

# Shared Developmental Origin and Architectural Divergence in Two Photosensitive Organs: The Eye and Pineal Complex

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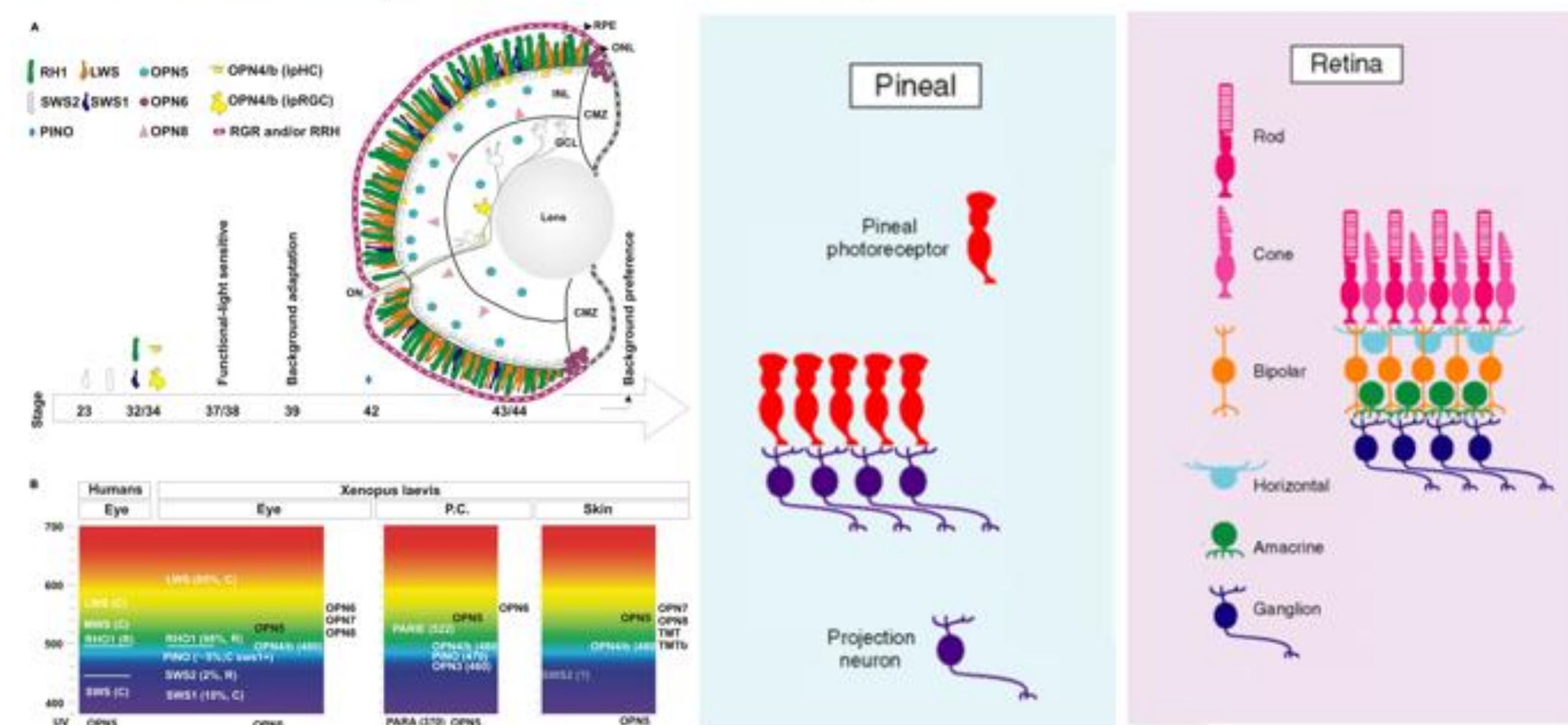
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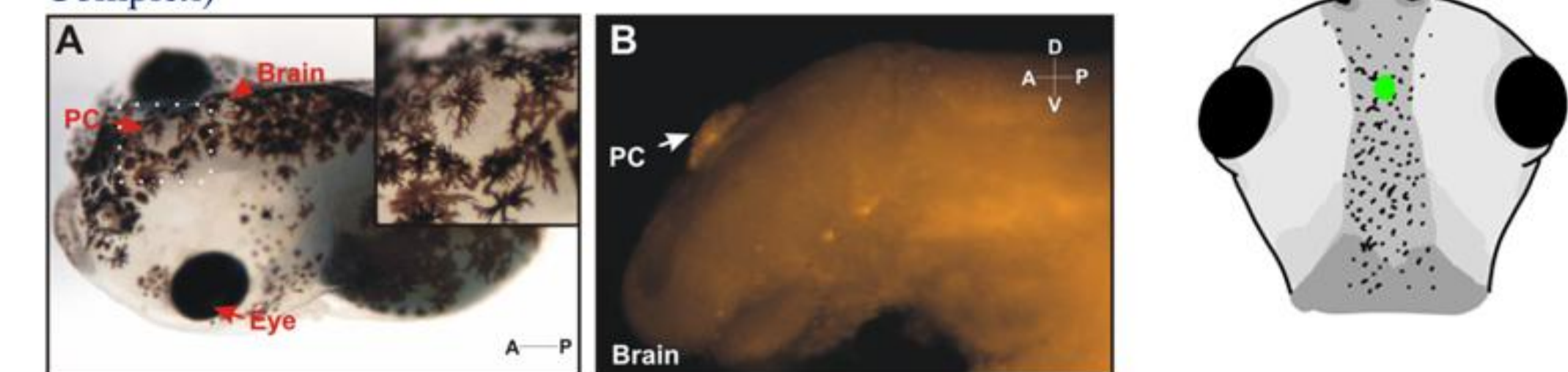
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## Introduction:

