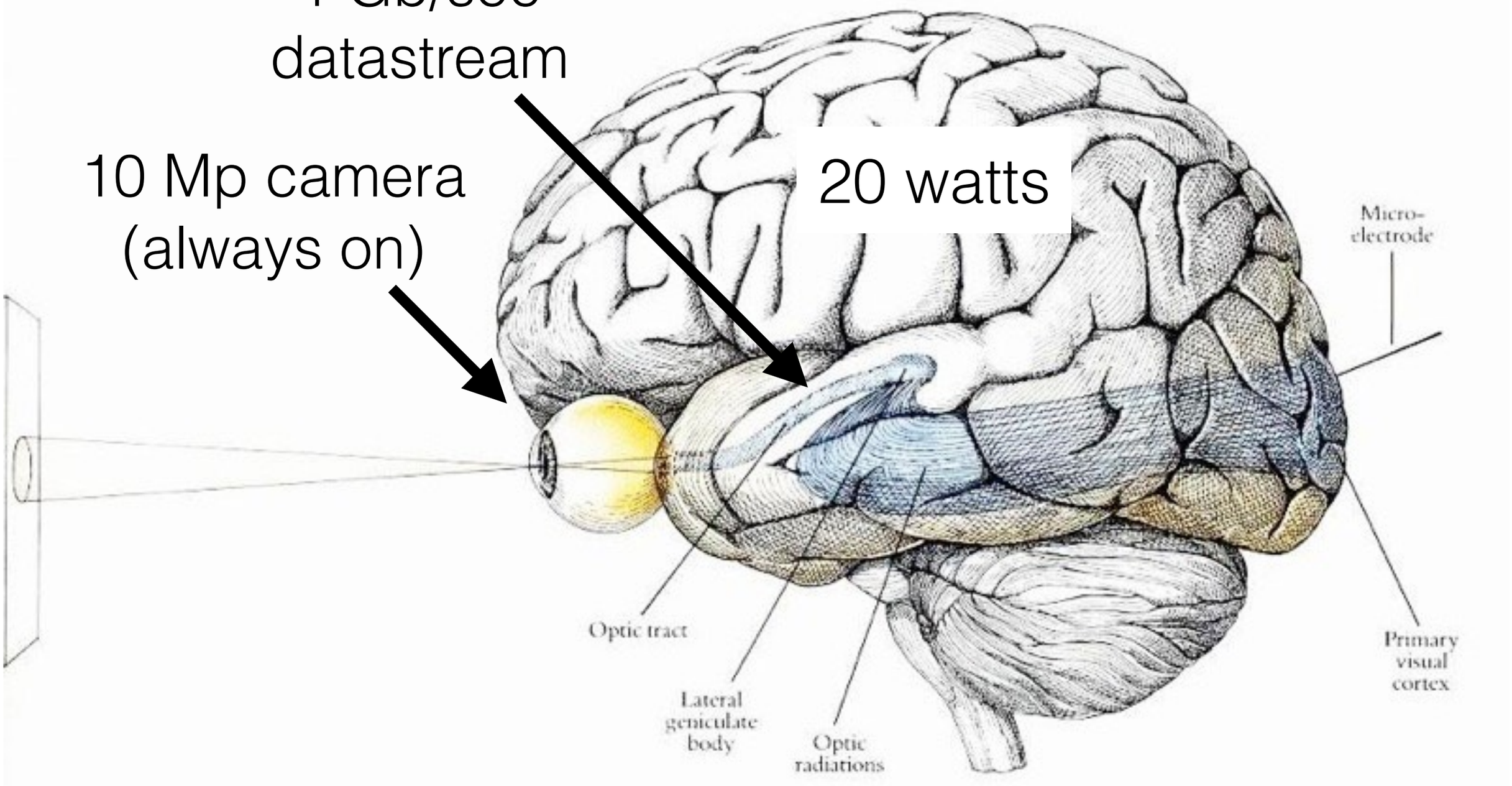
Efficient coding

1 Gb/sec
datastream

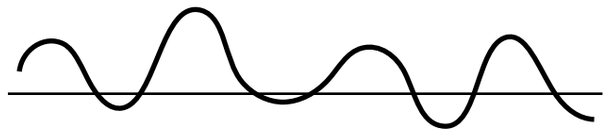
10 Mp camera
(always on)

