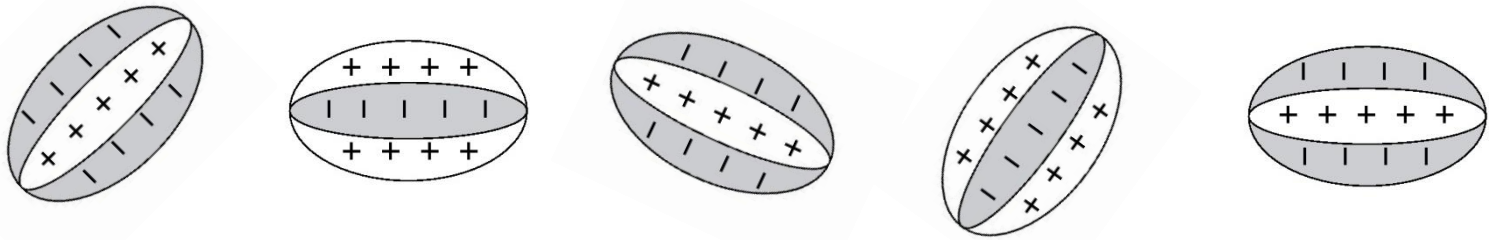
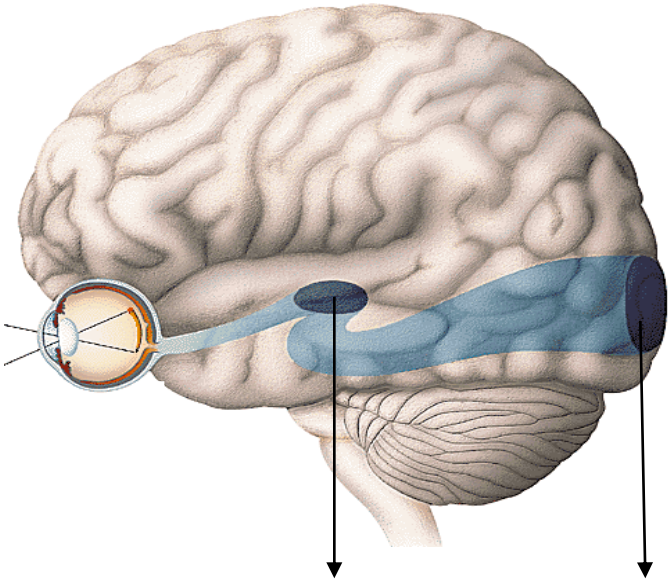
II. **Mechanistic** Model of Receptive Fields

- The Question: *How* are receptive fields constructed using the neural circuitry of the visual cortex?



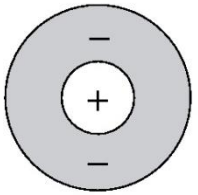
How are these *oriented* receptive fields obtained from *center-surround* receptive fields?

II. Mechanistic Model of Receptive Fields: V1

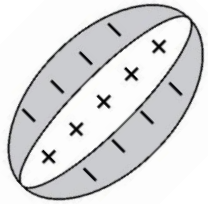


LGN
(Lateral
Geniculate
Nucleus)

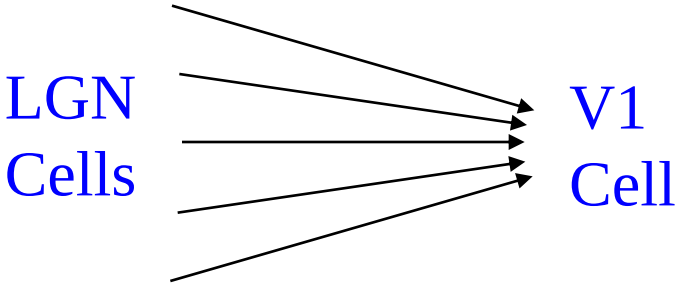
V1
(Primary
Visual
Cortex)