A) The developmental timeline below indicates when these opsins and associated behaviors first appear. B) Schematic compares opsin expression in the eye, pineal complex, and skin (tail or MEX cells), aligned with their peak spectral sensitivities, and includes a comparison to human visual opsins.



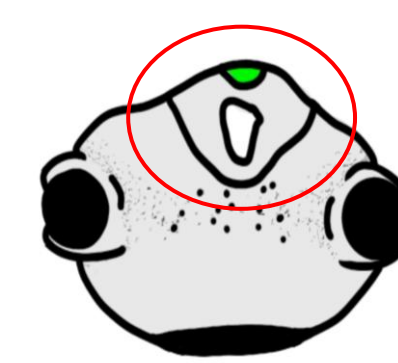
Animal Model: *Xenopus laevis* have the third eye (Pineal Complex)



Category	Markers	Retinal Layer
Transcription Factors	Islet (Isl1/2)	Ganglion Cell Layer (GCL), Inner Nuclear Layer (INL)
Transcription Factors	Otx2	Outer edge of INL, Outer Nuclear Layer
Transcription Factors	Pax6	INL, GCL
RNA binding protein	Rbpms2 (Hermes)	GCL
Photopigment marker	Opn5 (Neuroopsin)	INL
Melatonin-producing cells	ASMT	ONL, subset of INL
Neuronal marker	HuC/D	GCL and INL
Photoreceptor	Pinopsin	ONL

## Methods:

- Using FISH (fluorescent in situ hybridization) to label mRNA of gene of interest.
- Using Immunohistochemistry to label markers.
- Using confocal Imaging (LSM900) to image eyes and pineal complex.
- All images are transversal section with 12-micron thickness.



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## Result

Figure 1. Partial colocalization of Pinopsin and Islet.

