

The Morphological Types and Connectivity of Horizontal Cells Found in the Adult Zebrafish Retina

Abstract

The zebrafish, *Danio rerio*, is a useful vertebrate model for studying the normal function of genes at the cellular and molecular levels. Zebrafish are used in forward-genetic screens to identify novel genes involved in normal structure and function as well as genetic mutations involved in inherited disorders. Since the visual system is highly conserved across vertebrates, many of the cells in the zebrafish retina structurally resemble and function like those found in other species. In order to characterize mutations leading to visual deficiencies, it is necessary to understand how a normal wild-type zebrafish retina is organized. Moreover, since the form of a retinal neuron affects its function in visual processing, it is important to know how these retinal neurons differ in morphological structure.

Horizontal cells are second-order neurons that connect to photoreceptor cells and process visual information laterally within the retina. Studies on the horizontal cells of other teleosts have revealed that different species have various types of horizontal cells with diverse morphologies and roles in visual processing. In the zebrafish retina, the different types of horizontal cells and the way in which horizontal cells connect to photoreceptors are unclear. Therefore, I investigated the morphology and connectivity of the horizontal cells found in the adult wild-type zebrafish retina.

Tiny crystals of the fluorescent dye DiI were placed onto the tips of glass electrodes, and the crystals were inserted into the inner nuclear layer of whole-mounted retinas. The somas, axons, and dendritic terminals of horizontal cells were labeled with DiI, and horizontal cells were imaged with a confocal microscope. Images were then analyzed according to dendritic arborization, cell depth, dendritic terminal morphology, and connectivity with photoreceptors.

Four types of horizontal cells (H1, H2, H3, and Rod HC) were identified. Cone-connecting H1 and H2 cells are similar in size and appearance, and both have dendritic terminals that are arranged in "rosette" clusters that connect to nearby cone photoreceptors without any apparent specificity. The cone-connecting H3 cells are much larger than H1 or H2 cells and have doublets of dendritic terminals arrayed in a rectilinear pattern. This regular pattern of the H3 cells corresponds to the dimensions of the zebrafish photoreceptor mosaic and indicates that H3 cells connect to specific photoreceptors. The horizontal cell dendritic terminal patterns suggest that the H3 cells are selective in terms of the type of cone photoreceptor they connect with, whereas the H1 and H2 cells do not exhibit such selectivity. Thus, H3 cells may process specific color information while H1 and H2 cells process non color-specific illumination. Rod horizontal cells were identified by their morphological and dendritic pattern, and they connect with rod photoreceptors via dendritic terminal spherules. This information about adult wild-type zebrafish horizontal cells can be applied to studies of zebrafish visual mutations that involve horizontal cells.