20 watts

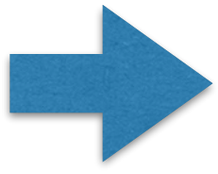


Analog-to-pulsatile conversion is lossy

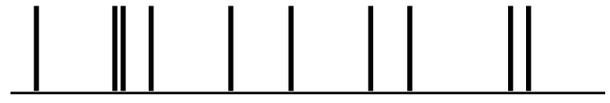
300 bits/sec



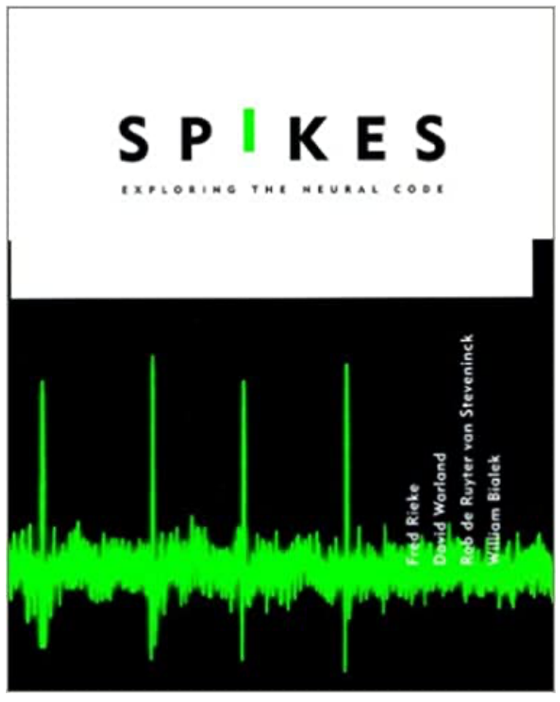
photoreceptors, bipolars



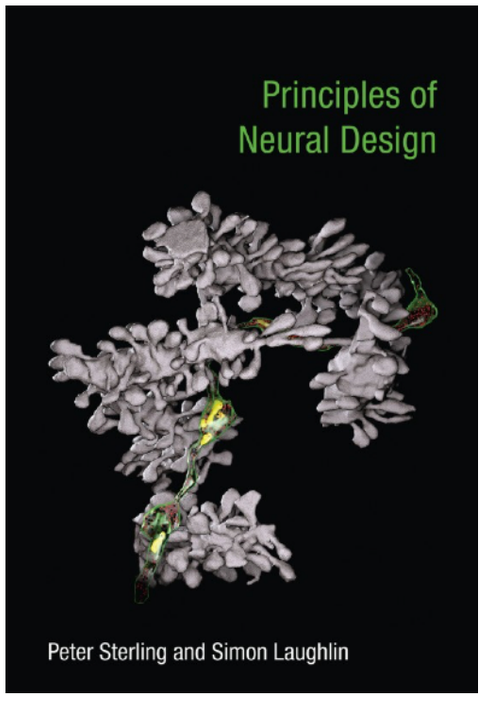
1-3 bits/spike



RGC's

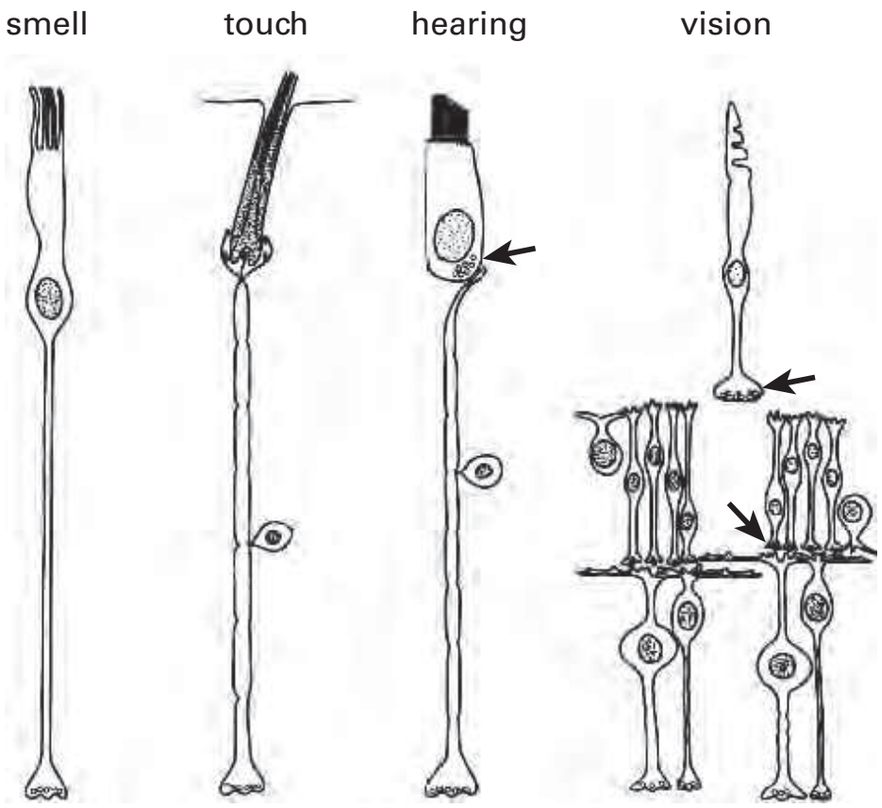


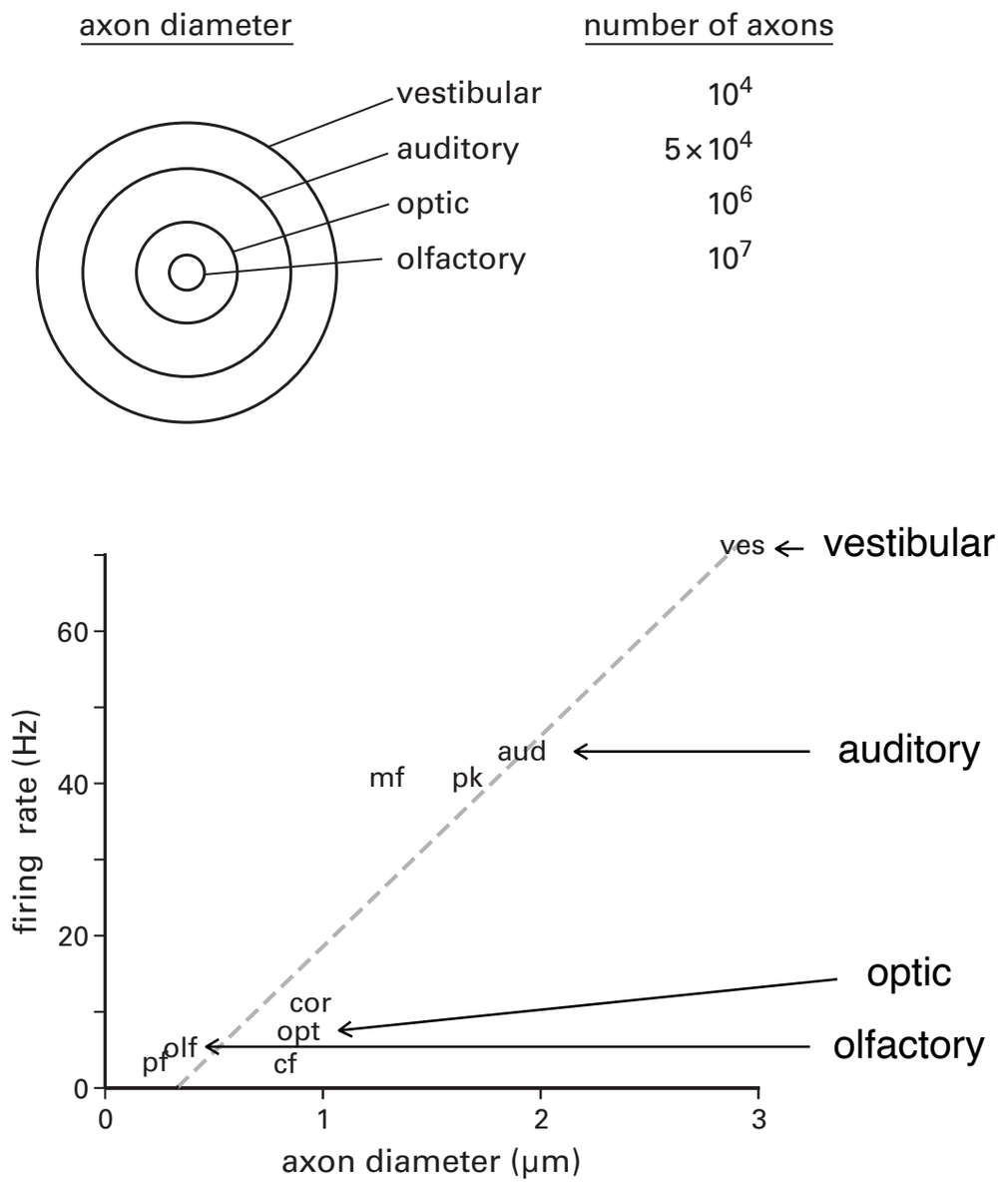
Rieke et al., 1997



Sterling & Laughlin 2015

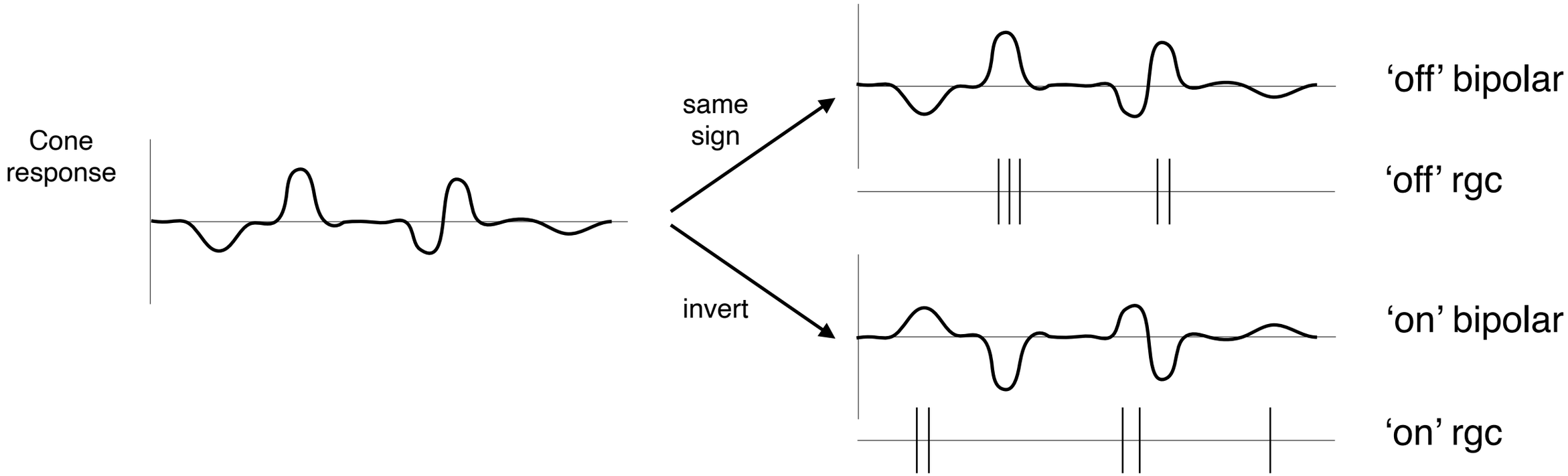
Retinal information processing is required to convert analog signals into an appropriate format for encoding with limited number of spikes