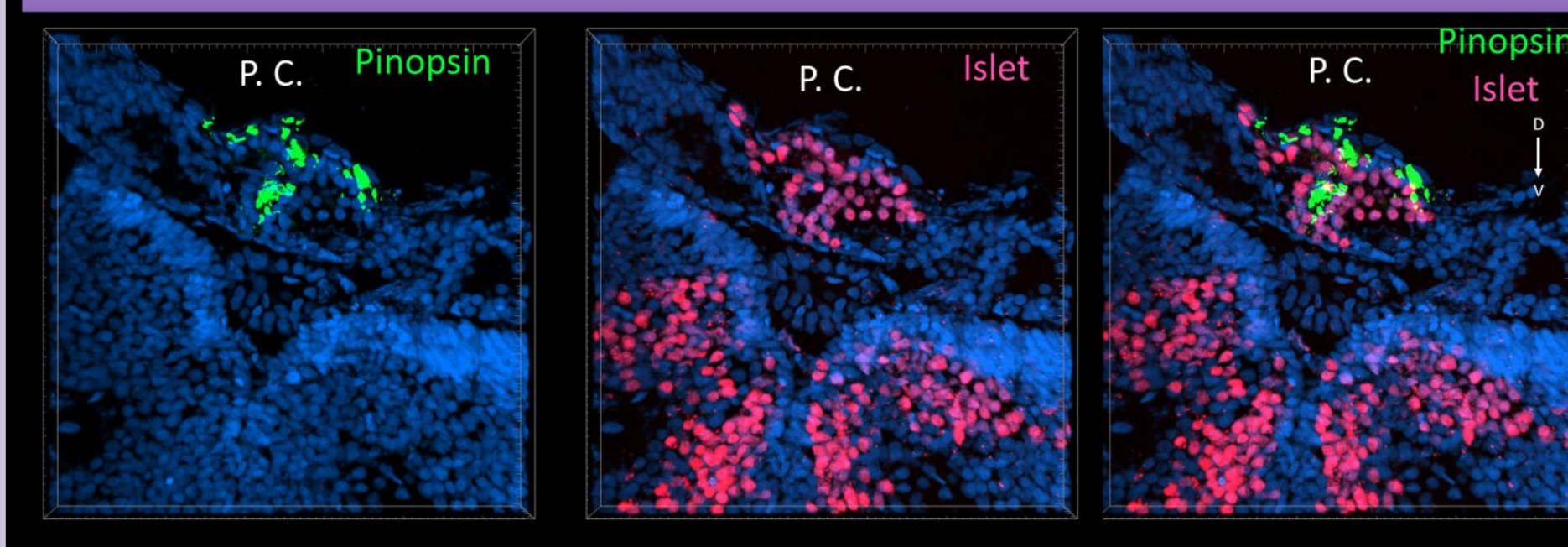


Figure 2. Otx2 expression in the majority of pineal cells, reflecting a shared specification program with retinal photoreceptors.

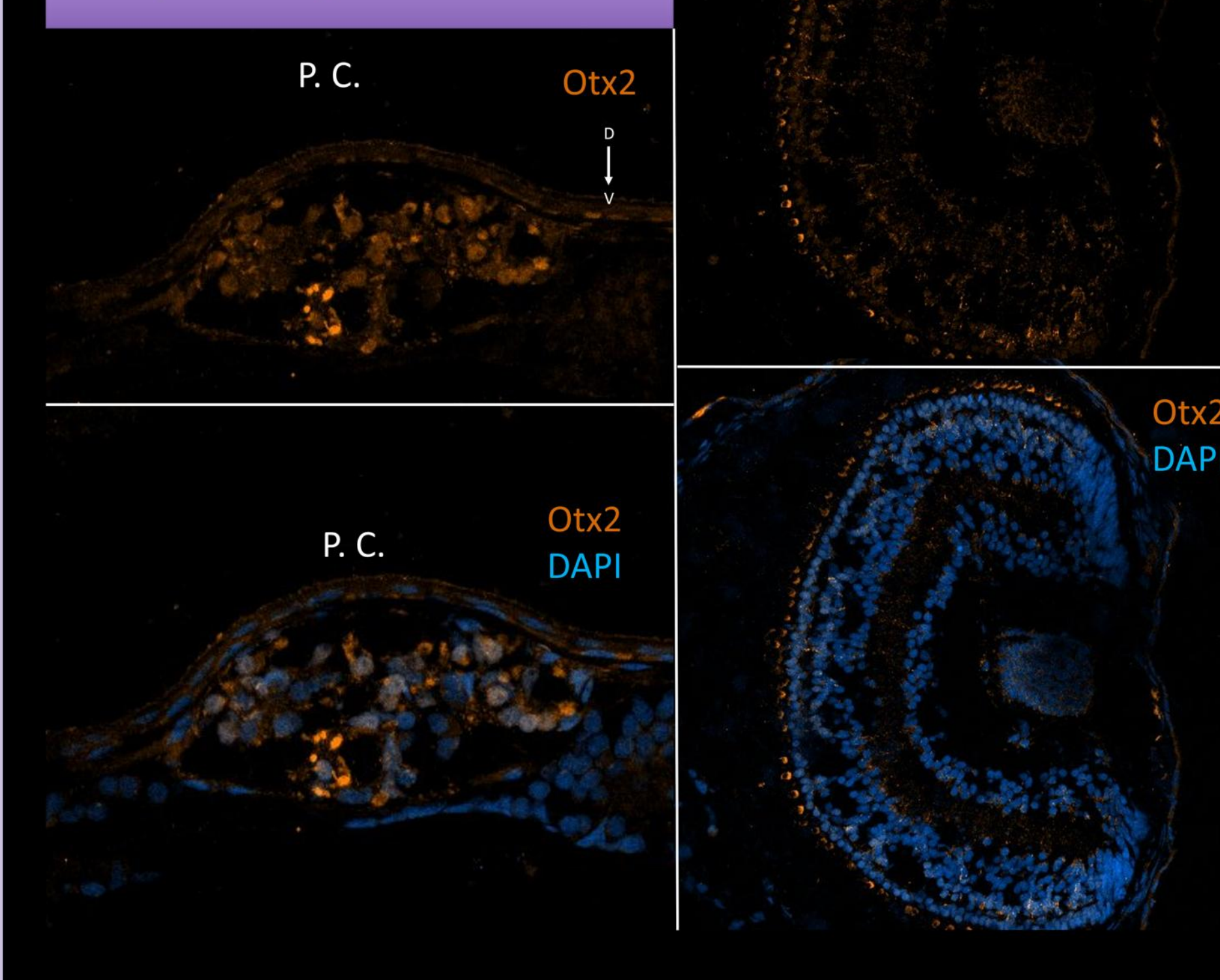


Figure 3. Divergent colocalization patterns of Islet and Otx2 in the pineal complex versus the retina.

