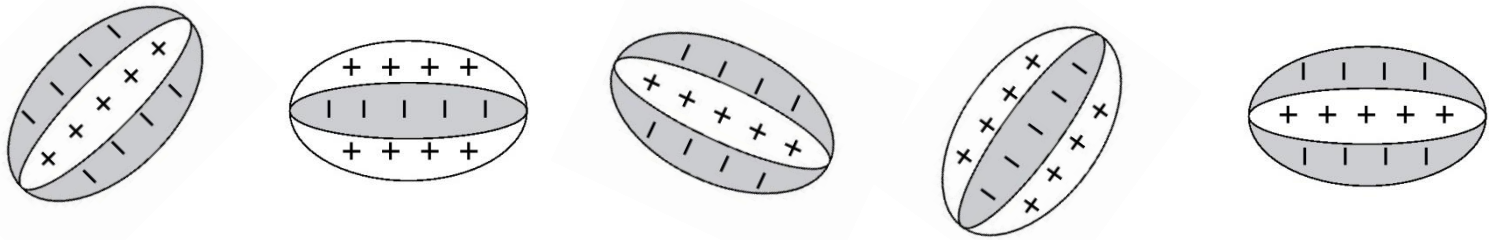
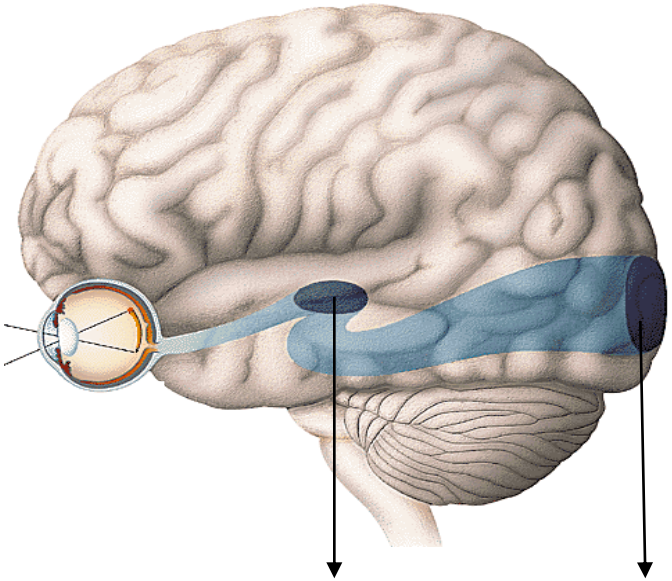
II. **Mechanistic** Model of Receptive Fields

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



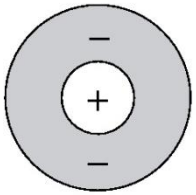
How are these *oriented* receptive fields obtained from *center-surround* receptive fields?

II. Mechanistic Model of Receptive Fields: V1

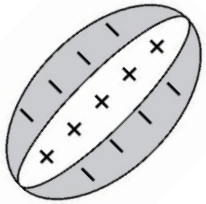


LGN
(Lateral
Geniculate
Nucleus)

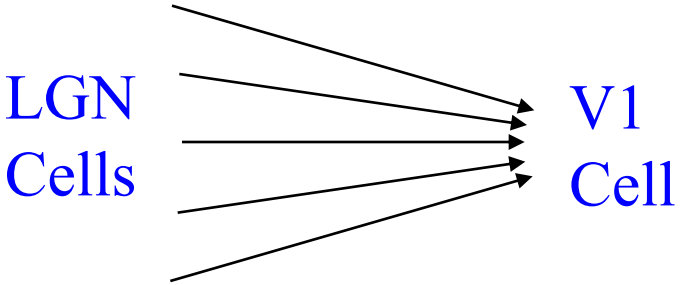
V1
(Primary
Visual
Cortex)



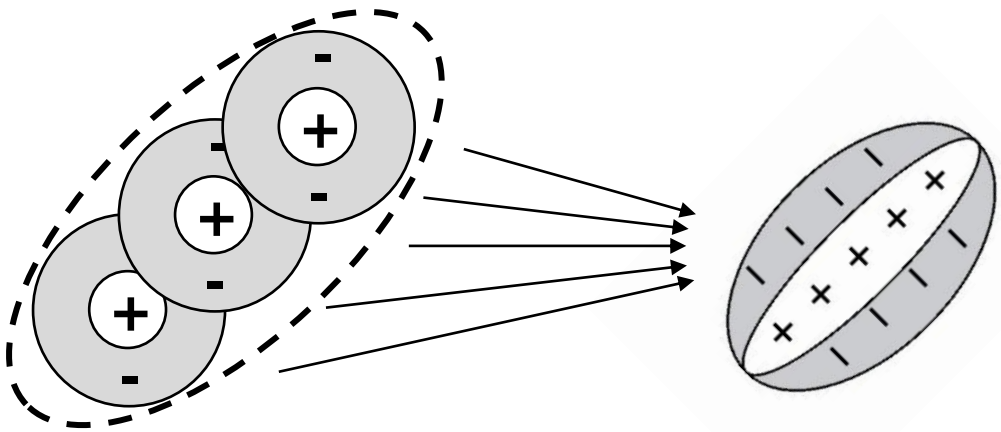
LGN RF



V1 RF



II. Mechanistic Model of Receptive Fields: V1



LGN Cells

V1 Cell

controversial because it does not take into account the (frequent) input from recurrent connections it has with its surrounding v1 cells, only the feed forward inputs from LGN cells