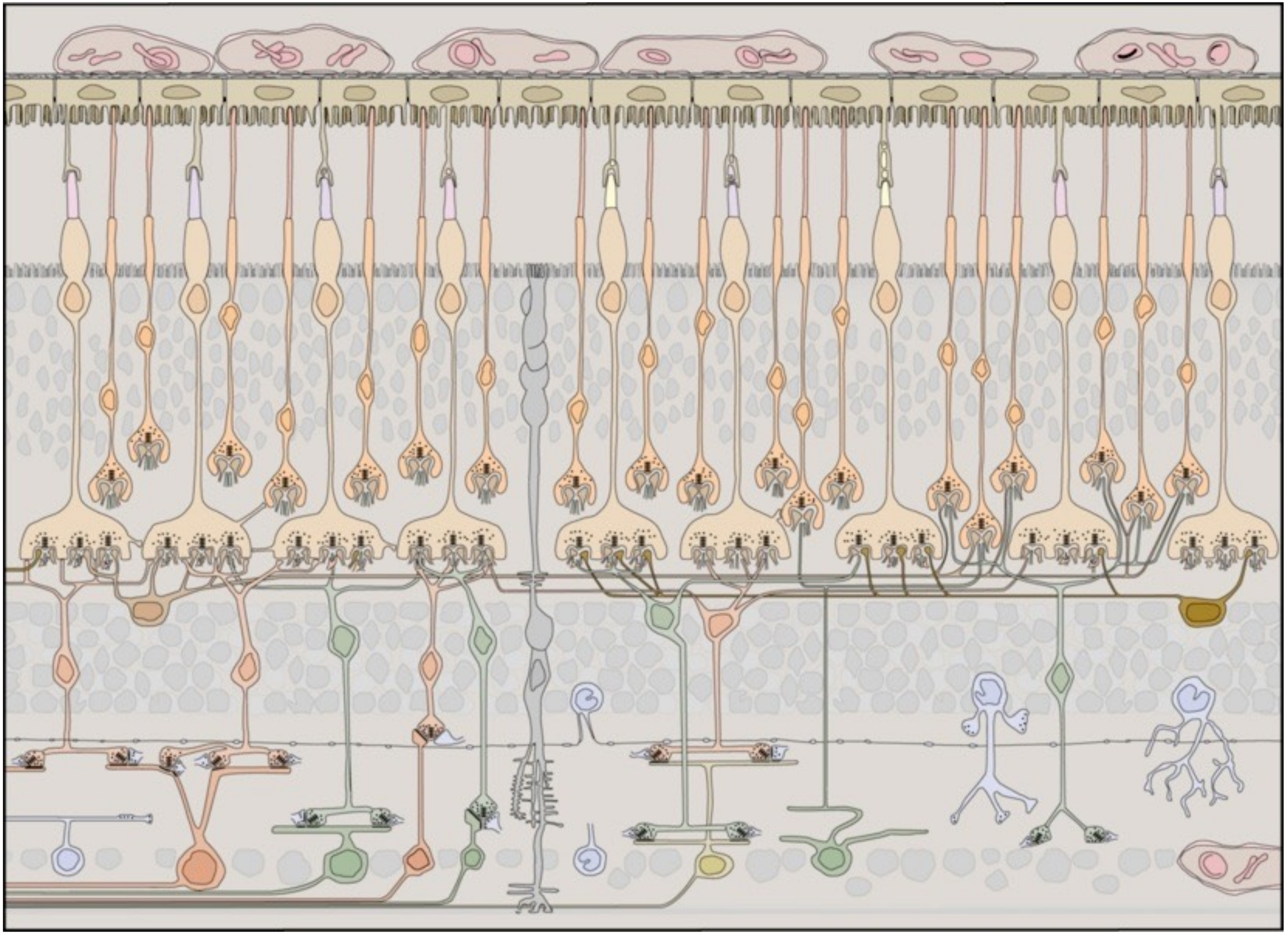


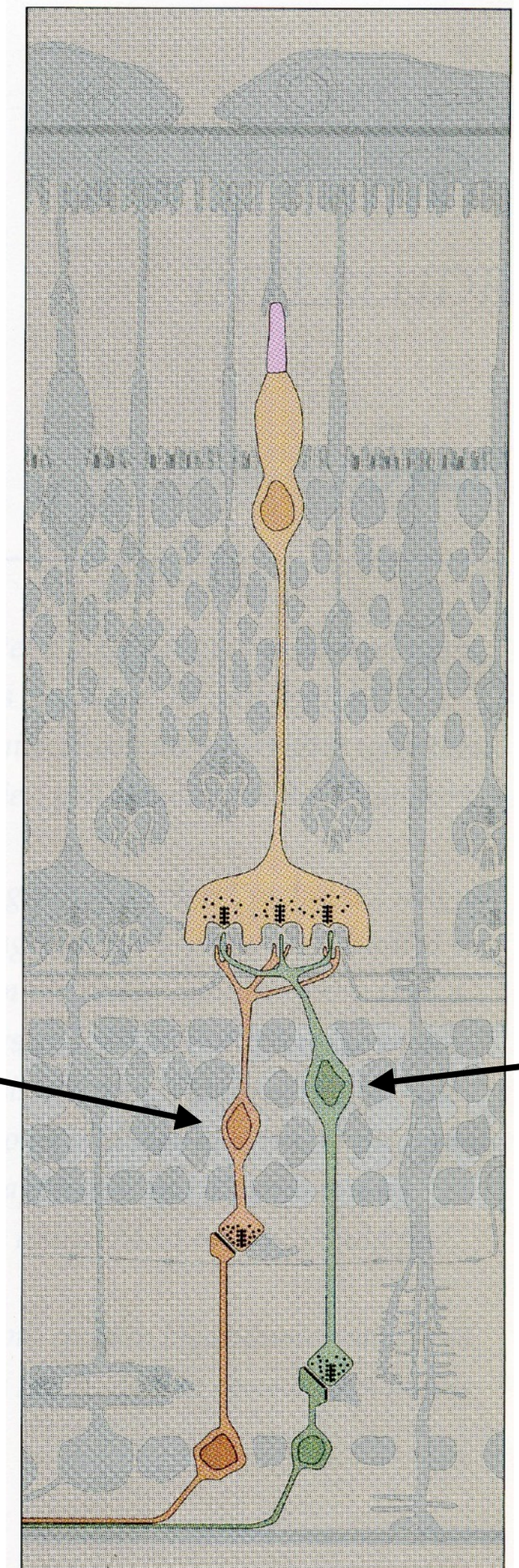


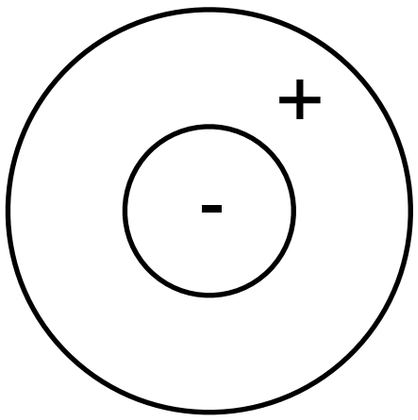
(from Sterling & Laughlin 2015)