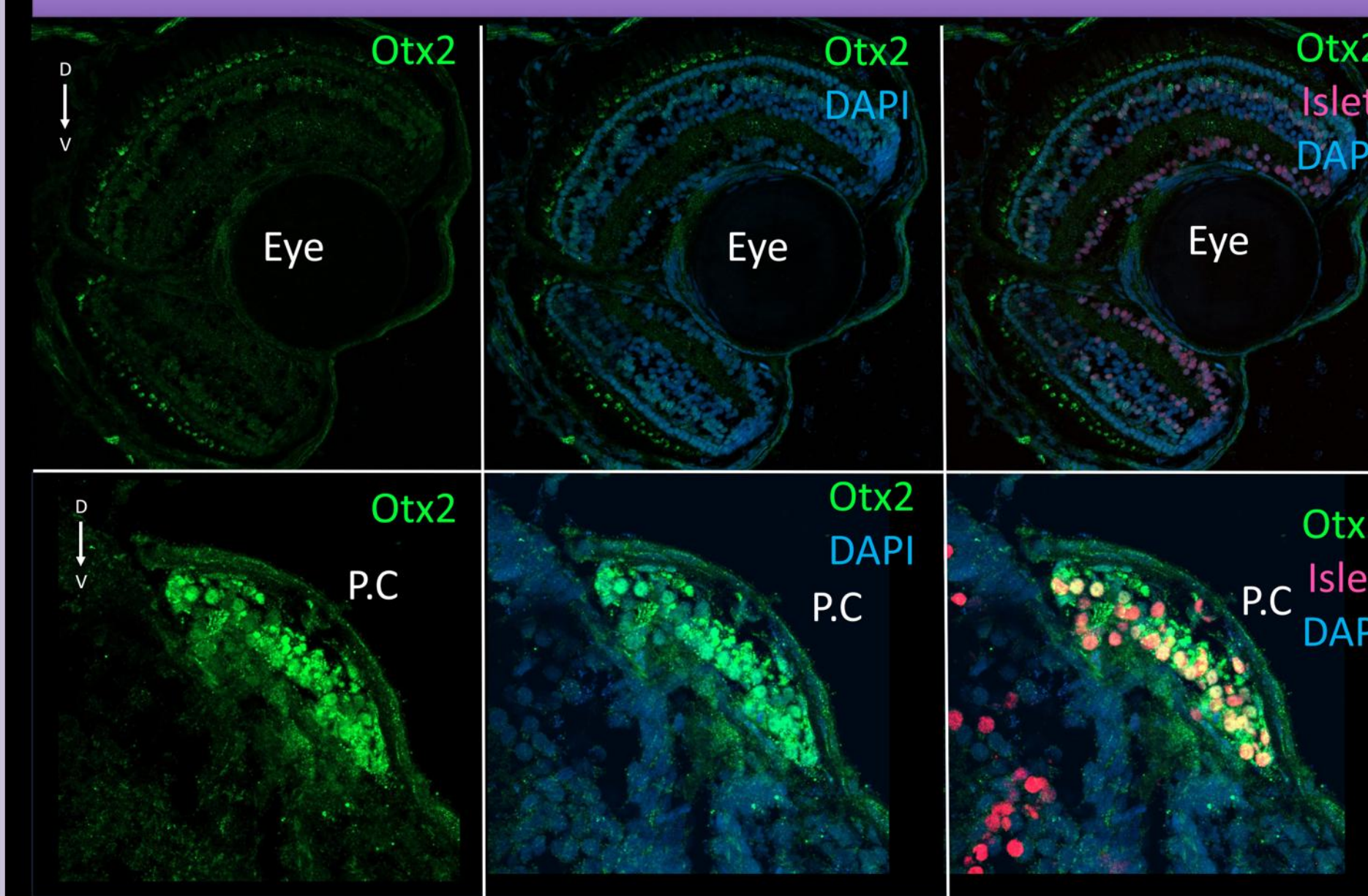


Figure 4. HuC/D labeled mature neurons do not colocalize with Pinopsin-positive cells in either the retina or the pineal complex.

