spiralling shell.

Left: Treasures from the expedition. Right: Specimens of *Neptunea angulata.*

The Naze beach is located just north of Walton-on-the-Naze, on the northeastern Essex coastline. It is primarily made up of the following rocks, listed from the base upwards by geological period, epoch and stage/ age:

Ice Age Sands & Gravels (Quaternary/ Middle Pleistocene - <2.5mya)
Red Crag Formation - Quartz-rich sands with mudstone pebbles (Tertiary/ Pliocene (Placenzian) - >2.5mya)
London Clay (Blackheath Beds) - Mudstone (Tertiary/ Eocene (Lutetian) - 53.6mya)

NB: it is wise to check tide times before visiting, as high tides will cut off access to and from the beach. Access to the beach is limited due to the highly friable nature of the deposits. The beach is currently retreating at an average of 0.5m annually, and the cliffs are therefore very unstable. They have also been designated an SSSI. For these reasons, it's not allowed to climb, or dig into the cliffs. However, it is permissible to take fossils which have been exposed due to weathering, tidal action and slumping at the base of the cliff.

One of the most noticeable fossils to look out for is ***Neptunea angulata***, formerly known as ***Neptunea contraria. Neptunea*** is a very attractive genus of gastropods with colours ranging from cream to buff/ ochreous, and graceful forms, with mostly dextral (right-handed) shells. However, there are a few exceptions. ***Neptunea angulata*** is one.

At first glance, it just looks like any other whelk (Buccinidae); however, on closer inspection and comparison to other species of whelk (at least 4 of which I picked up on the same expedition), it can be seen that its specimens all coil **in a uniformly opposite direction** to that which is normally expected, or considered to be "usual"; put simply, they all wind to the left **(sinistral),** rather than the more commonly found right **(dextral).**

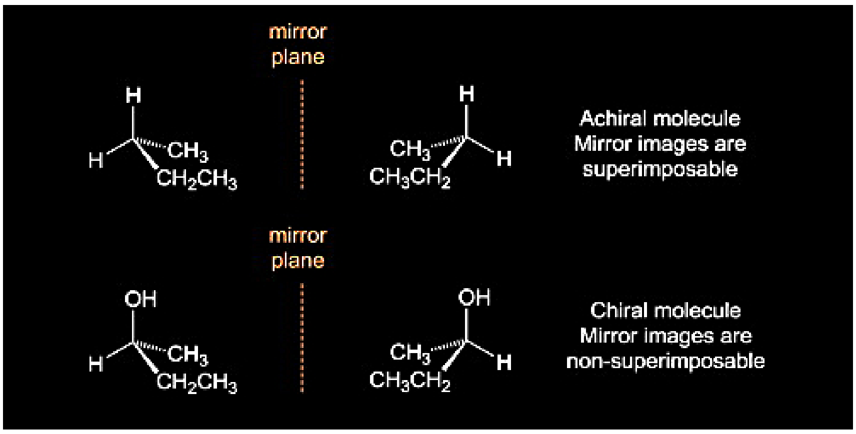
Left: Species of whelks with ordinary coiling. Right: *Neptunea angulata* compared to a dextrally spiralling shell.

I decided to do a spot of research, as I was intrigued by the number of questions this threw up. What makes a shell dextral or sinistral in the first place? Where did these shells originally come from? And who were their ancestors, or living relatives?

<u>The origins of sinistral coiling</u>

Some online sources claim that it's not known what causes sinistral spiralling in shell growth. I decided to do a bit more digging for evidence at this point, and my intuition proved correct when I found that in the light of more recent scientific research, that's not strictly true; there is indeed an element of randomness involved, but also a chance of a perfectly feasible explanation.

If you are a Chemistry nut, as I used to be, the most logical thing seems to be to go back to a basic "A"-level syllabus, and look no further than the principle of **chirality** in molecules (whether they are **dextro- or laevorotatory - that's right- or left-handedness, to you and me**). Chiral molecules in amino acids - the modular construction elements of life - often originate due to the fact that a typical carbon atom (one of the constituents of amino acids) has 4 connection points. These can attach to other atoms in such a way that the result is 2 molecules which are essentially the same compound, but from a physical point of view, are mirror-images of each other.



Chirality in molecules.