Retina encodes +/- fluctuations around the mean with two separate populations



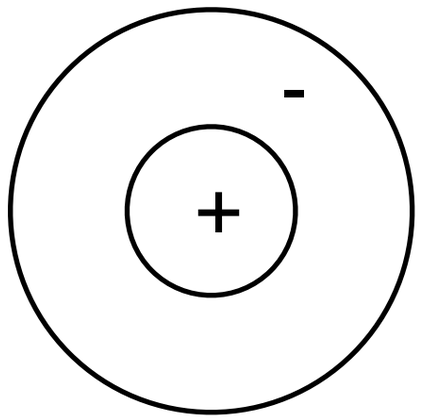




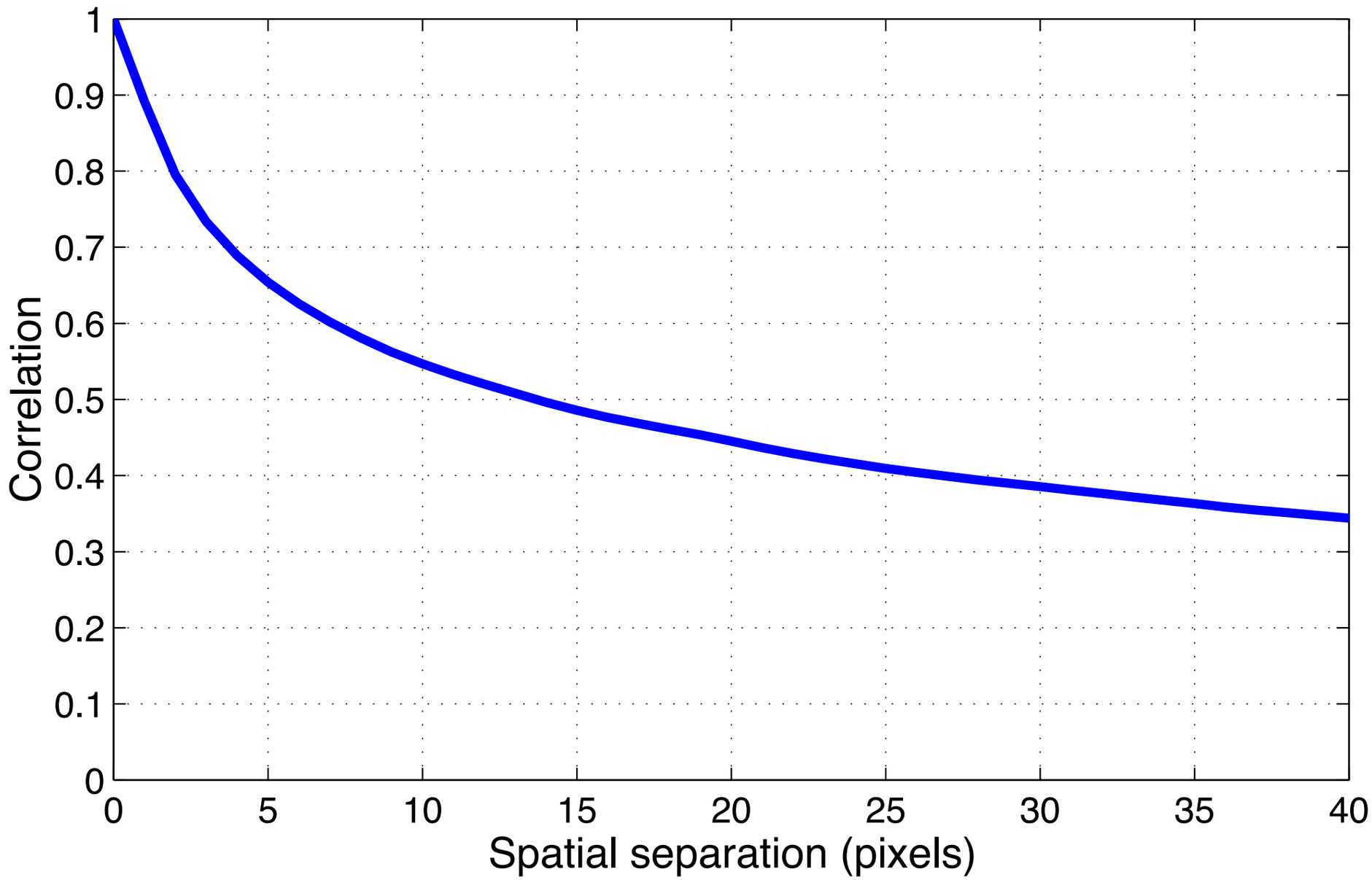


‘off’ cell

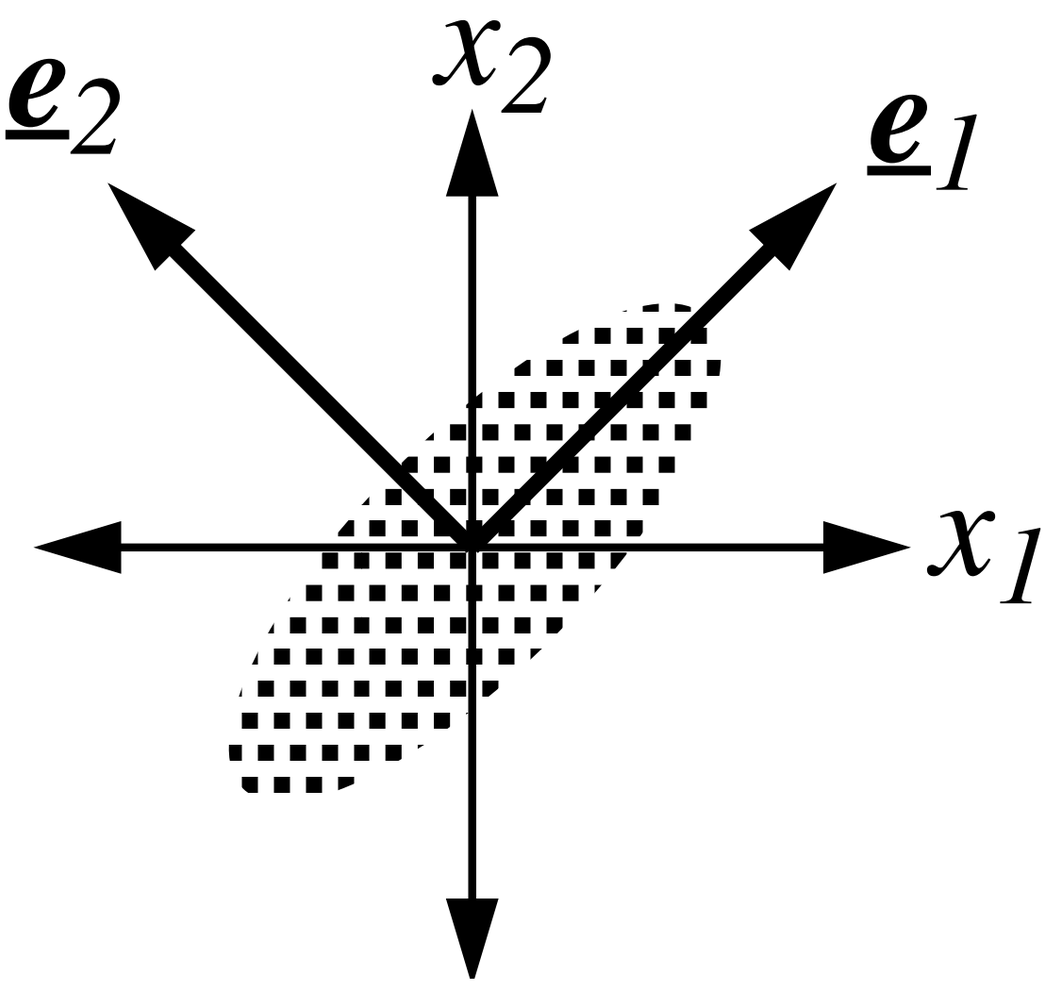
‘on’ cell



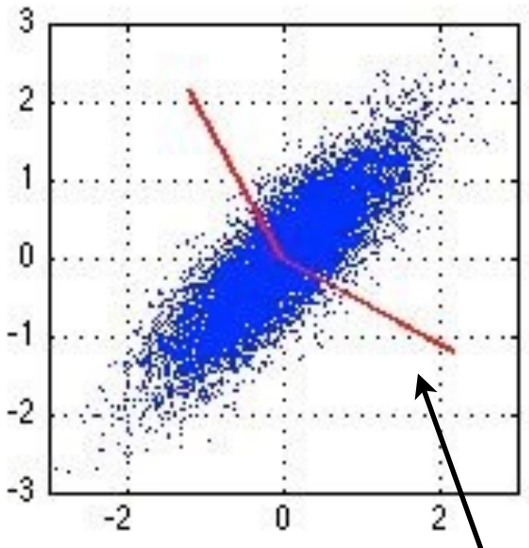
Auto-correlation function of natural images



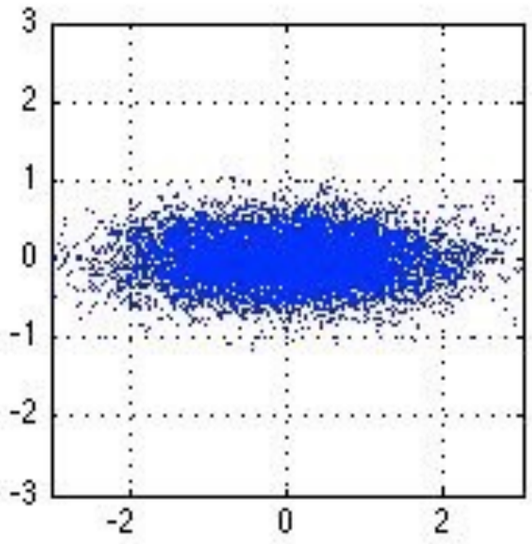
