Chemical Engineering
Fall 2023 Seminar Series

Ways of Seeing: Lessons From Single-Cell Genomics About the Evolution of Neurons Underlying Vision

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3:00-4:00pm
2:45pm Reception

The processing of visual information relies on diverse (>100) types of neurons in the retina, a thin neural film residing in the back of the eye that serves as an outpost of the brain. The basic plan of the retina is beautifully conserved across all living vertebrates, despite species differing profoundly in their visual needs. Some species are diurnal, other nocturnal; some are terrestrial, others aquatic; some mainly hunt, others forage for colorful fruits. How neuron types in the retina might have evolved to accommodate these varied needs has not been systematically studied. I will describe the results of a four-year effort to relate retinal cell types across 20 species by combining single-cell genomic measurements, machine learning, and molecular neuroscience techniques. We discover that the degree of variation in cell types is not uniform, but increases from the outer retina to the inner retina, suggesting that evolution preferentially acts to shape the retinal output. Despite this variation, we show that numerous types are shared across species based on conserved gene expression programs that likely trace back to an ancestral vertebrate >400 million years ago. Of note, we have identified rodent orthologs of the so-called “midget” cells which comprise >80% of the retinal output in humans, subserve high acuity vision, and are believed to be specific to primates. In contrast, the mouse orthologs have large receptive fields and comprise <2% of mouse output neurons. Strikingly, projections of both primate and mouse orthologous types are overrepresented in the thalamus, which supplies the primary visual cortex. We suggest that midget cells are not “primate innovations”, but descendants of evolutionarily ancient types that decreased in size and increased in number as primates evolved, thereby facilitating high visual acuity and increased cortical processing of visual information. Knowing the orthologs of midget cells in several accessible models will aid efforts to slow their degeneration in blinding diseases such as glaucoma.

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