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How do fish see and what we can learn from their visual system

The highly connected brain circuit is capable to process many functions. It is full of mysteries and its properties and connections are still not clearly understood. Studying brains in different species might be the key to understanding more about the brain and its structures. Sensory functions of the brain are being used by many species to perceive surroundings and identify objects in order to perform a behavior and respond to environmental changes. Vision is one of the sensory functions and it is essential for survival. Even lower-order animals such as fish need to perceive their environment to locate food, water, mates, and escape from predators. Fish are vertebrates like humans and even though their brains are way smaller and simpler, their nervous systems have many similarities to humans. Both human and zebrafish visual system consists of the eyes including the retina, the optic nerve, optic tract, and visual centers to receive and process visual information.

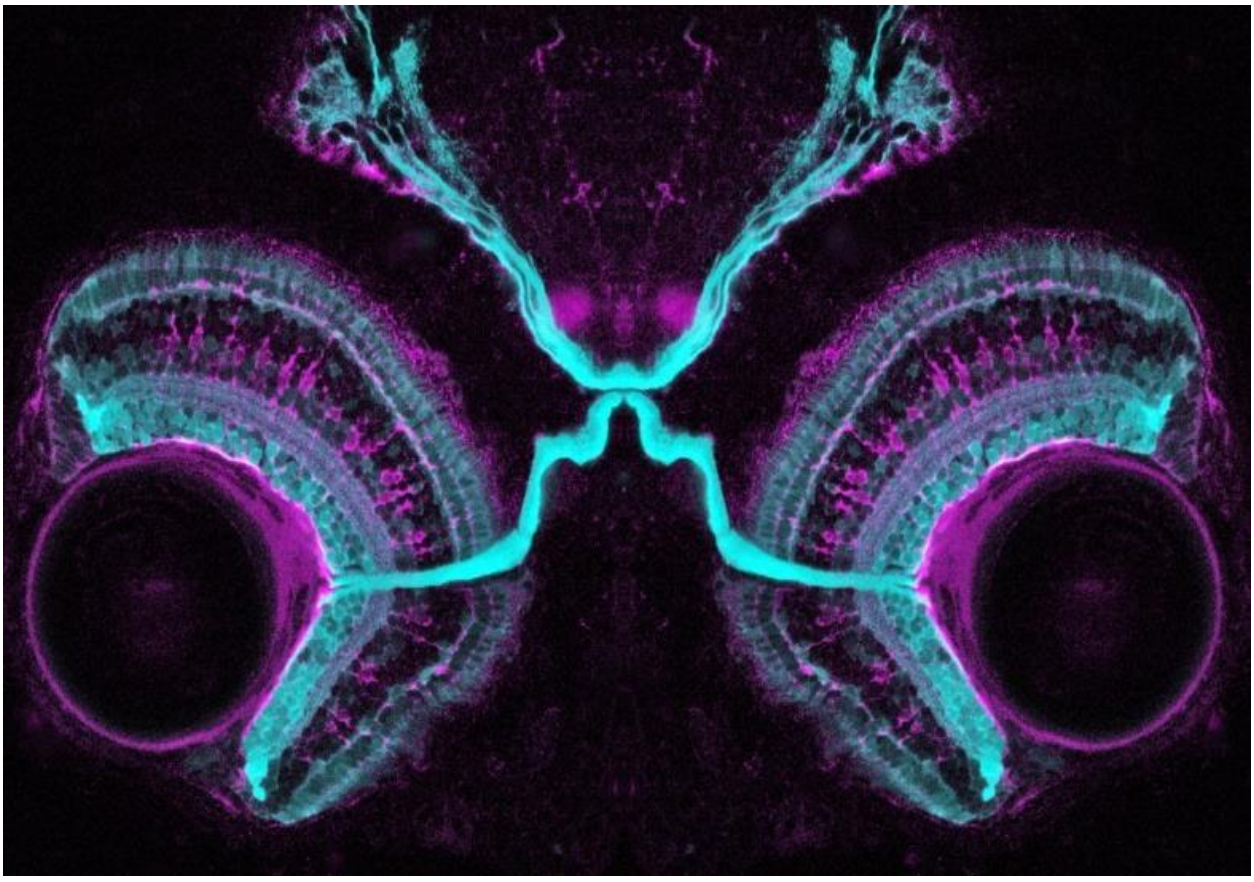

Figure 1 from Dr Kara Cerveny & Dr Steve Wilson, Wellcome Images | Image showing the visual system in a four-day-old zebrafish embryo from frontal view including its both eyes and frontal brain. Neurons, their projections and photoreceptor cells are marked with cyan, other types of cells are shown in purple.

Eyes include a lens similar to the ones in cameras. This lens can change its shape through tiny muscles to focus on the object according to its position, far or close, and capture light rays from it. Light rays enter the eye, pass through the lens and make an upside-down image on the back of the eye. In the back of the eye, there is the retina, the outermost part of the brain. It includes photoreceptors, special cells that are light-sensitives. They transduce the information they get from light rays to brain signals, and send it to other cells of the brain through to the optic nerve. The optic nerve transfers the visual information to the optic centers of the brain where it will be processed and the image gets flipped back to its right position. Neuroscientists are interested not only in how we capture that an object is seen, but also types of nerve cells that are involved in this procedure and how visual cues are actually processed in the brain.