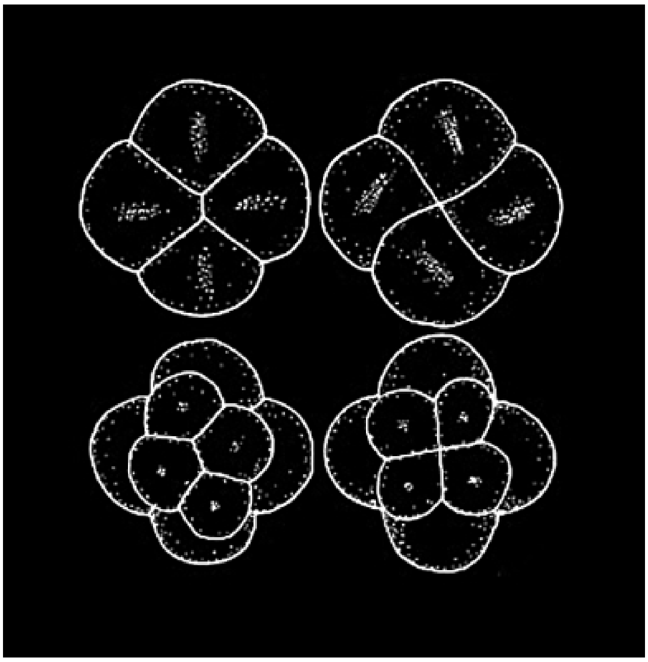
What creates left-handedness in the first place? The answer is simply: **a combination of certain physical and chemical conditions which feed back on each other**. This principle is not only true for simple molecules, but also for larger organisms, and it's clear that more recent researchers have thought so too (see **the end of this article** for links to this research).

From studies which have been made, it has been shown that left-handedness in ***Neptunea angulata*** and other gastropods appears to originate from the lack of a gene called **Lsdia-1**, which, along with its partner molecule **Lsdia-2**, regulates the production of the protein **formin.** Formin, in turn, regulates the production of the structural protein **actin**. Fun fact: to you and me, actin filaments are what give you and me and other animals their shape - yes, we'd be blobs without actin - and it's the most abundant protein in all living things.

The Lsdia-1 gene also seems to have some inhibitory effect on the manifestation of the Lsdia-2 gene - in that, once you remove Lsdia-1, with only Lsdia-2 left in charge - it's found that the resulting snails become left-handed!

Dextral shells **express their genetic makeup very soon following conception/ fertilization.** The resulting cell division shows the beginnings of spiral growth beginning to happen in a clockwise direction, going on to produce a dextral shell. Though this may seem unbelievable, the right-or left-hand mode of growth is claimed to have been observable at the **single-cell stage -** and certainly at the **8-cell stage** of development - around what will become the axis of rotation of the shell, called the **columella (or spindle)** in an adult snail.

In contrast to dextral shells, sinistral shells don't show any sort of inclination or differentiation at this early stage; **their growth pattern only emerges later on.** Some individuals indeed go on to show a more pronounced sinistral tendency (anticlockwise growth) either partially or fully, and mature to a successful adulthood. Others either fail to develop, or don't even make that stage.



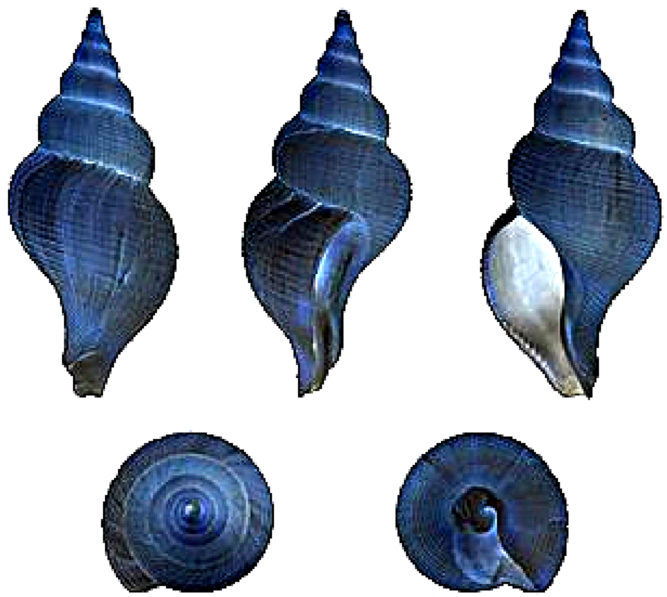
Early cell division in left-handed (left) and right-handed (right) snails.
Note how the drawing in the top LH corner shows NO rotation!

Dextral traits are dominant over sinistral when snails mate, but handedness in snails is **most commonly inherited from the mother.** With hermaphroditic snails (many terrestrial snails) this means that if a left-handed “mother” snail mates with a right-handed “father” snail, (both of them being hermaphrodites), the offspring of the “mother” snail will be left-handed. However: hermaphroditic snails can also self-fertilise, in which case the resulting offspring from the “mother (+father) snail” could, in theory, all be right-handed. **(If you are confused by all this - I admit, so was I - before I sat down, read, and inwardly digested!)**

Neptunea angulata individuals, like many marine snails, are **single-sex snails, so the hermaphroditic principle described above does not apply.** Therefore, I’d presume that the endemic left-handedness of the snail indeed arose from **an original pair or pairs** - an Adam, and an Eve. That is to say, both the male and the female were left-handed. It would have been easier for them to mate (left-and right-handed snails have difficulty reproducing together). Applying Mendelian genetic selection principles, they would both have coded for the recessive left-handed gene. **This probably explains why, despite my Google searches (and even Google is not exhaustive) I have found no evidence of a dextrally coiling *Neptunea angulata/ contraria* mollusc - since the species, and the way in which it has evolved, has simply not coded for that gene expression.**