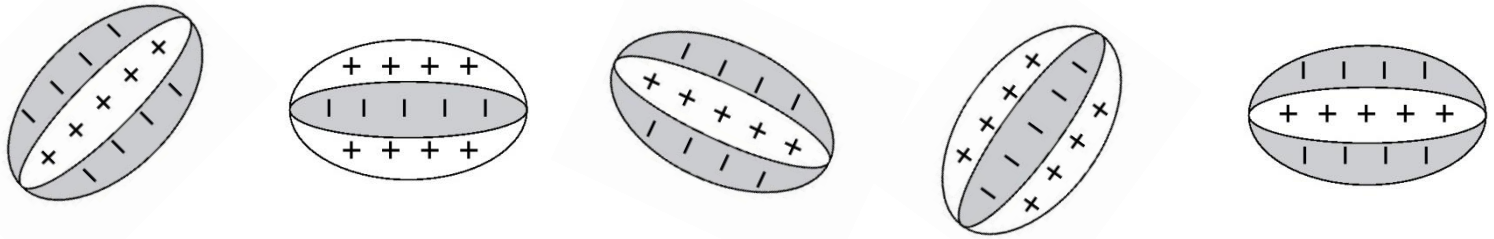
Model suggested by Hubel & Wiesel in the 1960s: V1 RFs are created from converging LGN inputs

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?

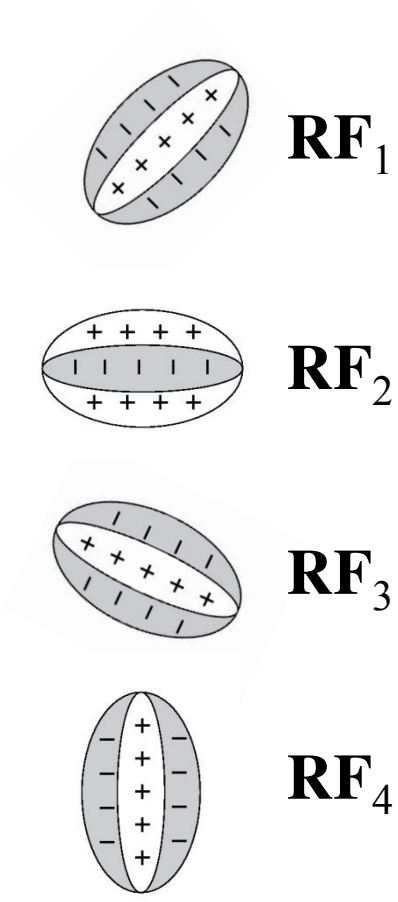
III. Interpretive Model of Receptive Fields

- 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 …:

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

(r: some weight for RF)

- *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

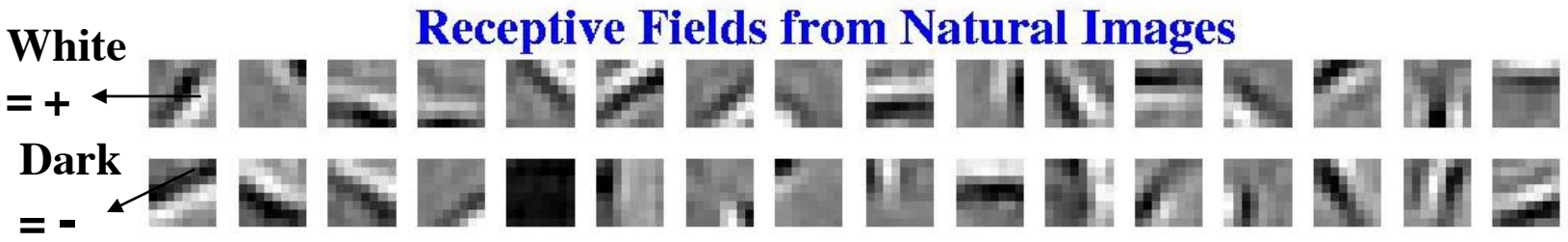
- Start out with random $\mathbf{RF}_i$ and run your efficient coding algorithm on natural image patches

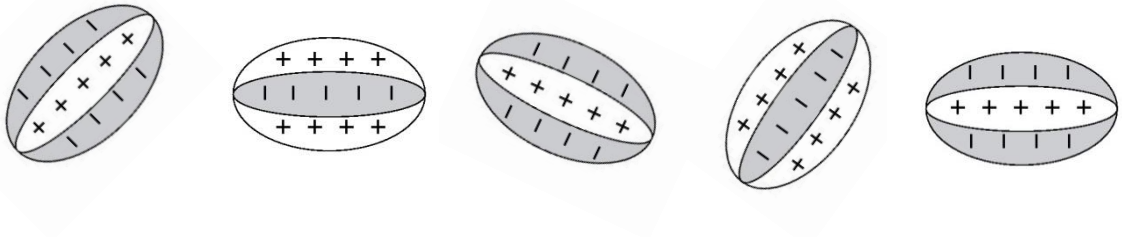
ICA: independent component analysis

Sparse coding ICA Predictive coding

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

III. Interpretive Model of Receptive Fields





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]