U of I Study: Thyroid Hormone Can Alter Color Vision in Zebrafish, Potentially in Humans

August 05, 2019

MOSCOW, Idaho — Aug. 5, 2019 — Exposure to thyroid hormone can alter eye function in zebrafish, a result with implications for curing color blindness and retinal degeneration in humans.

The University of Idaho study found the dosage of thyroid hormone in zebrafish could switch the type of opsin — proteins that support color vision — produced in individual eye cells called cones, likely influencing the animals' color vision. Zebrafish and humans have similar genetics when it comes to color vision.

The researchers' findings were published today in Proceedings of the National Academy of Sciences and could lead to new therapies for visual disorders.

Cones distinguish color in vertebrates. Individual cones are sensitive to different colors of light depending on the type of opsin protein the cone produces. A cone that produces red-sensitive opsin is mainly responsive to red light. In humans and other primates, the genes that determine if a cone produces red- or green-sensitive opsin sit next to each other on the X chromosome.

Whether a cone became red- or green-sensitive was thought to be a random process due to this configuration. Recent research has suggested otherwise, said Robert Mackin, a doctoral student in U of I's College of Science and lead author of the study.

"Red and green are the most important colors we see," Mackin said. "They allow for our high-acuity vision, which we use for driving and reading. The red and the green cones that allow us to see these colors can die through diseases like macular degeneration, which affects many of the elderly."

The team tested whether thyroid hormone, which is pivotal in the development of the retina, could control which of the two opsin genes are turned on in zebrafish. Similar to the genetic arrangement in humans, zebrafish have neighboring opsin genes that produce red- and orange-sensitive opsin instead of red and green.

The study exposed zebrafish embryos and larvae to greater levels of an active form of thyroid hormone (T3). In those zebrafish, the number of cones that expressed the red-sensitive opsin gene increased with the dosage of T3. Alternatively, if the thyroid gland was removed, the number of cones expressing orange-sensitive opsin increased compared to normal zebrafish. The findings indicate thyroid hormone can control whether red- or orange-sensitive opsin genes are turned on in zebrafish, Mackin said, a process that's not random.

Although individual cones usually produce only one type of opsin, the team found larvae exposed to T3 had individual cones that switched from triggering the orange-sensitive to the red-sensitive opsin gene. This finding suggests cones can change the type of opsins they produce. The authors suggest zebrafish may use thyroid hormone to tweak their eyesight as they grow and change their swimming and feeding behaviors.

"Our primary goal is to figure out the basic science and understand how opsin expression is controlled," Mackin said. "We hope that we and other researchers may be able to test this process in humans and then develop new treatments or therapies for preventing visual disorders from occurring or cure color blindness and vision loss diseases."

U of I researchers Deborah Stenkamp, a professor; Ruth Frey, a research specialist; Carmina Gutierrez, an undergraduate with the National Science Foundation Research Experiences for Undergraduates program; Ashley Farre, a doctoral student; and Diana Mitchell, an assistant professor, co-authored the paper alongside Shoji Kawamura from the University of Tokyo.

Media note: An image associated with the study's findings is attached to this email.

Image caption: Thyroid hormone changes the color sensitivity of cones. Increasing concentrations of an active form of thyroid hormone (from left to right) cause a switch from "orange-sensitive" cones, indicated by magenta fluorescence, to "red-sensitive" cones, indicated by green fluorescence, in whole eyes obtained from larval zebrafish. The cones that appear white are caught in the act of switching.

Photo credit: Robert Mackin and Deborah Stenkamp/University of Idaho.

This project was funded under National Institutes of Health grants 5R01EY012146 and P30GM103324. The total funding from these grants including supplements was $1,784,404.48 of which 100% is the federal share. This project was funded under National Science Foundation grant 1757826. The total funding from this grant is $363,930 of which 100% is the federal share.

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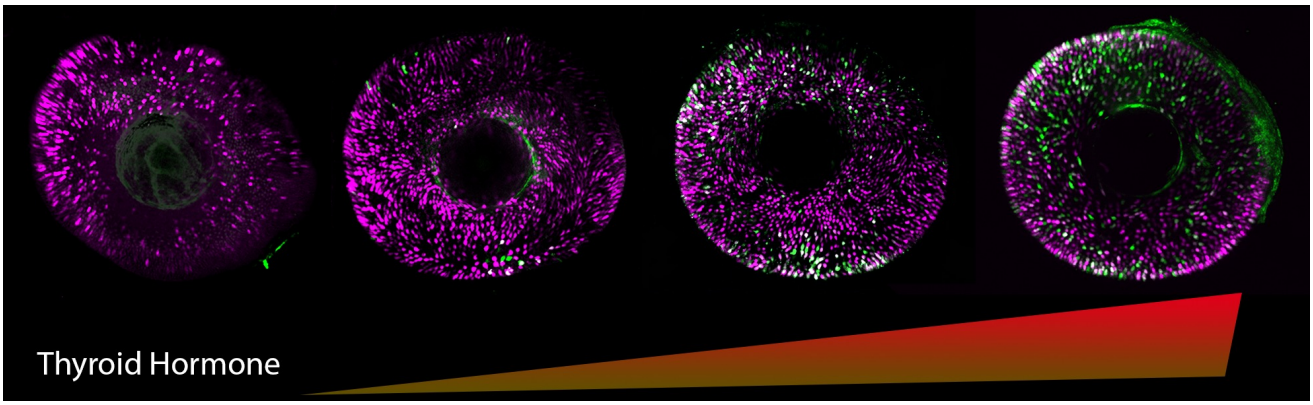

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