PCA
(Principal Components Analysis)



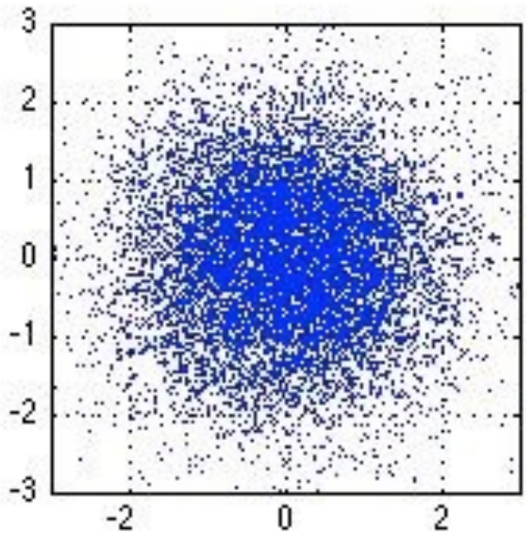
Whitening



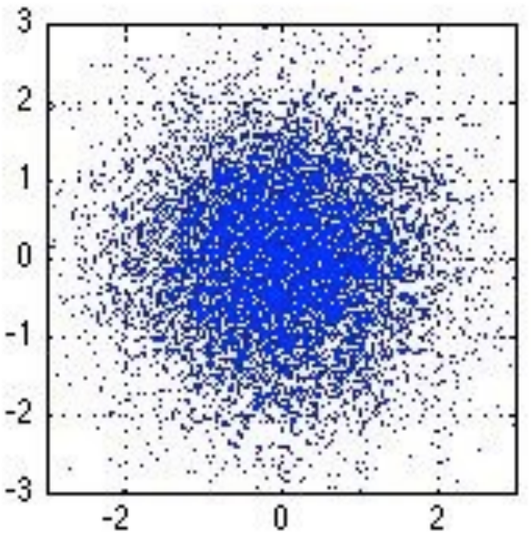
$\mathbf{X}$



$\mathbf{E}^T \mathbf{X}$



$\mathbf{\Lambda}^{-\frac{1}{2}} \mathbf{E}^T \mathbf{X}$



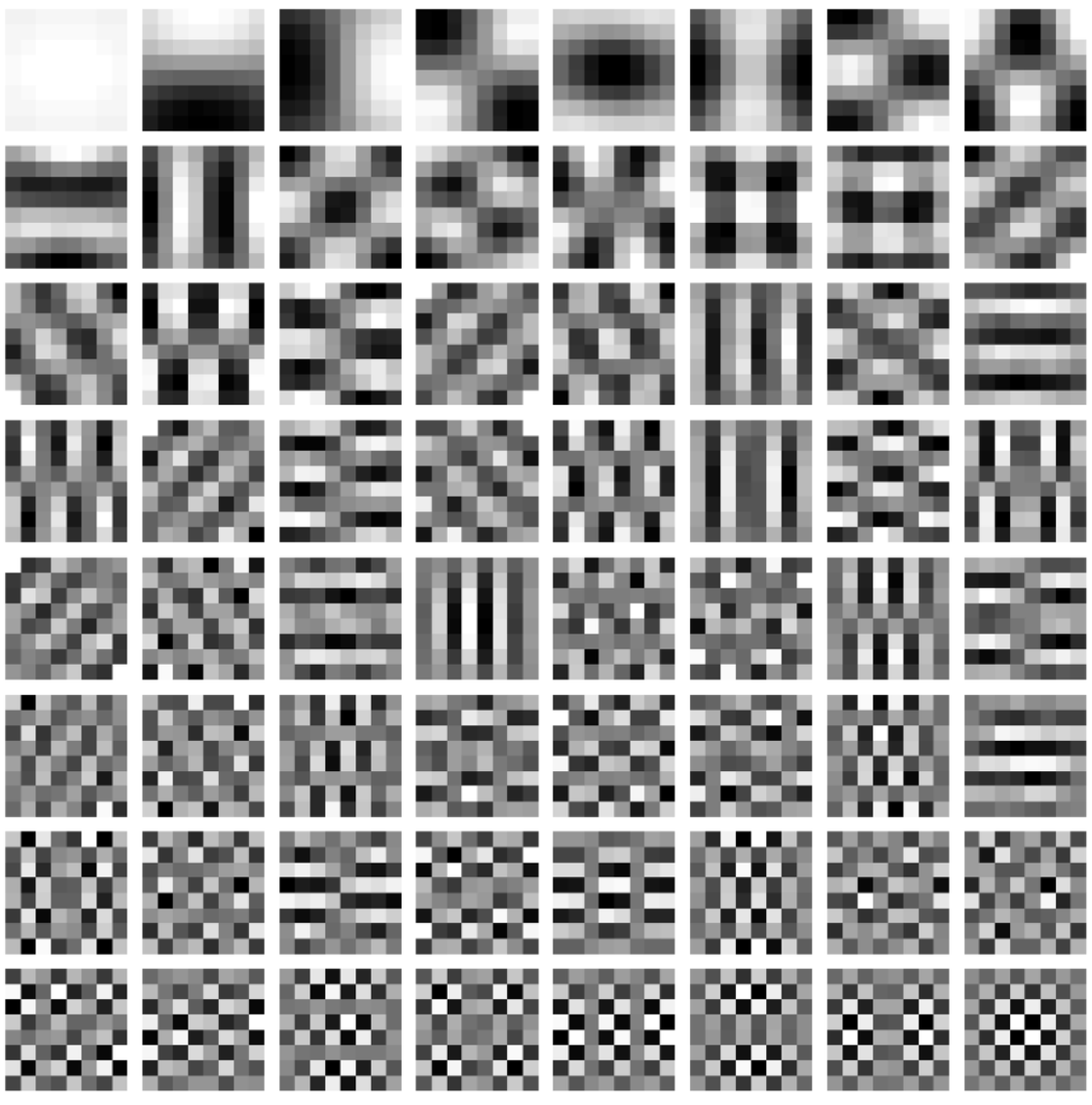
$\mathbf{E} \mathbf{\Lambda}^{-\frac{1}{2}} \mathbf{E}^T \mathbf{X}$

