Scientists offer new insights into early eye evolution

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Scientists at the University of Hawaii at Manoa's Kewalo Marine Laboratory in Honolulu have discovered light-detecting cells in the embryo of a brachiopod, a marine invertebrate, whose organization may be similar to the primitive precursors of the human eye.

As detailed in the research article, “Ciliary photoreceptors in the cerebral eyes of a protostome larva,” published online March 1, 2011, in the BioMed Central open access journal EvoDevo, the organization of these cells is extremely simple, lacking the complex features seen in the eyes of vertebrates, thereby offering a glimpse into the earliest stages of eye evolution.

Researchers have long hypothesized that the complex human eye evolved from a very simple patch of cells on the surface of a primitive animal, slowly increasing in complexity by adding features such as pigmentation, a lens, and neuronal connections to the brain. To date, however, few examples similar to the earliest stages of this process have been identified.

Drs. Yale Passamaneck and Mark Martindale of Kewalo Marine Laboratory, along with colleagues in Germany and Norway, identified two distinct groups of light-detecting cells in the brachiopod embryo that may provide such examples. Both groups of cells contain light-sensitive cells called ciliary photoreceptors, the same type of cells that are responsible for light detection in the human eye.

The researchers found that the eyes of the fully developed brachiopod larva are composed of only two cells—with one of the cells containing a lens to collect light, while the other containing pigments to block light coming from behind the eye. Both cells have connections to a group of neurons called the ganglion, allowing signals produced in response to light to be sent to other parts of the embryo.

Together, this configuration allows the embryo to detect the direction of light and respond to it by changing its swimming behavior. This configuration is the first example in the large group of animals called protostomes (which also includes insects and mollusks), shown to use the ciliary photoreceptors found in human eyes.

Surprisingly, the researchers also found light-sensitive cells very early in the development of the brachiopod, before any neurons had formed, based on the expression of the light-sensitive gene ciliary opsin, which converts light into a chemical signal within the cell. This light-sensitive structure is unprecedented in terms of its morphological simplicity, being composed of only a single layer of cells on the surface of the embryo, and having no neuronal connections to other cells.

These cells likely act individually, autonomously responding to light by changing the pattern of beating of cilia on their surface. This simple organization of non-neuronal light sensitive cells is remarkably similar to what has long been hypothesized as the earliest stage in the evolution of complex eyes.

Said Dr. Passamaneck, lead author of the study, “This research provides a new model for understanding the very earliest stages of eye evolution, how simple cells on the surface of an animal could become able to respond to light, and how these simple cells could be connected to eventually form something as complex as the human eye."