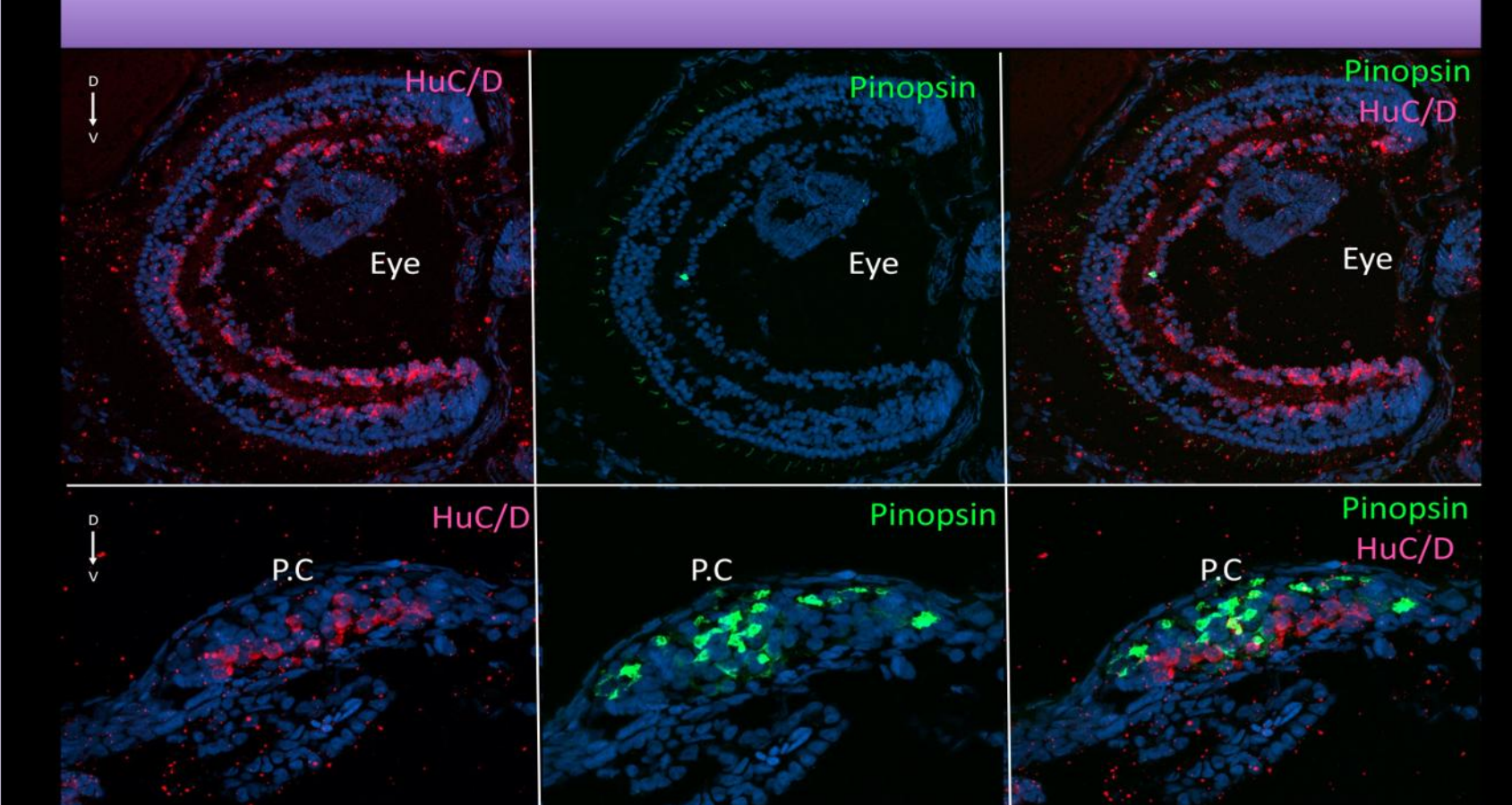


Figure 5. rbpms2 (RNA-binding protein with multiple splicing 2), is known as Hermes. It serves as a specific cell marker for retinal ganglion cells (RGCs). While rbpms2 is robustly expressed in the retina, it exhibits minimal expression within the pineal complex. Previous study indicates that Rbpms2 protein is synthesized in the eye and subsequently transported through the optic nerve to the brain.

