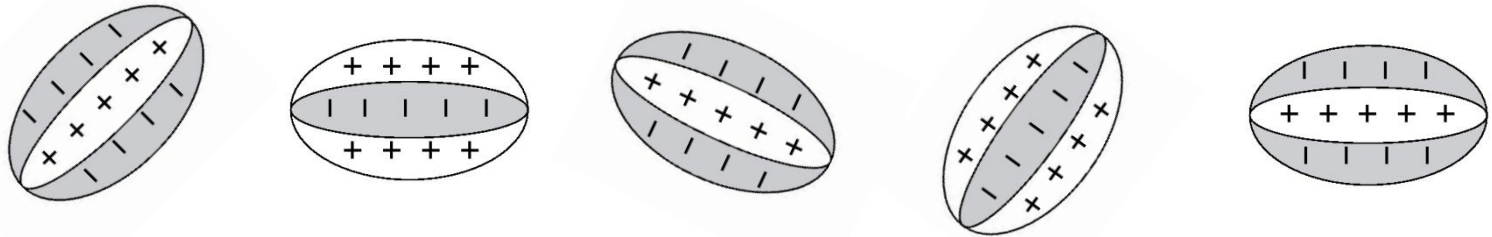


## II. Mechanistic Model of Receptive Fields

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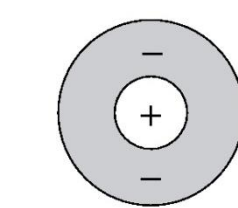
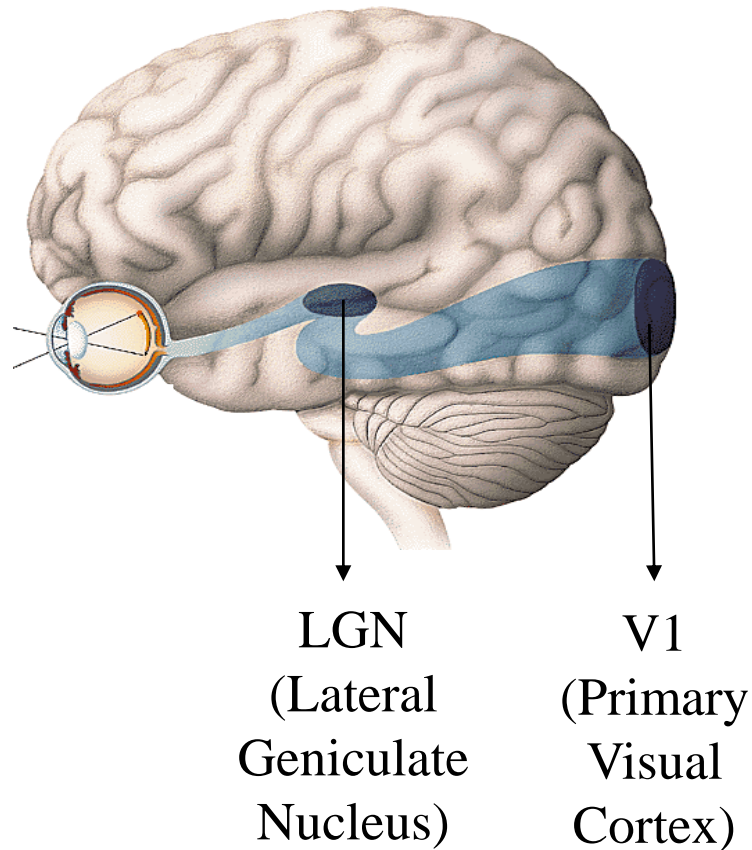
♦ The Question: *How* are receptive fields constructed using the neural circuitry of the visual cortex?



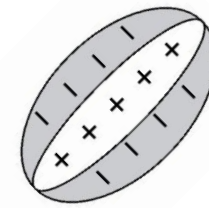
How are these *oriented* receptive fields obtained from *center-surround* receptive fields?

