Fish use deafness gene to sense water motion

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Fish sense water motion the same way humans sense sound, according to new research out of Case Western Reserve University School of Medicine. Researchers discovered a gene also found in humans helps zebrafish convert water motion into electrical impulses that are sent to the brain for perception. The shared gene allows zebrafish to sense water flow direction, and it also helps cells inside the human ear sense a range of sounds.

The gene encodes a protein in hair cells, the cells that receive sound inside the ear. Mutations in the gene can cause deafness in humans. In addition to inside their ears, zebrafish have hair cells along their whole bodies to sense water flow. Hair cells on the surface of zebrafish bodies

face different directions to sense water moving all around them. But, the new study found hair cells facing different directions are not identical as previously thought—each uses the deafness gene slightly differently.

"We found detection of water flow from the front of the fish is more dependent on the zebrafish gene tmc2b than water flow from the back of the fish," said Brian McDermott Jr, PhD, associate professor of otolaryngology at Case Western Reserve University School of Medicine and University Hospitals Cleveland Medical Center. "Water flowing from the front of the fish accompanies forward swimming, therefore, it is routine. But water coming from the rear could mean a predator in pursuit. Zebrafish therefore use different molecular mechanisms to distinguish water flow direction."

McDermott and Ruben Stepanyan, PhD, assistant professor of otolaryngology at Case Western Reserve University School of Medicine published the findings today in *Nature Communications*. The study dives into mechanotransduction—how hair cells sense mechanical sound waves, or in this case, water waves, and convert them into brain signals. McDermott's team discovered hair cells on the zebrafish skin use different mechanotransduction genes—like tmc2b—depending on their orientation. "Not all hair cells are the same. They are different based on the direction they face, and that is key to detecting the direction of water flow," McDermott said. The study identifies tmc2b as central to mechanotransduction. The gene is required for hair cells to transmit signals to the brain, which could explain its role in genetic deafness. "Our findings are directly connected to human hearing," McDermott said. "We studied a zebrafish gene that is analogous to a human gene that causes deafness, and here we show the defect is in the process of mechanotransduction."

The researchers used their findings to create a "mechanosensory map" of zebrafish hair cells. The map shows how a hair cell's location and

orientation relates to its ability to sense water motion. It also shows how different hair cells require, or can function independently, of the deafness gene tmc2b. The map could inform future studies related to human hair cell mechanotransduction, and the causes of genetic deafness.

Said McDermott, "Zebrafish hair cells are particularly accessible for experimentation, unlike hair cells of the ear of mammals, so they offer a special advantage. You can study the development and functioning of intact hair cells to a higher level in fish than those of the mammalian ear."

Differences in hair cells help fish sense water flow patterns—and may also help humans sense different sounds. "In mammals, hair cells are the sensory cells of the ear," McDermott said. "Our findings suggest that in mammals, including humans, there may be molecular differences between hair cells that allow us to hear the wonderful range of sounds that we enjoy."

More information: Shih-Wei Chou et al, A molecular basis for water motion detection by the mechanosensory lateral line of zebrafish, *Nature Communications* (2017). DOI: 10.1038/s41467-017-01604-2

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