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Holding on to Ancient

I suppose it was the first time a delicate, glassy sea creature had died while speeding along one of Britain's thundering, three-lane highways. Every few minutes I glanced nervously over the steering wheel to check on the passenger. By some miracle it survived for hundreds of miles. My guilt had eased each time I looked and saw it was still plump like an oversized, crystalline gooseberry, eight little rainbows flickering across its body.

Normally these animals have whole oceans to wander through. No wonder this one was uncomfortable confined to a small jar of seawater. The unavoidable came swiftly, between two glances, and when I looked back all that was left was a small pile of goo. I carried on driving. I would deal with the dead sea creature later.

It had been me who found it, two days earlier, drifting over my wellington boot. Golf-ball sized and almost perfectly see-through, I instantly knew what it was. A ctenophore, with a silent C. *Teen-oh-for*.

You can't make plans to meet a ctenophore. All you can do is serendipitously find yourself in the exact right place when one happens to glide by. I've spotted them before while swimming down and up through open, blue water at the beginning and end of scuba dives. I didn't expect to see one while teaching on a field trip to the chilly, springtime coast of south Britain. This ctenophore made its appearance while I was standing in shallow water of a winding estuary, some six miles inland from open sea.

Without taking my eyes off it — look away and it would be gone — I yelled 'Pot! Someone get me a pot.'

A few hours later, the class of students gathered round and took turns to see the ctenophore and watch it glinting in the strip lights of the field station laboratory. I had no idea my discovery would be so celebrated.

It turned out that no one had ever found a ctenophore on this study trip before. In thirty years of bringing generations of Cambridge University students to the same stretch of Devonshire coastline none had ever shown up. Mine was the first.

All I had thought when I gently scooped it into a glass jar was how I wanted to hold onto it and watch it for a while. All the other ctenophores I've seen have floated along and vanished from sight in seconds, like songbirds flying past, leaving the briefest impressions in my mind. This time I could look at it for as long as I wanted.

I watched it manoeuvre carefully around its three dimensional world and probe the water with its two tentacles. In the wild, it would be hunting for tiny flitting animals, copepods, amphipods, the travelling offspring of barnacles. Its trailing fronds were twenty times the ctenophore's body length, so long they gathered in a tangle on the bottom of its seawater jar; then the creature would retract them and the sticky knot never tied tighter but unravelled and wound back in. Here was a creature with no brain and no eyes yet still it reacted to the world around it and somehow seemed to know where it was.

I wanted my students to see it too, to have their own encounters with a rare, pelagic visitor. It gave us a chance to see a beautiful thing, so ephemeral and normally far out of sight. The ctenophore did something else too. It coaxed us all to pause from our rock pool searches and look up from our microscopes. It pushed into our view ancient and powerful ideas about what it means to be an animal. It showed us that big, important questions about life on Earth remain unanswered.

The reason I had come to the coast in the first place was to help introduce the class to the immense diversity of living things. From the seemingly mundane surroundings of the British seaside, it only takes a few hours to find representatives from most of the major animal groups alive today.

Peer under rocks, search carefully among seaweed, wade down to the lowest shores as the tide sweeps out and there they are: crabs and shrimp (crustaceans); sea slugs and snails (molluscs); sea stars, feather stars, cushion stars (all of them echinoderms); sea anemones and solitary corals that look like tiny egg cups (the cnidarians, with another silent C, and the same group that jellyfish belong to); there are sponges (porifera) that look more like fungi than animals, and a host of fishes that lurk in transient pools waiting the tide's return. The fishes are chordates, together with all the back-boned animals including humans.

Each of these groups occupies a particular branch on the tree of life. My colleague drew a version of that tree on the whiteboard at the front of the lab. It isn't an actual tree but a boxy diagram of forked lines nested within each other, arranged around a central trunk.