<u>The evolution of *Neptunea angulata*</u>

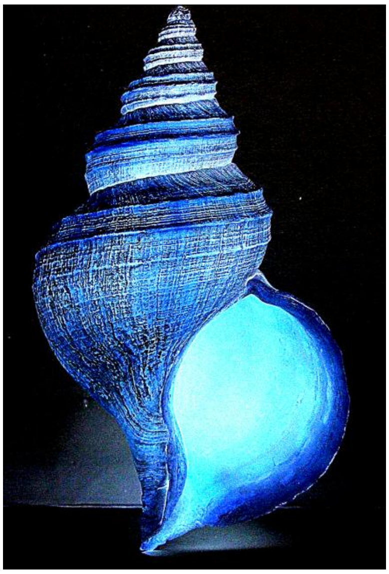
The species we’re concerned with here is popularly referred to as ***Neptunea contraria,*** even now - however, this is an antiquated term, as this species was renamed some time ago. There’s evidence that points to the fact that the modern ***Neptunea contraria*** (a Mediterranean species, and not to be confused with the original fossil version) is indeed descended from the fossils we see here, but that the latter are extinct (and now referred to as ***Neptunea angulata*** - just to make confusion worse confounded).



The modern *Neptunea contraria.*

What is the difference, you may ask? If you want to get technical, you can dose up on the research **outlined in the links I've provided,** which gives some idea about the differences in taxonomy (classification) based upon certain shell characteristics such as the length of whorls per turn of the shell, the tightness of the coiling, the ornamentation, and other elements - all which make a difference to the classification of a species.

So, how did the original ***Neptunea angulata*** pair come about? Was there a common ancestor? Mapping of fossil origins of this species trace it back to the Pacific, from where its Adams and Eves apparently made their way across what is now the Bering Strait, before ending up in the North Atlantic, and what is now the North Sea. Pointers indicate that the left-handed snails may well have been derived from a right-handed ancestor of very similar appearance and which shares a number of characteristics, namely ***Neptunea lyratodespecta***, which is represented in the Icelandic fossil record (***Neptunea despecta,*** a closely resembling right-handed shell, is shown below).



Neptunea despecta

The development of the species seems to have expanded and contracted over time. If, for the sake of argument, you want to take ***Neptunea lyratodespecta*** as a starting point - there is an explosion of variation in shell ornament shown in ***Neptunea angulata*** specimens throughout its history (depending on geographic location) during the Pliocene.

This indicates that the species became fairly spread out over a wide area. However, there are indicators that some environmental phenomena which impacted evolution, such as the drying up of water bodies and resultant migration of the species to more hospitable environments, must ultimately have occurred in order to enable the species variants to congregate together. This would have resulted in their consolidation into a more homogeneous and less variable species, which was recognizable as such - at the beginning of the Ice Age (Pleistocene).

<u>The benefits of left-handedness!</u>

We've briefly spoken about chirality at its most basic level, in molecules. Chirality can invest different versions of the same molecule with different properties; the left-handed version of aspartame has a sweet taste, whilst the right-handed version is completely tasteless (**see links at the end of this article**).

By the same token, thus too, do left- and right-handed snails (or other organisms) have different quirks. The same principle applying to molecules on the micro level, also applies to organisms on the macro level - in that there are **both physical and chemical reasons for their manner of growth, which influence and are constantly feeding back on each other.**

For the reasons which have been put forward in this article, some families or genera of snail are **exclusively sinistral, and coil only in an anticlockwise direction.** There are both perks and drawbacks to having a sinistral shell; on the one hand, it makes mating difficult. On the other hand, it's claimed there is evidence that sinistral individuals can be more resistant to predators (who are fooled by the typical structure of their prey appearing in reverse), but then go on to develop a whole new predator profile of their own.

Overview

I must admit that I went to The Naze not quite knowing what to expect. It was - pardon the pun - a clean-slate experience! I had done no prior research, but was enormously pleased with the finds from my maiden voyage. It is always exciting to delve into the questions that these kinds of discoveries raise, however amateur they may be - and humbling, to consider their age. The fact that their traces still survive after 2 1/2 million years, where it is doubtful that you or I or any traces of our output will remain even for a fraction of that time after we are gone - somehow, I think, puts our comparatively small human world, and all its shenanigans, into perspective!

Christina Brodie
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Links used in this article:

https://www.britishshellclub.org/sinistral-shells---ruscoe.html#:~:text=A%20sinistral%20shell%20is%20a,aperture%22%20appears%20on%20the%20left.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3105295/

https://pa01000125.schoolwires.net/cms/lib/PA01000125/Centricity/Domain/366/Chap6%20Chirality.pdf

https://www.pbs.org/newshour/science/how-a-snails-shell-gets-its-twist

https://www.sciencedirect.com/science/article/pii/S0960982216300604

https://en.wikipedia.org/wiki/Neptunea_angulata

https://academic.oup.com/icb/article/54/4/677/2797866

https://www.researchgate.net/publication/269859099_Pliocene_to_Quaternary_sinistral_Neptunea_species_Mollusca_Gastropoda_Buccinidae_from_the_NE_Atlantic

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