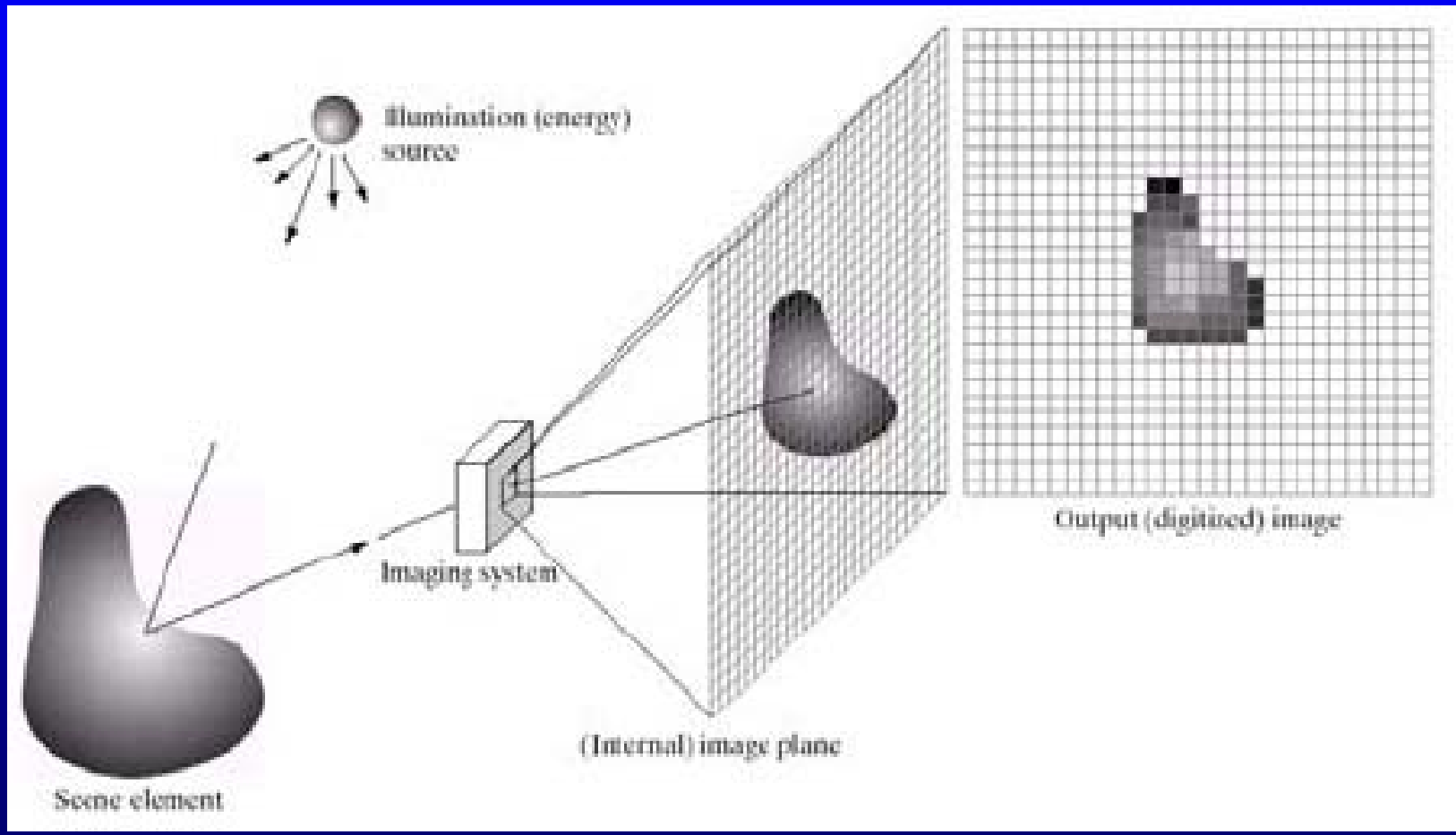
Conceptos Básicos

Procesamiento Digital de Imágenes:

¿Que es visión ?