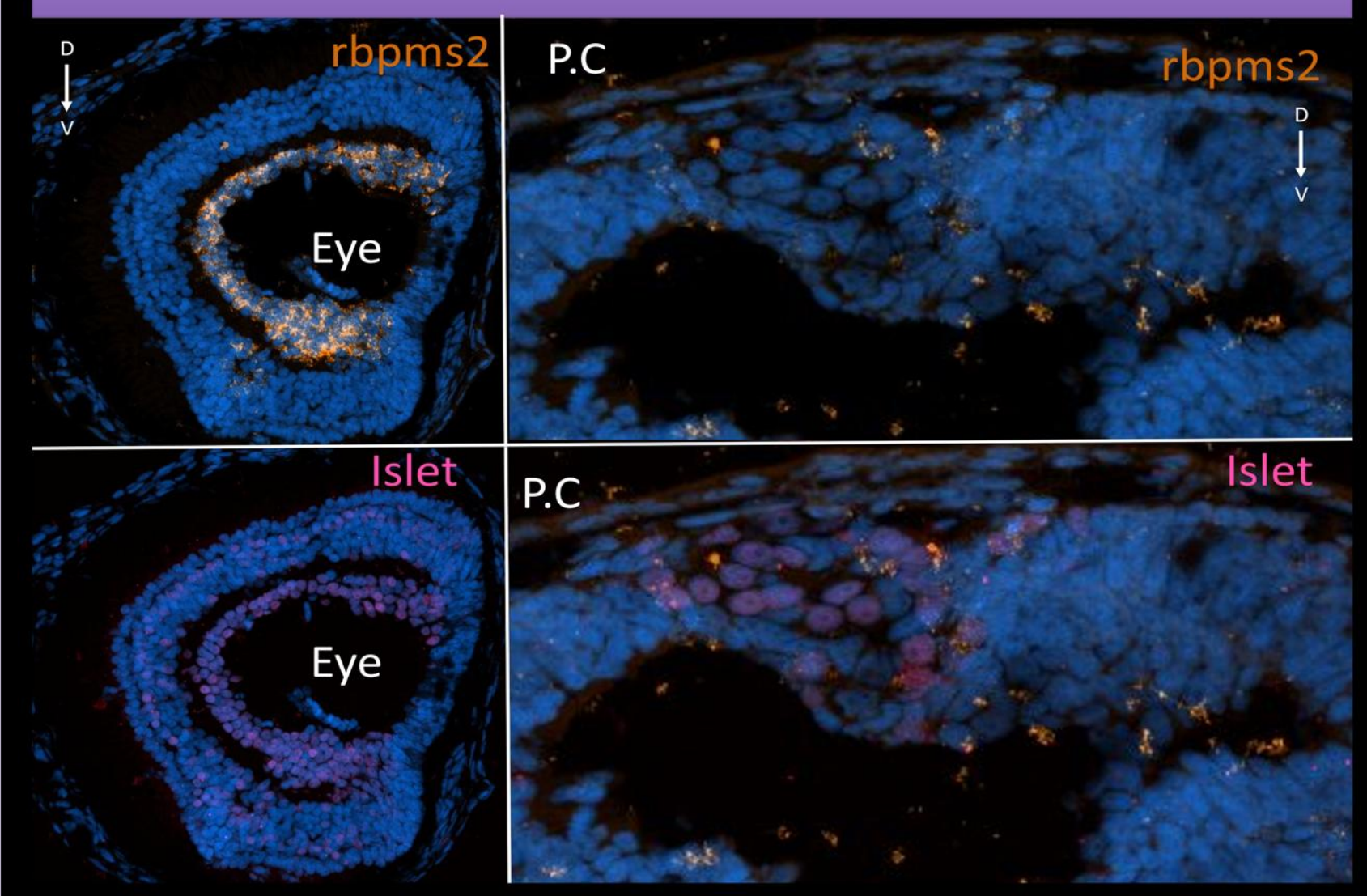


Figure 6. ASMT expression in retinal photoreceptors identifies melatonin-producing cells. In the eye, melatonin functions as a neurotransmitter. These ASMT-positive cells do not colocalize with Islet-positive populations within Retina.