$$\mathbf{Y} = \mathbf{W} \mathbf{X}$$

$$\mathbf{W} = \mathbf{E} \mathbf{\Lambda}^{-\frac{1}{2}} \mathbf{E}^T$$

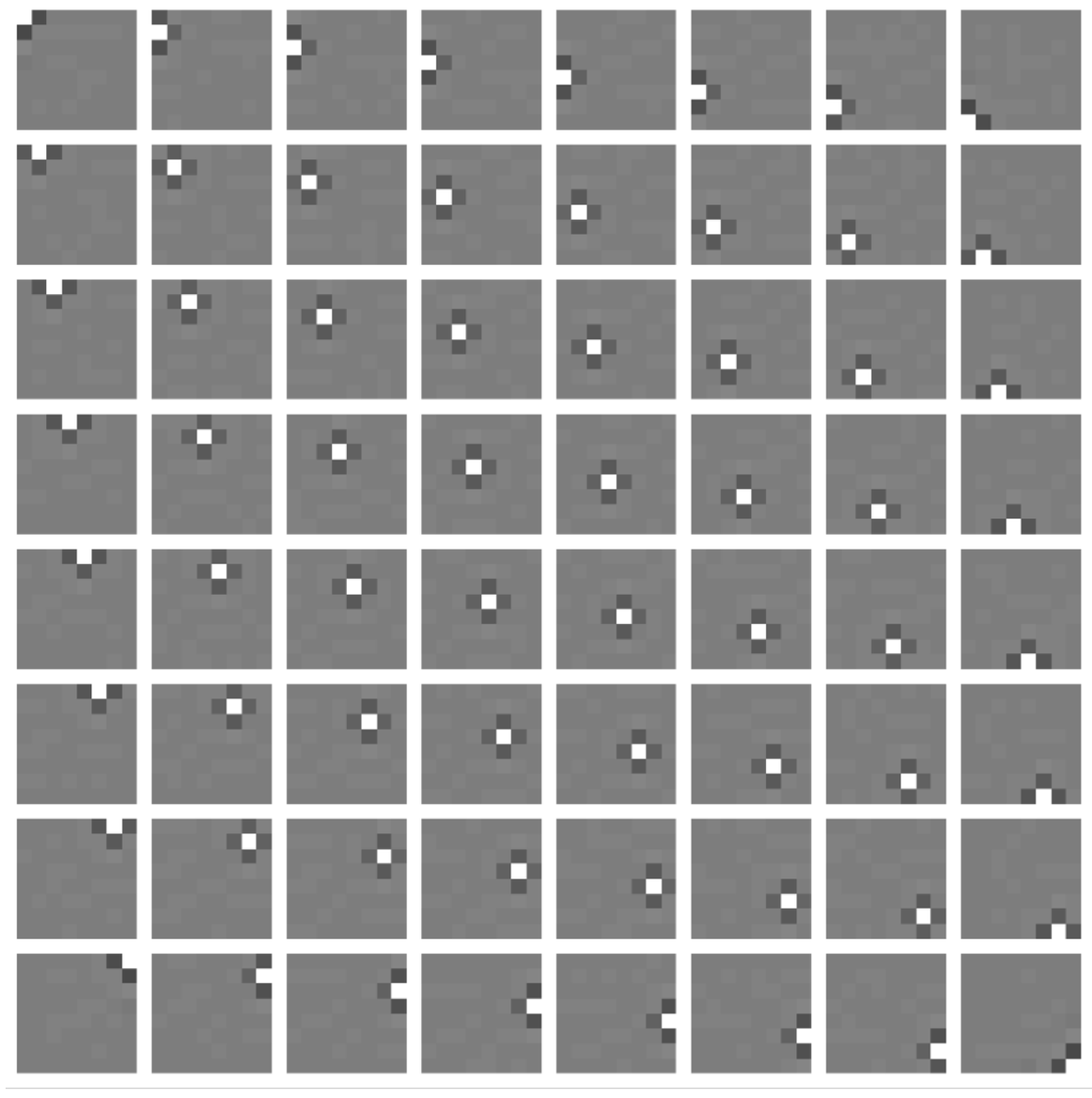
PCA

$$\mathbf{W} = \mathbf{E}^T$$