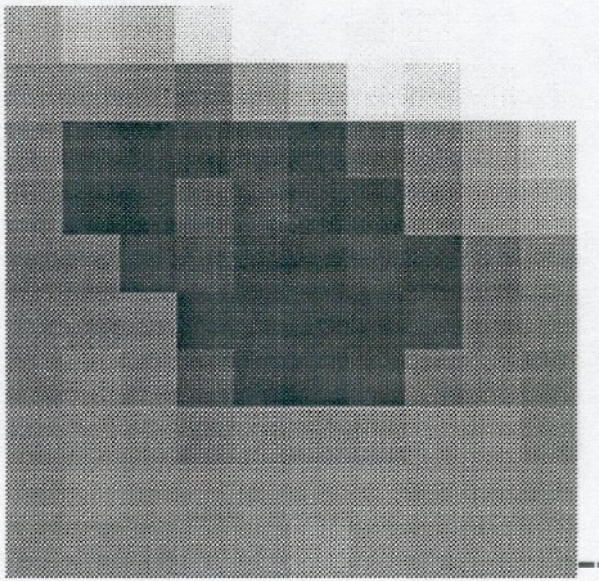
Definición

Conceptos Básicos



Conceptos Básicos

- **Imagen Digital**
- **Pixel**



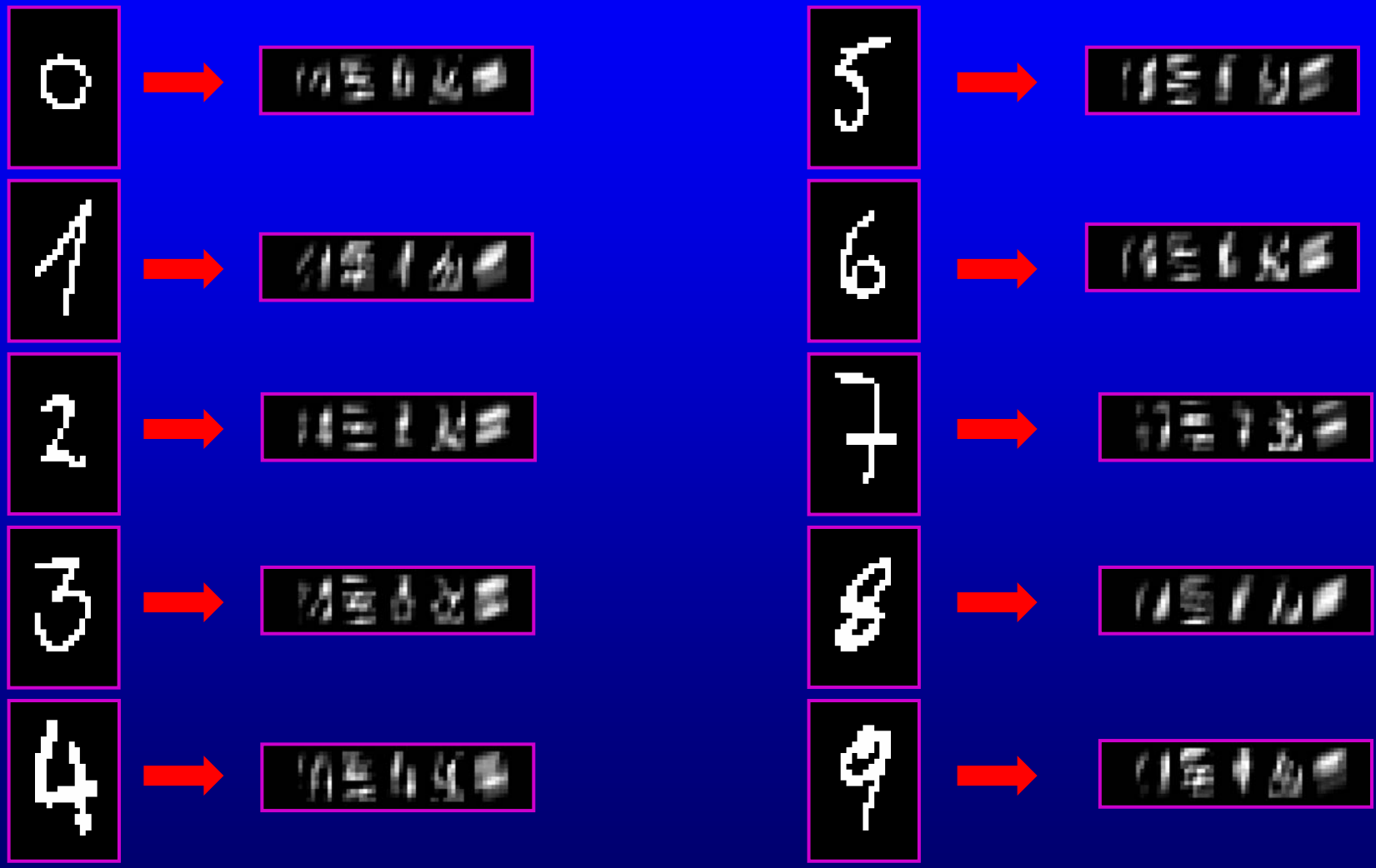
142	174	164	218	250	255	250	252	255	255
107	107	102	80	127	174	237	218	252	255
90	34	24	34	34	24	51	88	127	164
80	26	19	53	34	19	24	85	117	137
78	76	34	44	26	26	34	24	71	90
85	85	90	26	26	26	26	34	76	83
88	102	90	53	26	26	34	73	85	78
102	110	105	90	98	105	105	110	107	93
107	115	110	110	110	117	115	110	107	102
105	110	110	117	110	132	115	110	107	105