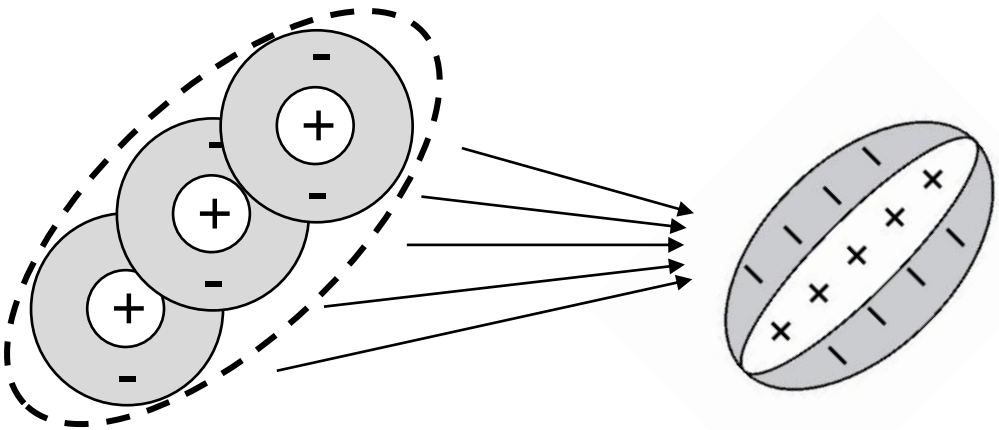
LGN RF



V1 RF



II. Mechanistic Model of Receptive Fields: V1



LGN Cells

V1 Cell

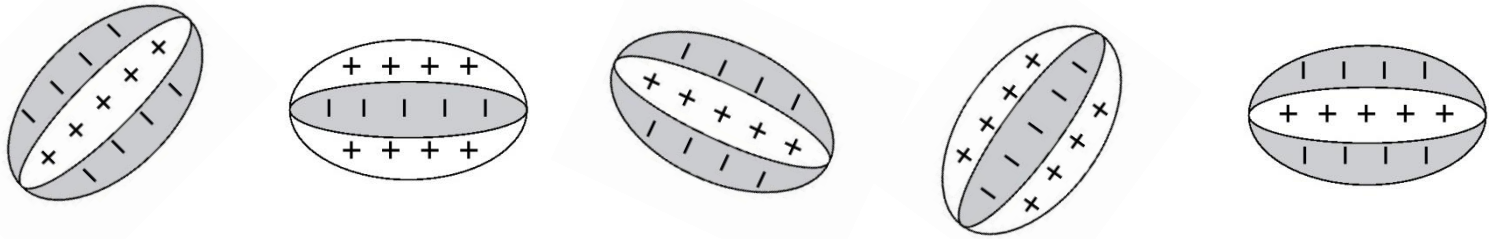
Model suggested by Hubel & Wiesel in the 1960s: V1 RFs are created from converging LGN inputs

Center-surround LGN RFs are *displaced along preferred orientation* of V1 cell

This simple model is still controversial!

III. Interpretive Model of Receptive Fields

- The Question: *Why* are receptive fields in V1 shaped in this way?



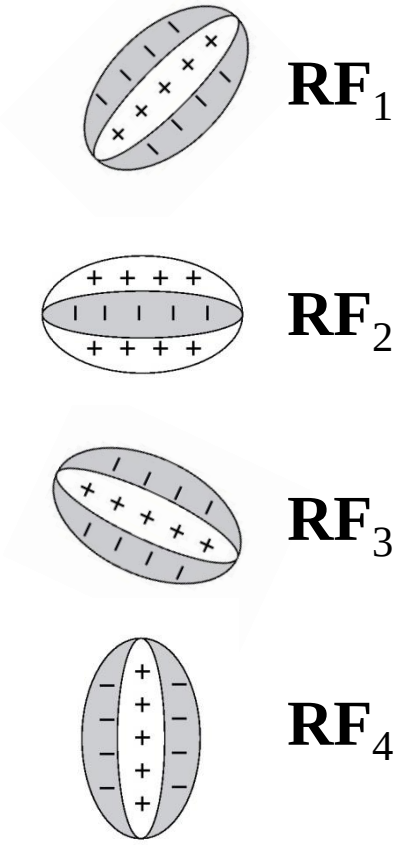
What are the computational advantages of such receptive fields?

III. Interpretive Model of Receptive Fields

- Efficient Coding Hypothesis: Suppose the goal is to *represent images as faithfully and efficiently as possible* using neurons with receptive fields $\mathbf{RF}_1$, $\mathbf{RF}_2$, etc.
- Given image **I**, we can reconstruct **I** using neural responses r_1, r_2 …:

$$\hat{\mathbf{I}} = \sum_i \mathbf{RF}_i r_i$$

- *Idea*: What are the $\mathbf{RF}_i$ that *minimize* the total squared pixelwise errors between **I** and $\hat{\mathbf{I}}$ and are as *independent* as possible?



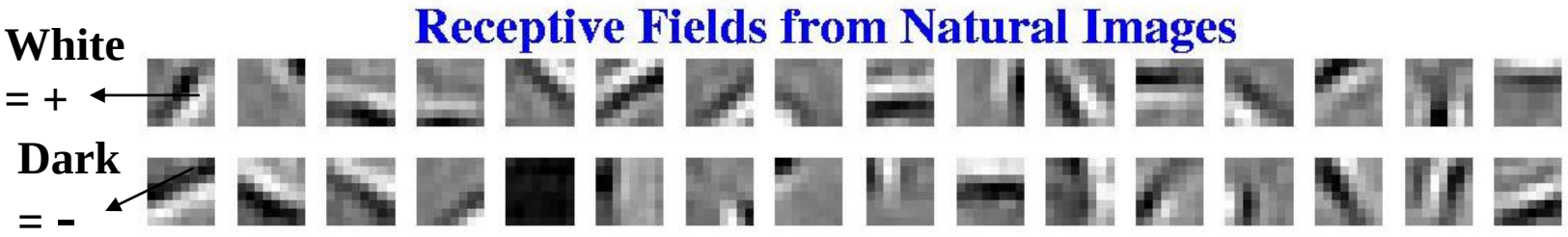
III. Interpretive Model of Receptive Fields

- Start out with random $\mathbf{RF}_i$ and run your efficient coding algorithm on natural image patches

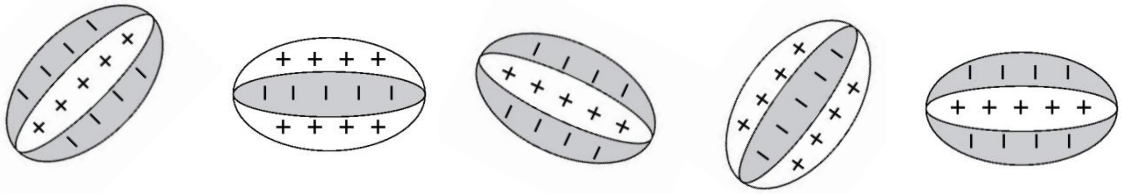
Sparse coding ICA Predictive coding

(Olshausen & Field, 1996; Bell & Sejnowski, 1997; Rao & Ballard, 1999)

III. Interpretive Model of Receptive Fields



Receptive Fields in V1



Conclusion: The brain may be trying to find *faithful and efficient* representations of an animal's natural environment

We will explore a variety of *Descriptive*, *Mechanistic*, and *Interpretive* models throughout this course.

But before we do that…

Neurobiology 101:
Introduction to neurons, synapses, and brain regions

[Next Lecture]