The humble sea sponge has a surprisingly intricate genome including the blueprint for complex vertebrates - and it’s not even a true animal. Elizabeth Finkel reports.

We only just survived being told we have the same basic gene set as a roundworm - 20,000 genes give or take a few. But a recent report goes too far: the sponge! It’s just a blob with no eyes, no nervous system, no muscle, no gut, no circulatory system, no tissues of any sort really - just cells embedded in a jelly matrix. They’re not even considered true animals. Yet, according to the Nature report by researchers at the University of Queensland and the Department of Energy’s Joint Genome Institute in California, the sponge genome also sports much of the basic tool kit of all animal life.

“There’s been a lot of surprises,” admits Bernie Degnan, the leader of the University of Queensland team that collected the decoded sponge, Amphimedon queenslandica, from the Great Barrier Reef.

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Great Barrier Reef. “We time travelled 600 million years back to reconstruct the ancestor of all living animals. Now we’re rewriting the way we perceive evolution.”

In recent years, biologists have had a treasure trove of creatures’ genomes to peer into. At first, it was their favourite lab models such as the fly and the worm. But increasingly the choices have become more strategic: those creatures that occupy key branches on the tree of life. Ever since 19th century taxonomists took a close look at the sponge, they realised it occupied a landmark position.

It was considered an ‘ur-animal’. Like the first attempt at civilisation in the ancient city of Ur in Babylon, the sponge was seen as a first attempt at multicellular life. It was not quite there, but possessed the hallmark features of an animal, instead of a plant or fungus. For instance, they have soft membranes around their cells, unlike the rigid wall of plants or fungi. And like all animals, they rely on outside sources to get their food - they filter water to capture bacteria and organic matter. They also had the key hallmark of being animal - they were a society of different cell types that had learnt to live together.

The reading of this animal’s genome promised to reveal crucial things about what it took to become an animal. More importantly, we would learn valuable things from what it didn’t have. The ‘missing’ genes would provide clues to how to make things that belonged to real animals, such as brain cells or muscles.

Researchers were staggered to find that in fact the sponge was not missing much at all. The gene number, though yet to be finalised, seems to be in the...
Horizontal transfer

How did the sponge get so tooled-up? One theory is that it evolved from groupings of protists (single-celled organisms) that had already evolved complex genes individually. An alternative theory for how the sponge acquired such a well-stocked tool kit is that it had them shipped in by viruses or bacteria. This freighting of genes from one species to another is known as ‘horizontal gene transfer’. It happens all the time between different species of bacteria and bacteria (known as agrobacteria). But recently researchers have been startled by examples higher up the evolutionary tree. In an April 2009 study published in Science, researchers at the University of Queensland discovered that the red finger sponge, Amphimedon queenslandica has members of all of the gene families coding for these features. So how did the sponge get these core features? One possibility is that the leap to becoming the ur-animal was a result of strategic alliances between different single-celled creatures known as protists. Each protist would have supplied key components to the tool kit. Genome readers are not the first to have been led to this idea. Sponge aficionados long ago noticed a group of hairy cells lining the pores of the sponge, which flush water through by beating their hairs like trained oarsmen. Some of the genes that made these cells - known as chaonocytes have been startled by recent researchers cousin of the sponge, such as trichoplax, red finger sponge (above) and green varieties, had acquired genes for precocious gene transfer. Arizona found the pea aphid, which has red and green varieties, had acquired genes for red pigment from a fungus. Given this revelation of wanton cross-species gene pilfering, perhaps the sponge likewise had its brain genes freighted in from some more complex species. "Not likely," says Bernie Degnan. Other distant cousins of the sponge, such as trichoplax, coral and comb jellies, also have these brain genes. Since these species are not linked to each other by direct descent, this suggests they inherited their common brain genes from a common ancestor. "There’s no need to evoke horizontal gene transfer," says Degnan.
So, in 2008, it was the unicellular choanoflagellate's turn to have its genome showcased in Nature. The particular species was Monosiga brevicollis. Monosiga gave the code readers a few surprises; the biggest was that among its set of approximately 9,200 genes, it carries the genes for 'integrin' - which is involved in cell adhesion and communication. Researchers had thought it an exclusively animal innovation. Unlike humans, humans have a nervous system tool kit. But maybe it's not so surprising after all. Some choanoflagellates occasionally get together to form spherical colonies of equal partners. It's easy to imagine how these tentative gatherings of hunter-gatherers might have become more permanent, leading ultimately to the delegation of different duties - as occurred in the sponge. These types of alliances and the genes they contributed may have produced the first well-tooled animal. It's a process that occurred over the 150 - 200 million-year period between the first protists and the appearance of the sponge ancestor (roughly the same amount of time that separates us and certain species of dinosaurs). "The fact that many of the genes required to build a brain or an eye predate the evolution of the structures themselves looks like a kind of genomic anticipation of things to come, but it makes perfect sense that before you have the structure, you need to have most of what you need to build it. Most new traits are largely enabled by what's lying around at the time rather than wholesale evolution of a swag of new genes," says Miller.

For Degnan, who has been sleuthing the origins of animals since his days as a doctorate student, the humble sponge has flipped the way he perceives evolution. "Any textbook would lead you to believe that simple animals would have simple genomes. As you peer in and see, you have to reconcile what you find within a new framework. It seems all animals inherited a phenomenally complex genome."

Elizabeth Finkel, a former biochemist, is a science writer and contributing editor of Cosmos. Her new book 'Genome: revelations from the code of life' will be published in 2011.