Understanding vision in small and easy-to-maintain model animals such as zebrafish helps understanding the human brain circuit for vision better. Thus, understanding how fish see gives us more insight into the human visual system.

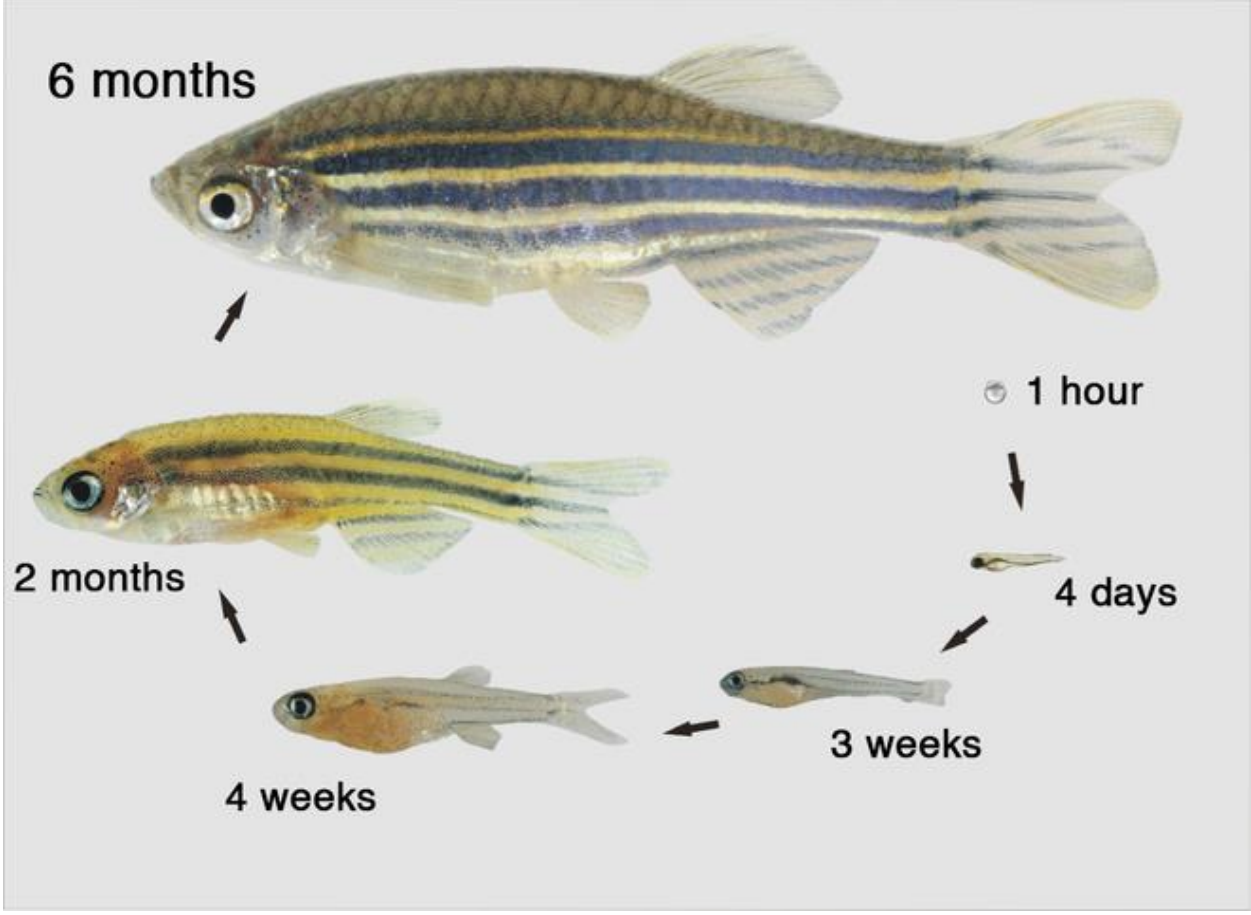

Figure 2 from Nüsslein-Volhard lab. Image shows different age groups in zebrafish from adult to embryos.

Zebrafish are quite popular animal models. Their genome has been all sequenced, thus there are many genetic tools available to manipulate their genes to study cells, connections, and neurological diseases. According to current scientists, human protein-coding genes are 70% related to zebrafish. Another outstanding characteristic of the zebrafish animal model is that they are transparent during the larval stage. Once they are about 5 days old, it is possible to see their brain, vessels, muscles, and even heart without any invasive procedures. Therefore, both their brain and eyes are quite accessible to record information about their visual system unlike other animal models such as rodents with thick skulls.

It is possible to image the whole visual circuity in one single animal (Figure 1), see the role of each cell in whole visual system and observe the development of vision in the different age groups of zebrafish (Figure 2). Using the zebrafish animal model enables studying human ocular diseases such as blindness. Blindness can be caused for many reasons, photoreceptor degenerations is one of them. Most of the blindness in humans is age related. Research teams at Harvard University and University of Idaho in USA identified several genes potentially connected to age-related blindness in zebrafish. Thus, understanding how fish see gives us more insight into the human visual system and help us to improve our understanding of vision and ocular diseases.

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