Elementos básicos para el proc. de imágenes

* Señales en función del espacio
    * muestreo espacial
    * representación de la muestra

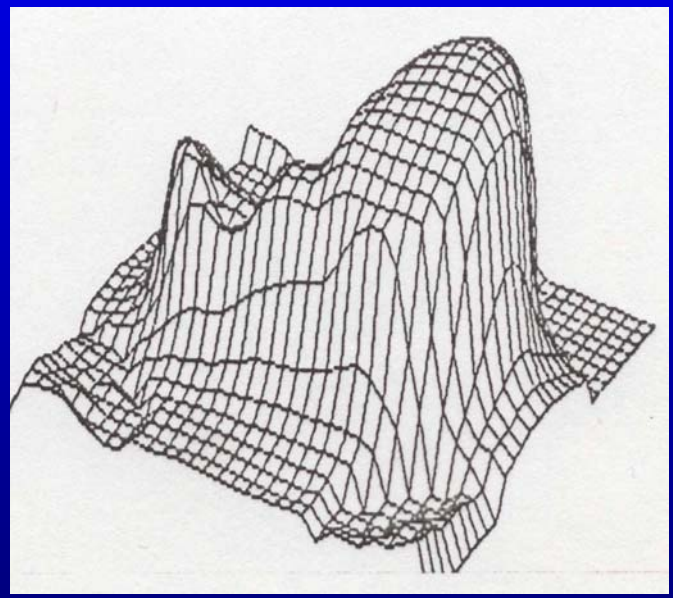
* Señales 2D

Transformaciones



Procesamiento Digital de Imágenes:

Representación

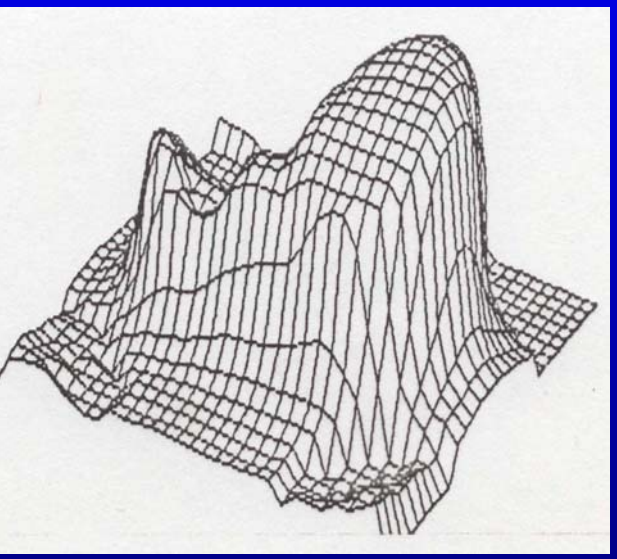


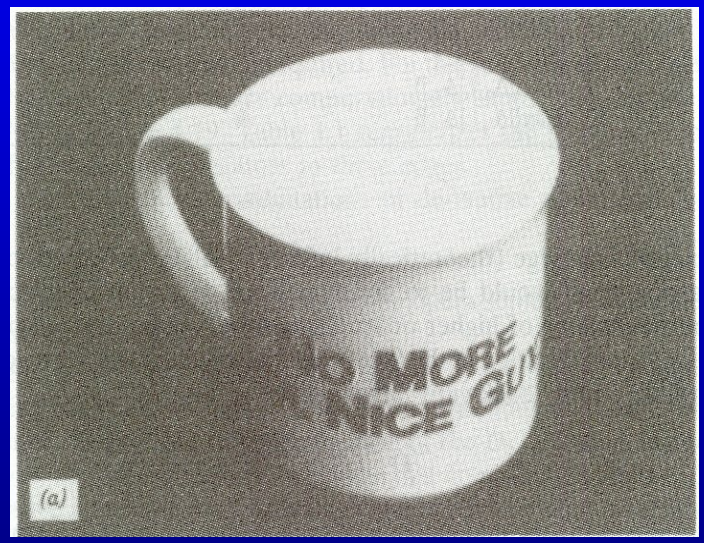
Procesamiento Digital de Imágenes:

Representación

Procesamiento Digital de Imágenes:

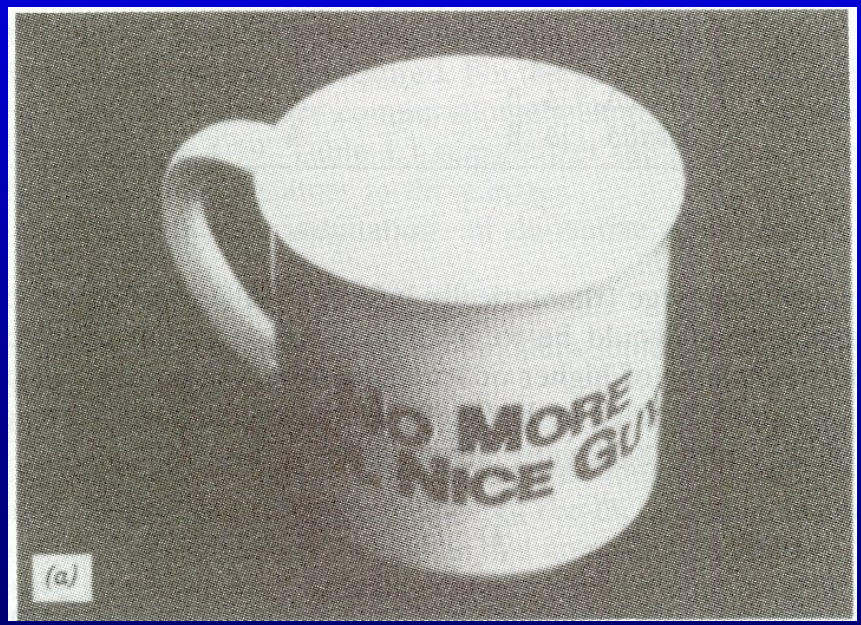
Representación

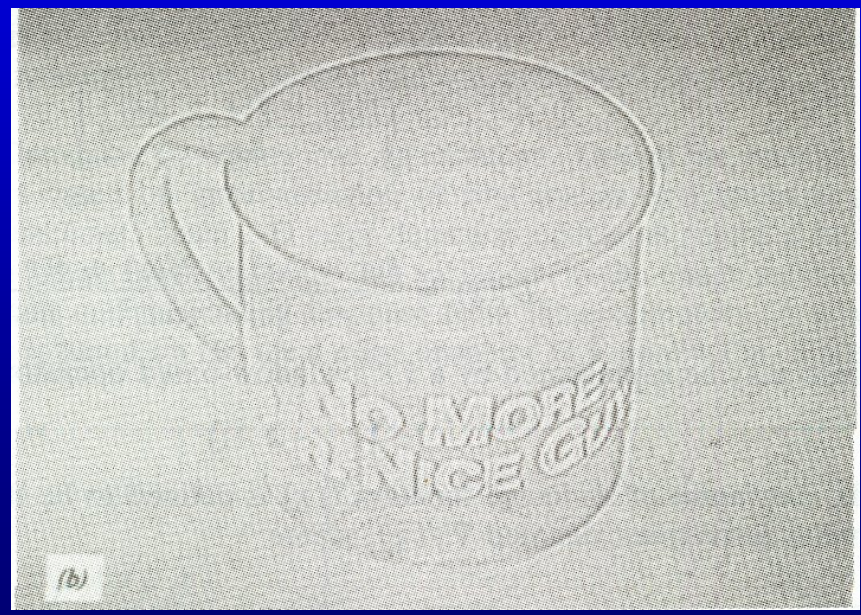




Procesamiento Digital de Imágenes:

