One of the primary goals in neuroscience is to figure out simple principles that explain how systems are organized. Barlow proposed… Barlow (1961) proposed one of the most successful theories in neuroscience, which states that sensory neurons should be organized to optimize the information they process with limited energy. This efficient coding theory has repeatedly been validated in the early visual system by making testable predictions that have been confirmed experimentally. Efficient coding explains why retinal ganglion cells (RGCs) have center-surround receptive fields, and why these neurons are separated into ON and OFF pathways that process light and dark information, respectively. Each RGC processes information in a relatively small region of visual space, and all neuron within the same functional type (e.g. ON and OFF pathways) tile the entire retina to form a ‘mosaic’. By building an efficient coding model, my lab recently found that whether ON and OFF mosaics should be aligned or anti-aligned depends on whether the internal noise levels of RGCs is low or high (Jun, Field & Pearson, 2021). My central hypothesis is that such an efficient coding model can explain empirical findings about the retina in more details, such as how colors and motion are processed.

**Aim 1:** Determine whether retinal ganglion cells process colors information efficiently.

Information in natural images is mostly achromatic, and differences between shades of red and green represent very little of the information. However, how the retina works seems to contradict that principle: Midget cells consist most (80%) of RGCs and encode red/green opponency, while parasol cells, which encode achromatic information, only represent a small fraction (10%) of RGCs. *My working hypothesis is that we can reconcile these two principles and show that encoding visual information with a high proportion of midget cells is efficient.* To do so, I will apply the efficient model previously built by our lab (Jun, Field and Pearson, 2021) to chromatic natural images. Because my preliminary results suggest that having more parasol than midget cells is efficient, I will need to make biologically realistic modifications to the model to replicate previous empirical findings. By doing so, I aim to uncover the minimal conditions that make midget cells the most efficient subtype of RGCs to encode natural images. Such modifications include non-overlapping photoreceptors, increasing the proportion of RGCs relative to photoreceptors, as well as introducing inhibition into the network.

**Aim 2:** Determine the computational benefits of inhibitory interneurons to make encoding more efficient

Amacrine cells are inhibitory interneurons that receive inputs from RGCs and inhibit them in return. These cells are responsible for multiple phenomena, such as contrast gain control and motion selectivity.

John’s advice:

Color is about how we optimize different input channels

So is motion?

Details about midget cells (etc) goes in background, not in specific aims

Present my project as something very general,

Core: My project is about understanding how efficient coding works with different correlated channels

Both correlated noise, color and motion fit in that problem

Efficient coding has particularly been successful in vision

Our lab showed that efficient coding model can be applicated in more complex scenarios to understand mosaics. Allows us to answer new questions

Most theoretical papers in vision assume that mosaics are infinite, assume linearity, etc.