Common evolutionary origins between vertebrates and invertebrates revealed

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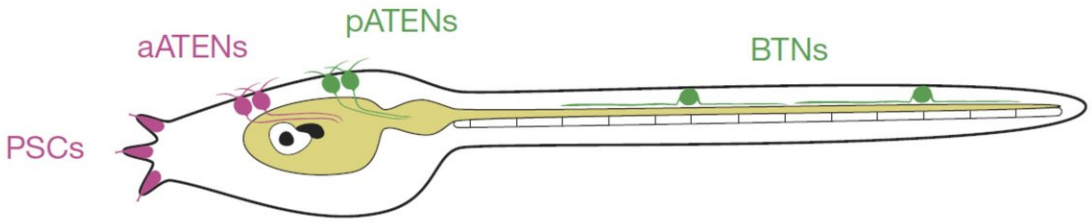

Diagram of Ciona tadpole showing the position of PSCs (palp sensory cells), aATENs (anterior trunk epidermal neurons9, pATENs (posterior apical trunk) and BTNs (bipolar tail neurons). Credit: University of Tsukuba

Placodes and neural crests are defining features of vertebrates (animals with a spinal cord surrounded by cartilage or bone). Placodes are embryonic structures that develop into sensory organs such as ear, nose, and lens cells, while neural crests develop into various cell lineages such as bone, craniofacial cartilage, and epidermal sensory neurons.

In spite of extensive study on placodes and neural crests, their evolutionary origins remain unclear. The puzzle is further compounded by evidence of the presence of rudiments of both cell types in invertebrate chordates (animals without a spinal cord). This spurred a team of Tsukuba-centered researchers to unravel this evolution mystery.

"For the purpose of our study, the researchers used a combination of lineage tracing, gene disruption and single-cell RNA-sequencing assays to explore the properties of the lateral plate ectoderm, a peripheral embryonic structure, of the proto-vertebrate, Ciona intestinalis, a marine invertebrate animal commonly known as the sea squirt," explains Ryoko Horie, one of three co-first authors of the study which was in the prestigious journal *Nature*.

By analyzing the regulatory "blueprint" of the Ciona embryo, the researchers identified several genetic determinants of the lateral plate ectoderm, and successfully obtained evidence for the interlocking regulatory interactions among them.

"The most striking deviation between the Ciona and vertebrate regulatory fate maps is the compartmentalization of the Ciona front lateral plate into two distinct domains," says corresponding author Takeo Horie.

The researchers found that the antero-posterior compartmentalization of the Ciona lateral plate led to the development of related but distinct sensory cell types, including palp sensory cells (PSCs), anterior trunk epidermal neurons (aATENs) and bipolar tail neurons (BTNs). aATENS have been shown to have dual properties of placode-derived chemosensory neurons, such as neurons involved in the sense of smell, while BTNs are thought to share properties with neural crest-derived dorsal root ganglia, a cluster of neurons (a ganglion) in a dorsal root of a spinal nerve.

Notably, the BTNs readily transformed into PSCs when regulatory genes of the former were misexpressed. The proof of transformation was confirmed by whole-embryo single-cell RNA-sequencing assays.

"Taken together, our findings suggest the possibility of the entire lateral

plate of the last shared tunicate and vertebrate ancestor being the source of both placodal and neural crest derivatives in vertebrates," says Takeo Horie.

More information: Ryoko Horie et al, Shared evolutionary origin of vertebrate neural crest and cranial placodes, *Nature* (2018). DOI: 10.1038/s41586-018-0385-7

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