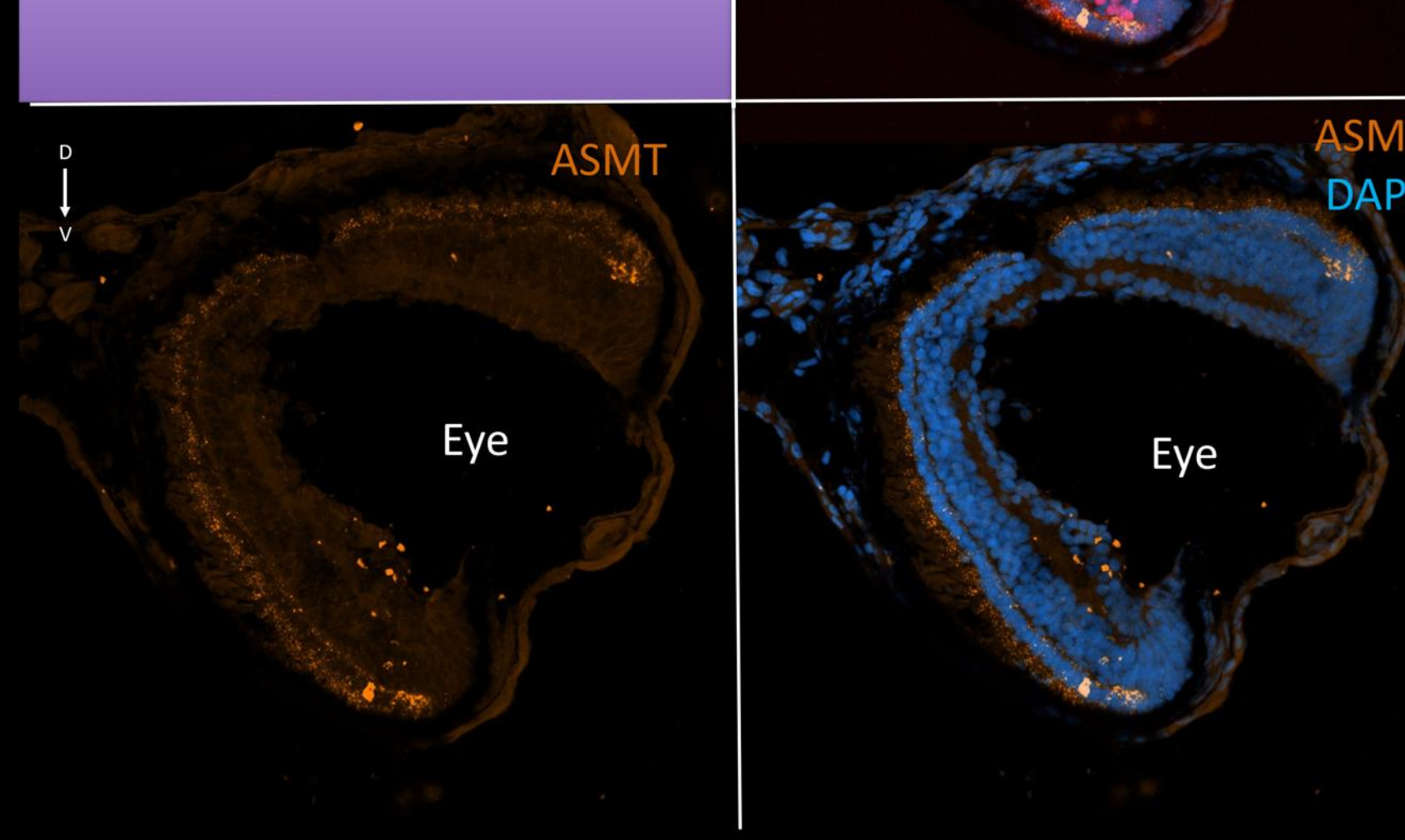


Figure 7. Colocalized of ASMT and Pinopsin in the pineal complex. ASMT-positive cells, identifying the melatonin-producing population, colocalize with Pinopsin-positive photoreceptors. This suggests that these specific photoreceptors function as neurosecretory cells, sensing environmental cues to regulate melatonin production.