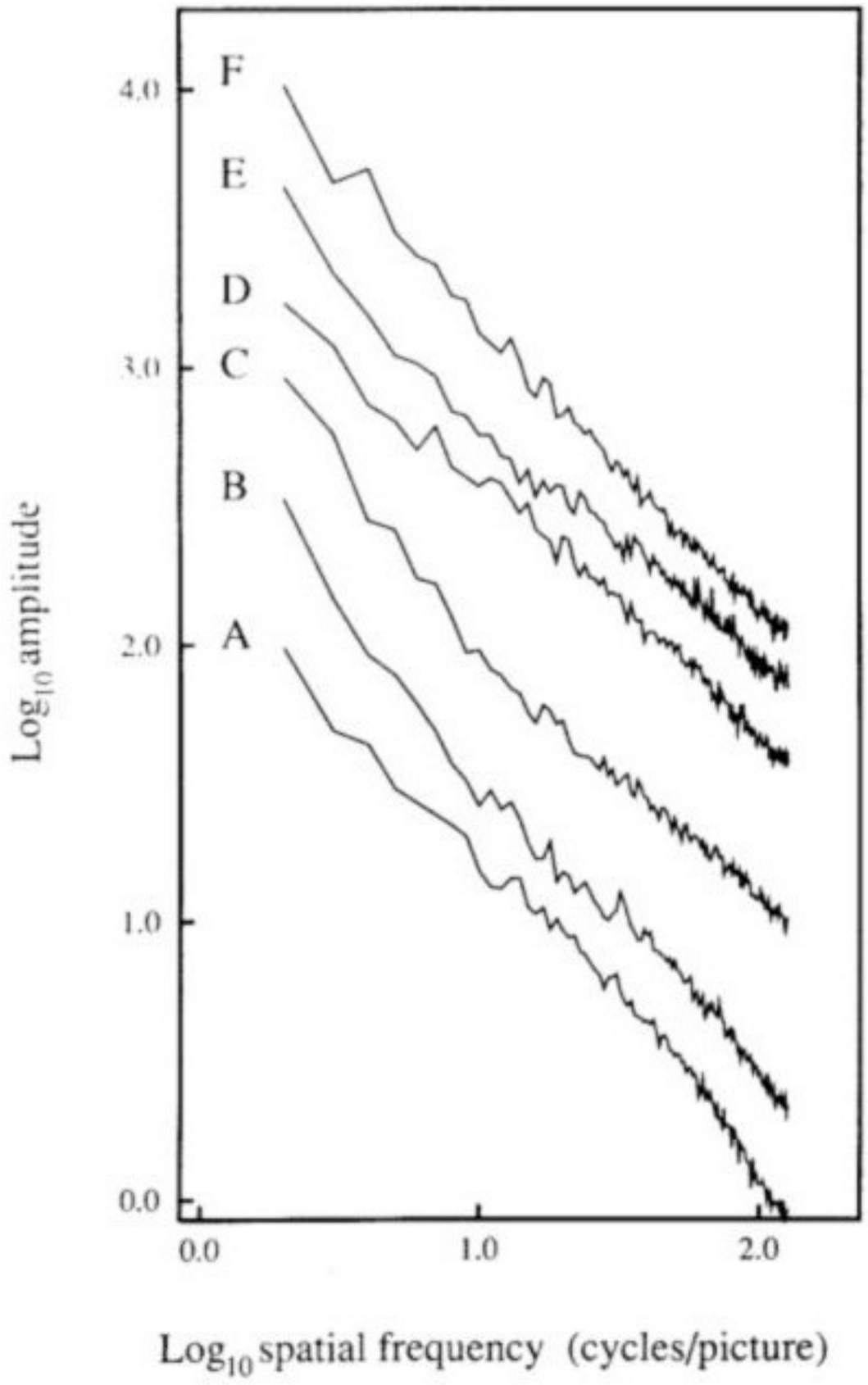


Whitening

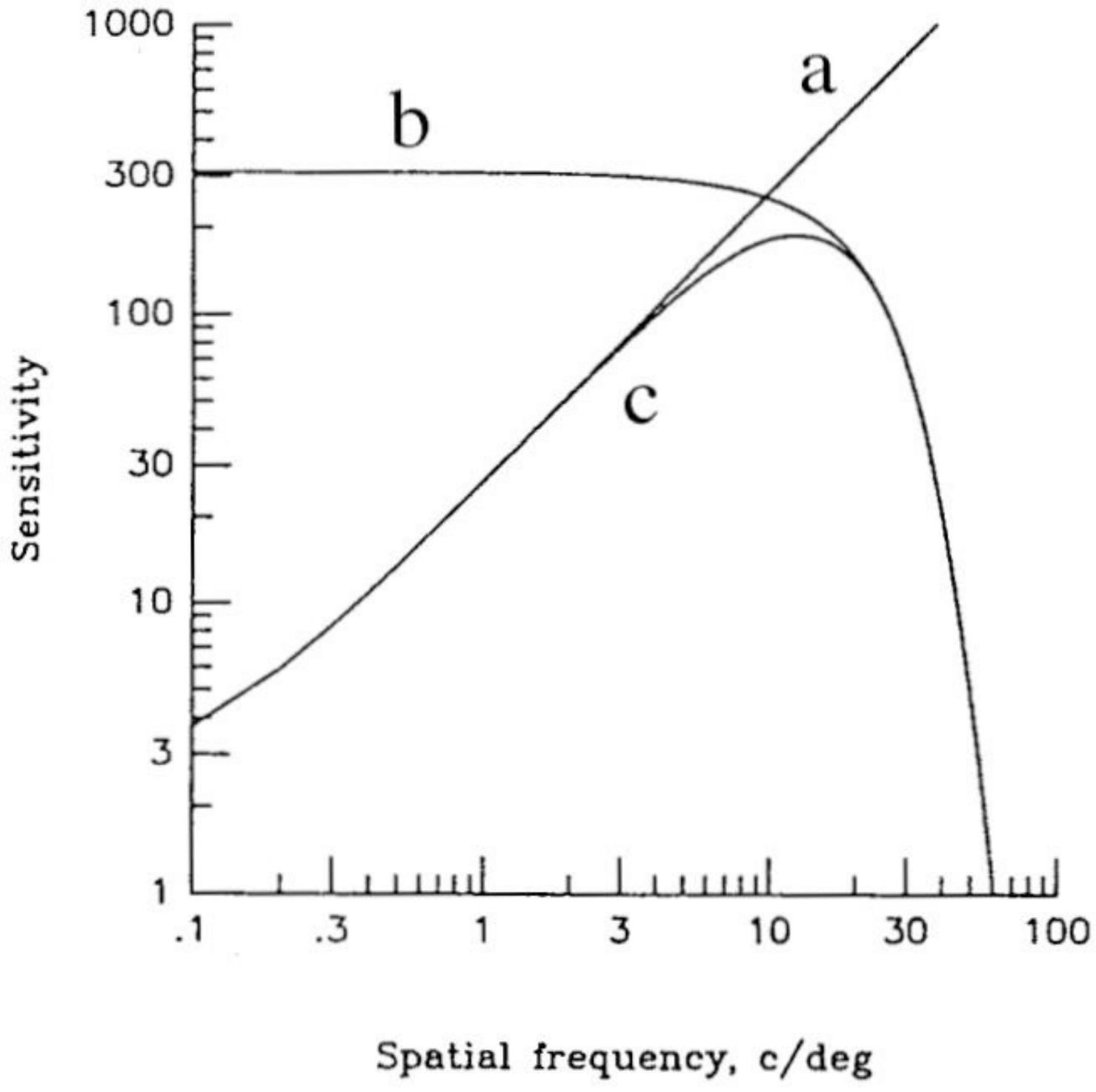
$$\mathbf{W} = \mathbf{E}\mathbf{\Lambda}^{-\frac{1}{2}}\mathbf{E}^T$$



Power spectrum (Field 1987)