It shows how each animal group is related to the others, how their ancestors split apart at some point in the distant past and went their own way. Some groups are more closely allied, others more distantly, and some emerged not so long ago in the grand process of evolution, the branches higher up the tree. The tree's shape is based on information about the form of animals, how their bodies are put together and the messages written into their DNA.

Ctenophores sit on their very own branch. Another name for them is comb jellies, although they aren't in fact jellyfish. Sure, ctenophores are mostly made of water, like jellyfish are, and they spend their time drifting through the ocean, catching food with stinging tentacles. But that's where the similarity fades away.

For one thing they don't move like jellyfish. Instead of pulsing with contractions of an umbrella-like body, ctenophores row themselves gently and smoothly along with thousands of tiny hairs called cilia. Like many jellyfish, some ctenophores are bioluminescent, they make their own light from chemical reactions inside them, similar to the cold light of a glow stick. Not the ctenophore I found, though. Its shining rainbows were created by rows of cilia, like tiny eyelashes beating in synchronised Mexican waves; their flickering splits ambient white light into its constituent parts and reflects rainbows into my eyes. Its movements and colours stemmed from the same gestures.

Ctenophores are also far more ancient than jellyfish. They could even be the most ancient living animals of all. Towards the bottom of the whiteboard tree of life float two lines unconnected to the trunk, one for sponges, the other for ctenophores. For a long time, scientists agreed on which line should go lowest, the first animal group to evolve, but recently things have started to become much less clear.

At around the same time that my students were exploring the shoreline, and unknown to most of us, a meeting of eminent neuroscientists was drawing to a close at the Royal Society in London. Up for discussion was the origin of nerves, nervous systems and brains. Nerves first arose early in the evolution of animals, perhaps as long as 600 million years ago. Although some plants have cells that behave a bit like nerves, bona fide nervous systems are unique features to animals. A controversial character in the Royal Society debate had been the ctenophore.

When Professor Leonid Moroz from the University Florida stepped up to the lectern he devoted his allotted half hour to uprooting the traditional tree of life and planting a whole new one. The conventional view is that sponges evolved earlier than any other animals still alive today. These are simple creatures with no muscles and no nerves, whose lives mostly entail sitting fixed in place on the seabed, a rock or a reef, silently filtering water as it trickles through their bodies. The story goes that sponges split off first from the animal tree of life, then nerves and brains came along later.

Moroz did something subtly but crucially different. Instead of putting sponges at the base of his tree, he put the ctenophores there. It may seem like an esoteric detail: which came first, sponges or ctenophores? This matters because sponges don't have nerves, and ctenophores do, revealing the compelling possibility that nerves evolved not once but twice.

It's astonishing that nerves and nervous systems evolved at all. A whole series of evolutionary steps were needed to make it all work. Nerve cells themselves had to emerge plus, crucially, their ability to talk to each other. The extraordinary thing about nerve cells is the way they gather information about the world around them, transmit and process it.

The possibility that this all happened on two occasions reveals a groundbreaking view on the evolution of life as we know it. It hints that there could be something inevitable about creatures evolving a means of sensing and responding to the world around them, to see, hear and learn things and communicate with each other. Perhaps it was bound to happen that animals would one day evolve to have ideas about how their own thoughts and memories are formed and stored. And it heightens the odds that maybe, just maybe, if there is life on other planets then there too roam animals with nerves that let them sense and move and think.

If ctenophores did come first, followed by sponges then all the other animals, there are a few possible explanations for what went on. The most ancient ancestor of all the animals could have evolved nerves and then sponges subsequently lost theirs. To many experts, though, this seems unlikely. Why cast off something as useful as a nervous system? Without one, an animal can't see, hear, talk or think. The only animals known to have downgraded their nerves are a handful of parasites. Another option, and the one Moroz supports, is that nerves did indeed evolve twice, first in the ctenophores and then again in the ancestor of all the other nerve-bearing animals.