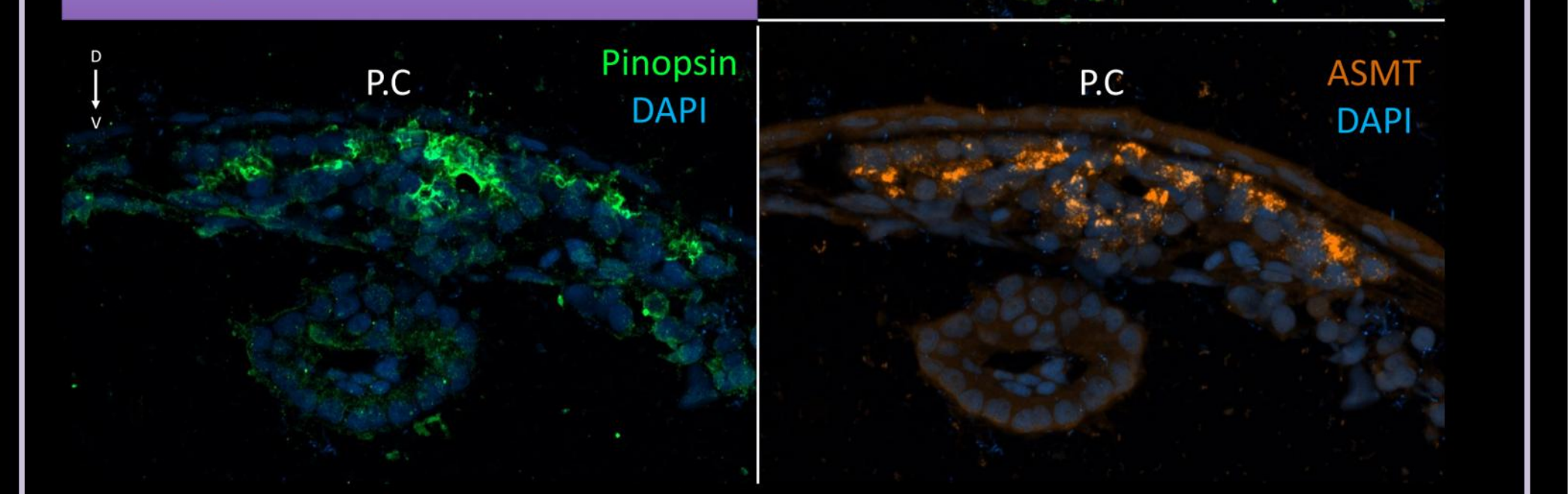
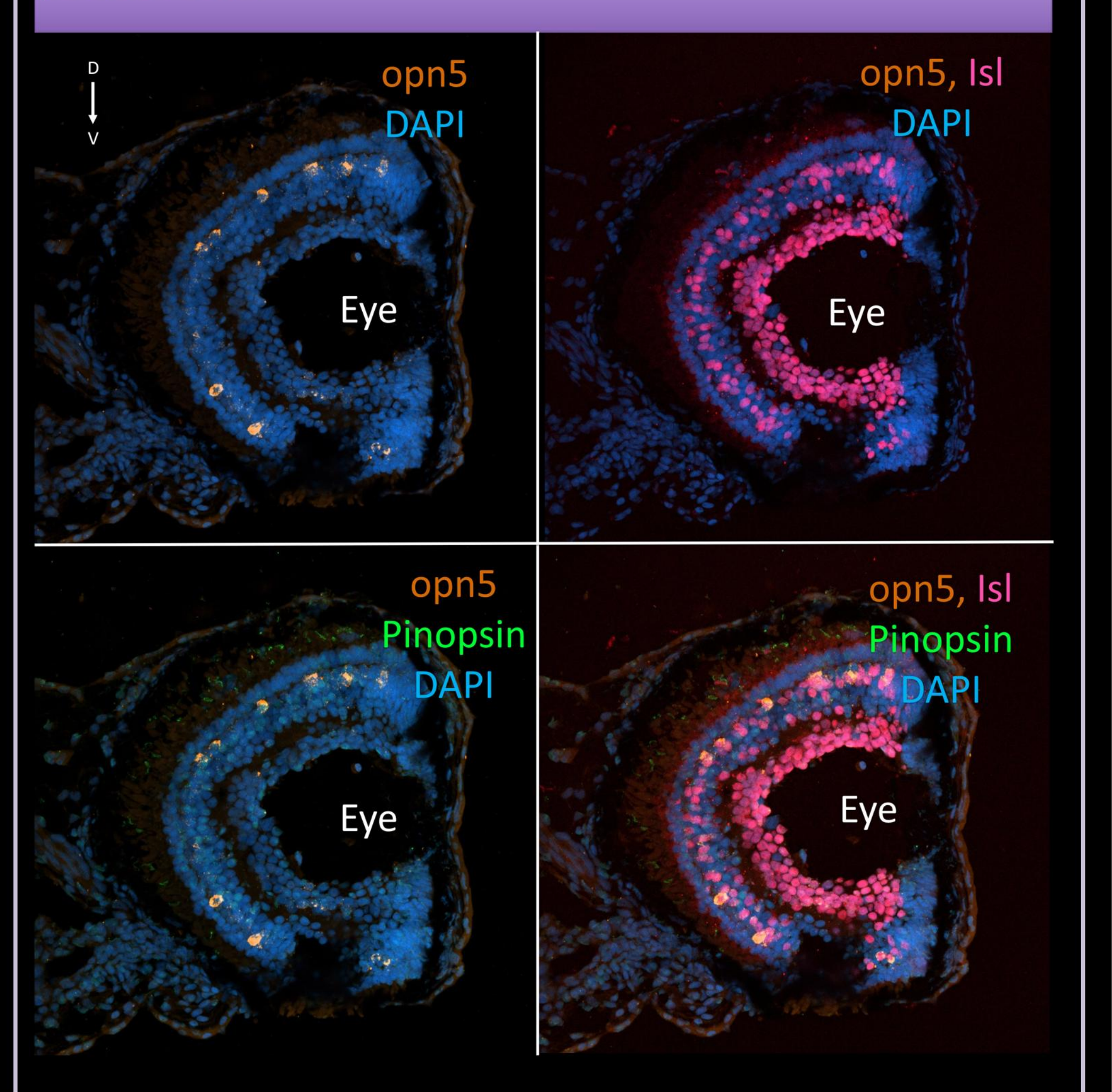


Figure 8. Opn5 (Neuroopsin) is localized to the inner nuclear layer (INL) of the eye and mainly colocalizes with Islet-positive cells.



**Conclusion and Future direction:** This study showed pineal cells specification has similarities and differences with eye structure. By stage 46, I observed that most pineal cells are already Otx2-positive. This study shows ASMT and Pinopsin are colocalized, which identifies these specific cells as a secretory cells and not projection neurons. In future, I'll look at other markers, including pax6 and otx5, that should give us much clearer picture of how these distinct cell population develop and function as a photosensitive organ.

## References:

- Bertolesi, Journal of Photochemistry and Photobiology, 2020  
Bertolesi, Journal of Frontier in Neuroanatomy, 2022