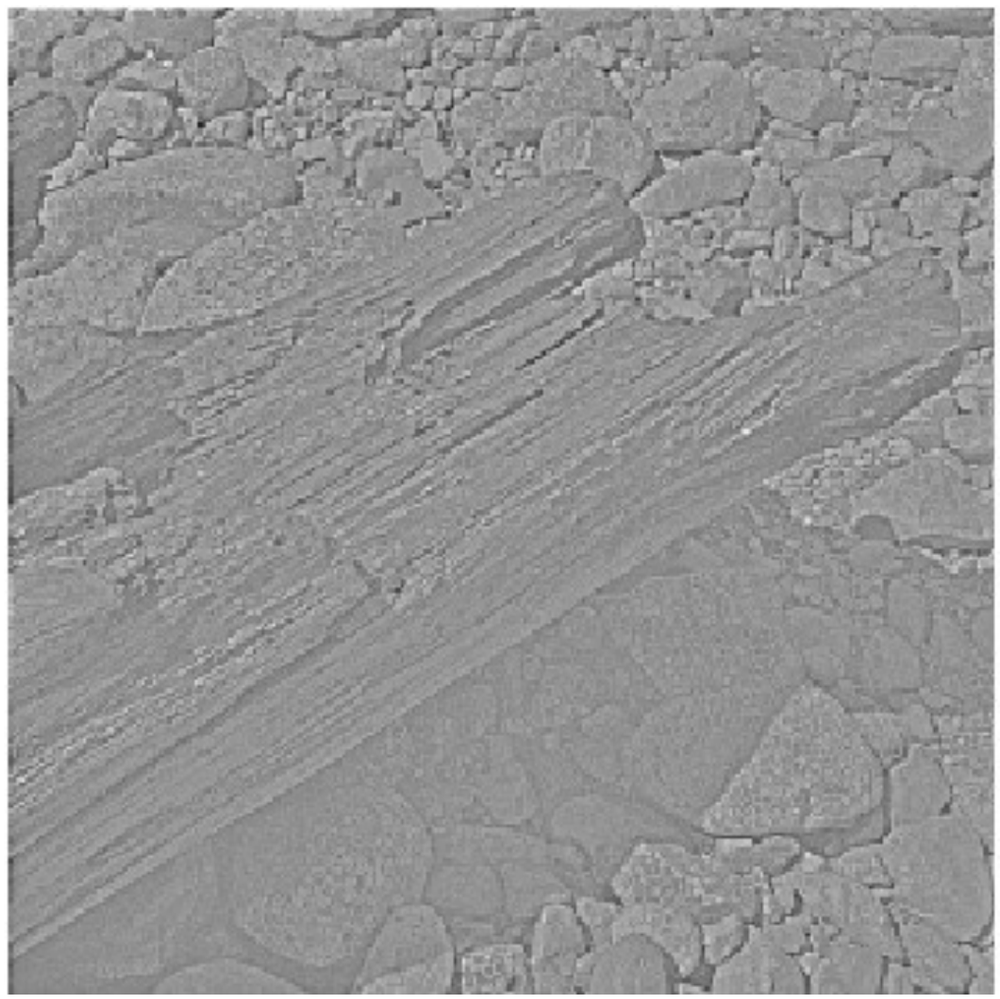
‘Whitening’ (Atick & Redlich, 1990)



Whitening

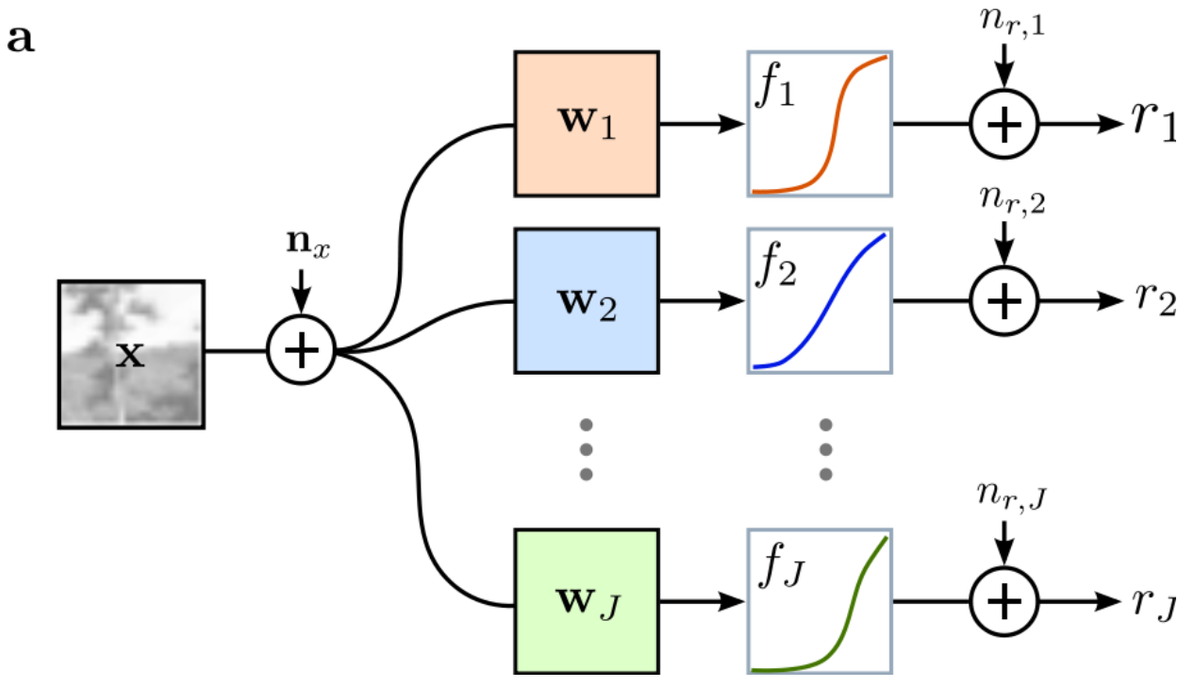
before

after



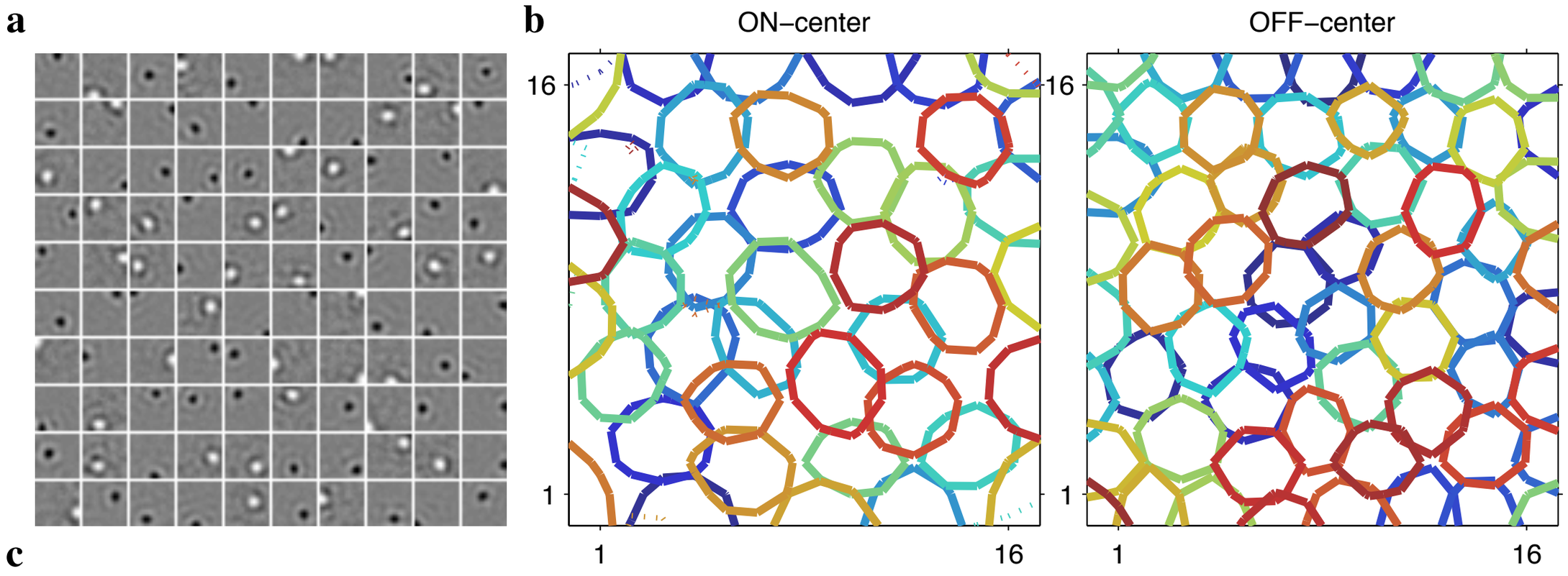
Efficient coding model of retina

(Karklin & Simoncelli 2012)



Objective function:

$$I(X;R) - \sum_j \lambda_j \langle r_j \rangle$$



Efficient coding model of retina

(Karklin & Simoncelli 2012)