## II. Mechanistic Model of Receptive Fields: V1

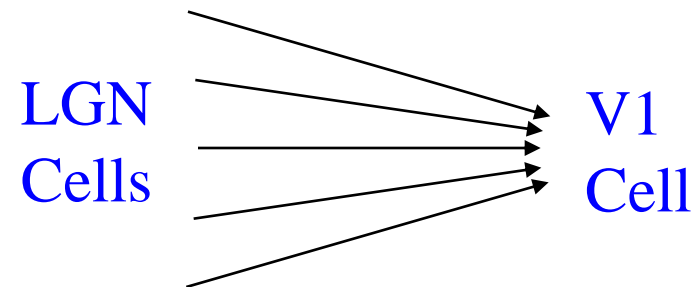
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LGN RF

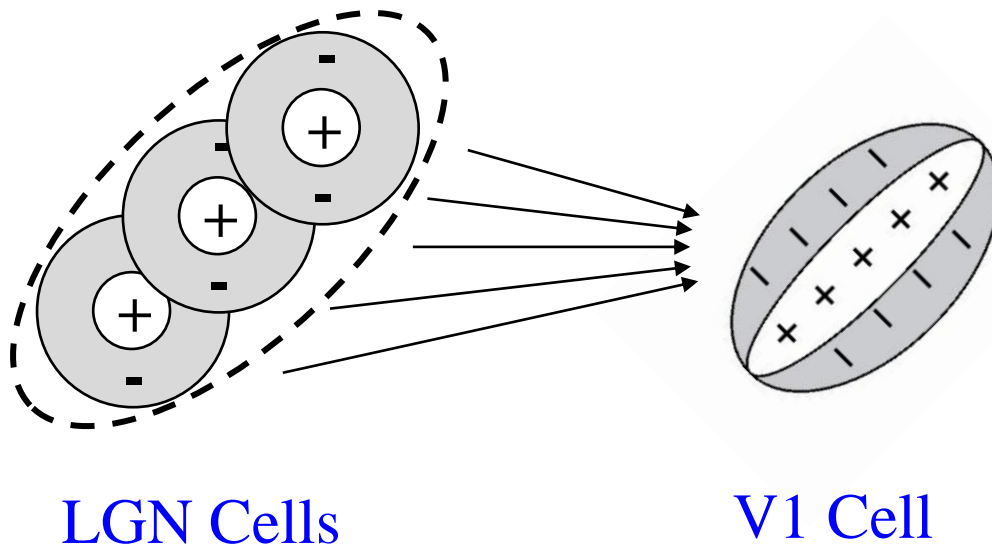


V1 RF



## II. Mechanistic Model of Receptive Fields: V1

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

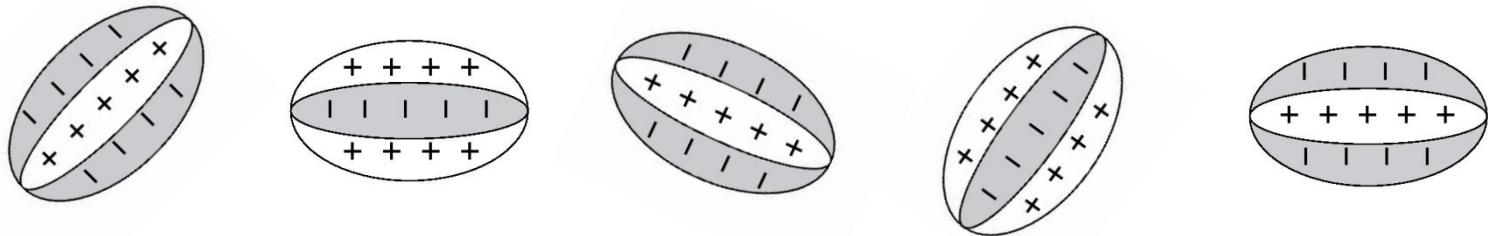
Center-surround LGN  
RFs are *displaced along  
preferred orientation* of  
V1 cell

This simple model is still  
controversial!