A few lines of evidence back up this radical theory. Moroz originally became suspicious that something strange was going on when he struggled to study ctenophore nerves. Even though ctenophores aren't big thinkers they do definitely have nerves, laid across their bodies in a net like a cobweb. Compared to other animals, though, ctenophore nerves are completely different. When Moroz soaked them in dyes that normally stain nerve tissue, nothing showed up. They seem to run on alternative machinery with different molecules whizzing around, transmitting messages from here to there.

Ctenophore genetics also hint at their ancient origins. Studies of three species, out of perhaps 150, have so far suggested their genetic clocks have been ticking for longer than any other animals.

I didn't know any of this until my well-informed colleagues began telling the class about these remarkable animals. As I gazed at the captive ctenophore sliding forwards and backwards through the water in front of me, its strange nerves were telling its hair-like cilia what to do. Nerves also coordinated the reeling in and out of its tentacles. I was seeing and processing all this with my own nervous system that I had only just learned is wired up in a very different way.

Something my ctenophore didn't do while I watched on was do a poo. Most animals have to at some time or other: they eat things, digest them for nutrients and energy then expel the bits that aren't needed. The way ctenophores do it has become the focus for yet more recent scientific controversy.

It's long been thought that the earliest animal guts had a single, dual-purpose opening to them— a mouth and anus rolled into

one, like corals and jellyfish have today. Take a ball of modelling clay, push a finger in to make a hollow and there you have a model of a simple two-way gut.

Arranged like this, an animal has to finish digesting its stomachful before taking another bite. It's much more efficient to do things on a one-way conveyor belt. Food in at one end, digestion in the middle, faeces out the other end. Worms evolved this smart trick and it recently emerged that ctenophores might do something similar too.

William Browne from the University of Miami in Florida has filmed ctenophores eating and pooping. He fed them bits of fish and shrimp genetically engineered to glow red (incidentally using a fluorescent protein originally found in a jellyfish). He tracked colourful food through the ctenophores' translucent body and fully expected undigested particles to spew back out of their mouths, as a German scientist first observed back in 1880. Instead, the red particles threaded through a network of canals in the ctenophores' bodies and popped out through two pores at the opposite end to the mouth. It seems ctenophores don't just have one anus, but two.

Once again, ctenophores are forcing scientists to have a rethink. Did one-way guts evolve just the one time, in the ancestor of all animals, then get lost in jellyfish, corals and sponges? Or did they evolve in ctenophores, then again later on? For now, there's no clear answer but the possibilities mess with the idea that evolution is neat and stepwise, that innovations emerge and push life in new directions. Ctenophores, with their unusual guts and curious nerves, could be experiments in animal life, showing that there's more than one way of doing things.

Naturally, not everyone agrees with the ctenophores-first theory. At least not yet. Such a big shake up of the pathway of evolution can't possibly settle into mainstream thinking without a lot of time and debate.

A big part of the problem is that many details of ctenophore life remain mysterious because they're so difficult to find and even more difficult to keep alive in captivity, as I found out on my way back from Devon.

My colleagues and I decided to try and take the ctenophore back to Cambridge to add to the Zoology Museum's collections. Without the necessary preserving fluids, though, we had no choice but to hope it would survive the journey intact.

I didn’t think it had been my idea. I usually insist on putting things back. On the final day of a field trip I’m always the one lugging seawater buckets down to the shore to return the creatures we’ve been observing and studying. Deep down, though, I knew that this time I wanted to hold onto the mesmerising thing I’d found. I gave in to the selfish urge to chase after it and keep it, to make it mine. And I didn’t argue hard for releasing the ctenophore. I guess I was tempted by the trivial stardom of proving to people back home that I was the ctenophore-whisperer. *Look what I found*. But that was not to be.

I held the ctenophore’s jar over the toilet bowl and thought about saying a few words. Then, lifting the lid on its temporary, confined ocean, the decomposing pong was so sharp it made me gag, tip and swiftly flush.

Goodbye ctenophore.

And sorry.

Note from the author: I would like to thank my writing group, Neuwrite London, for helping me shape this essay in its early form.