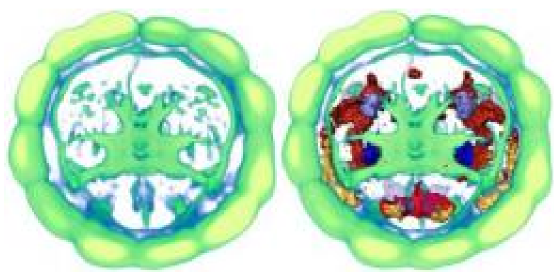
Brainy worms: Evolution of the cerebral cortex

September 2 2010



A virtual Platynereis brain (left), created by averaging microscopy images of the brains of 36 different individuals, onto which scientists mapped gene activity (right). Perspective shows the brain as viewed from inside a Platynereis larvae, at 48 hours' old. Credit: EMBL/R.Tomer

(PhysOrg.com) -- Our cerebral cortex, or pallium, is a big part of what makes us human: art, literature and science would not exist had this most fascinating part of our brain not emerged in some less intelligent ancestor in prehistoric times. But when did this occur and what were these ancestors?

Unexpectedly, scientists at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany, have now discovered a true counterpart of the cerebral cortex in an invertebrate, a marine worm. Their findings are published today in *Cell*, and give an idea of what the most ancient higher brain centres looked like, and what our distant ancestors used them for.

It has long been clear that, in evolutionary terms, we share our pallium with other vertebrates, but beyond that was mystery. This is because even invertebrates that are clearly related to us - such as the fish-like amphioxus - appear to have no similar brain structures, nothing that points to a shared evolutionary past. But EMBL scientists have now found brain structures related to the vertebrate pallium in a very distant cousin - the marine ragworm Platynereis dumerilii, a relative of the earthworm - which last shared an ancestor with us around 600 million years ago.

"Two stunning conclusions emerge from this finding", explains Detlev Arendt, who headed the study: "First, the pallium is much older than anyone would have assumed, probably as old as higher animals themselves. Second, we learn that it came out of 'the blue' - as an adaptation to early marine life in Precambrian oceans."

To uncover the evolutionary origins of our brain, EMBL scientist Raju Tomer, who designed and conducted the work, took an unprecedentedly deep look at the regions of Platynereis dumerilii's brain responsible for processing olfactory information - the mushroom-bodies. He developed a new technique, called cellular profiling by image registration (PrImR), which is the first to enable scientists to investigate a large number of genes in a compact brain and determine which are turned on simultaneously. This technique enabled Tomer to determine each cell's molecular fingerprint, defining cell types according to the genes they express, rather than just based on their shape and location as was done before.

"Comparing the molecular fingerprints of the developing ragworms' mushroom-bodies to existing information on the vertebrate pallium," Arendt says, " it became clear that they are too similar to be of independent origin and must share a common evolutionary precursor."

This ancestral structure was likely a group of densely packed cells, which received and processed information about smell and directly controlled locomotion. It may have enabled our ancestors crawling over the sea floor to identify food sources, move towards them, and integrate previous experiences into some sort of learning.

"Most people thought that invertebrate mushroom-bodies and vertebrate pallium had arisen independently during the course of evolution, but we have proven this was most probably not the case," says Tomer. Arendt concludes: "The evolutionary history of our cerebral cortex has to be rewritten."

More information: Tomer, R., Denes, A., Tessmar-Raible, K., & Arendt, D. Cellular resolution expression profiling reveals common origin of annelid mushroom bodies and vertebrate pallium. *Cell*, 26 August 2010.

Provided by European Molecular Biology Laboratory