# III. Interpretive Model of Receptive Fields

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



What are the **computational advantages** of such receptive fields?

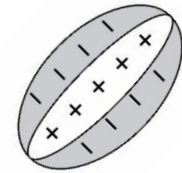
# III. Interpretive Model of Receptive Fields

- ◆ **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.

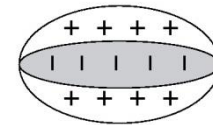
- ◆ Given image  $\mathbf{I}$ , we can **reconstruct**  $\mathbf{I}$  using neural responses  $r_1, r_2 \dots$ :

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

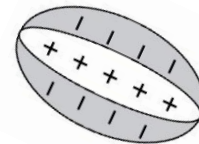
- ◆ **Idea**: What are the  $\mathbf{RF}_i$  that *minimize* the total squared pixelwise **errors** between  $\mathbf{I}$  and  $\hat{\mathbf{I}}$  and are as *independent* as possible?



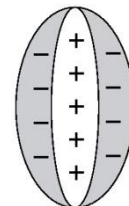
$\mathbf{RF}_1$



$\mathbf{RF}_2$



$\mathbf{RF}_3$



$\mathbf{RF}_4$

# III. Interpretive Model of Receptive Fields

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

**Natural Images**



□ Receptive Field Size

**Sparse coding**

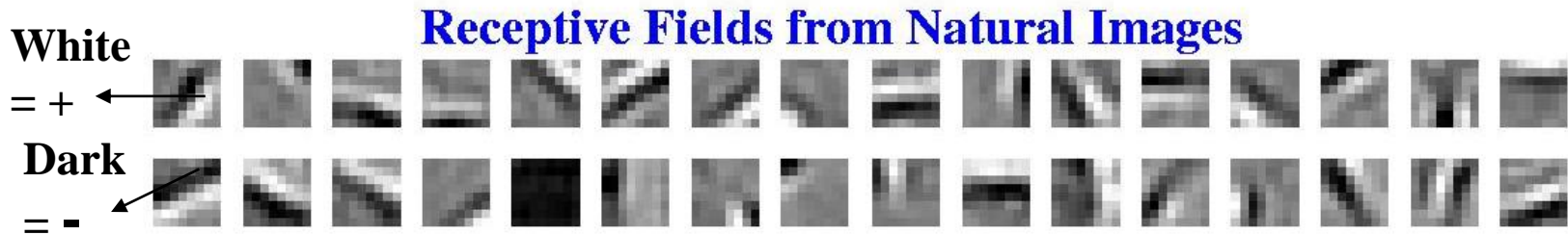
**ICA**

**Predictive coding**

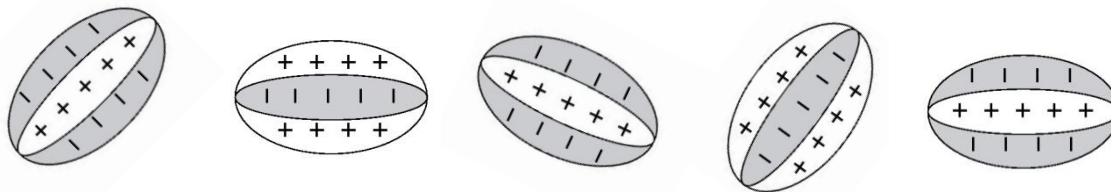
(Olshausen & Field, 1996; Bell & Sejnowski, 1997; Rao & Ballard, 1999)

# III. Interpretive Model of Receptive Fields

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## Receptive Fields in V1



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

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

But before we do that...



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# Neurobiology 101:

## Introduction to neurons, synapses, and brain regions

[Next Lecture]