Representación





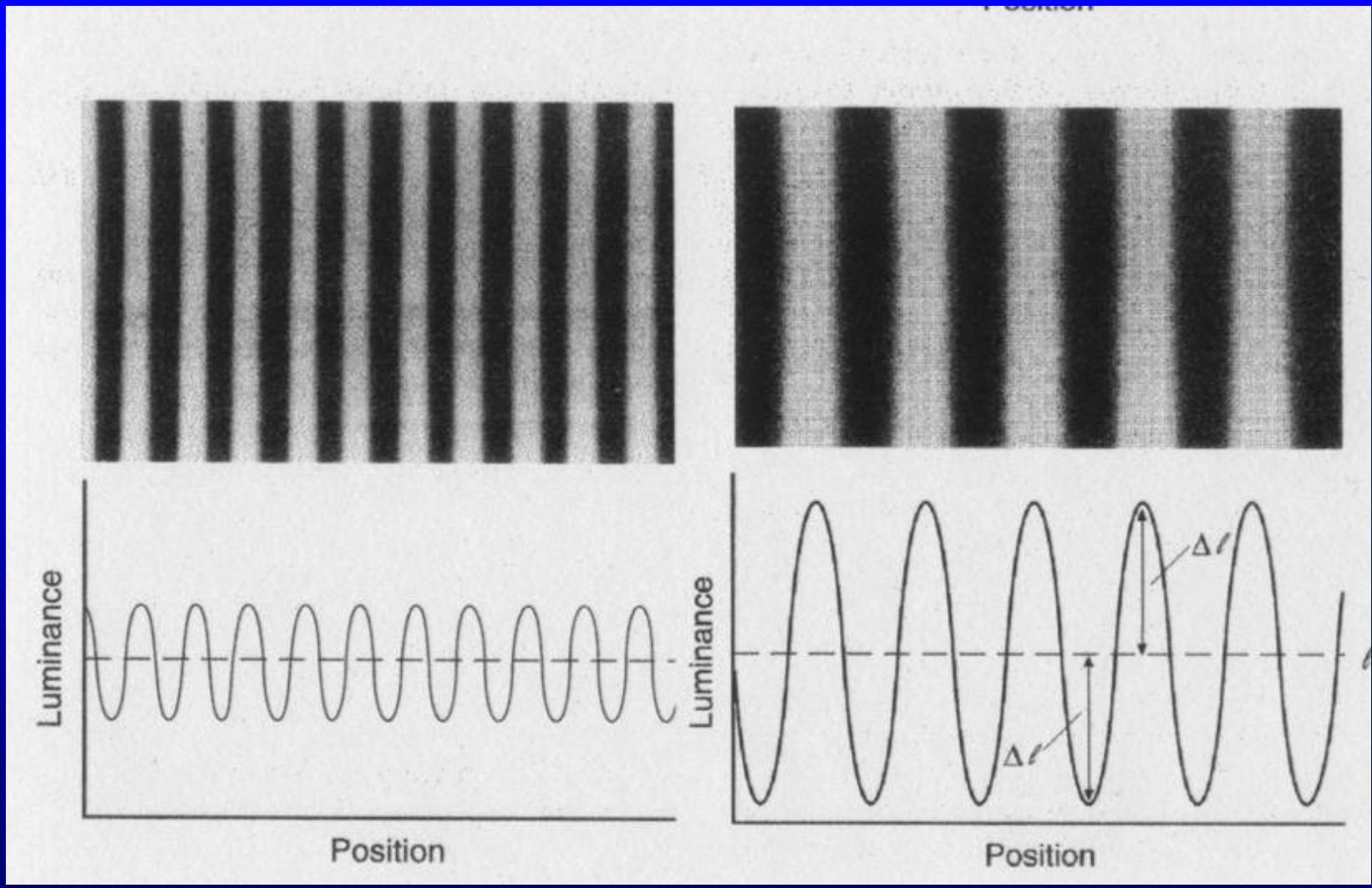
Resumen

- Objetivos de la visión artificial (definición)
- Imagen Digital
- Iluminación (espectro)
- Muestreo
- Representación (transformaciones)

Definición de Imagen:

* cualquier función bidimensional 2-D (o 3D)
* luminancia, absorción R-X, perfil de T, impedancia eléctrica, etc.
* gran cantidad de aplicaciones

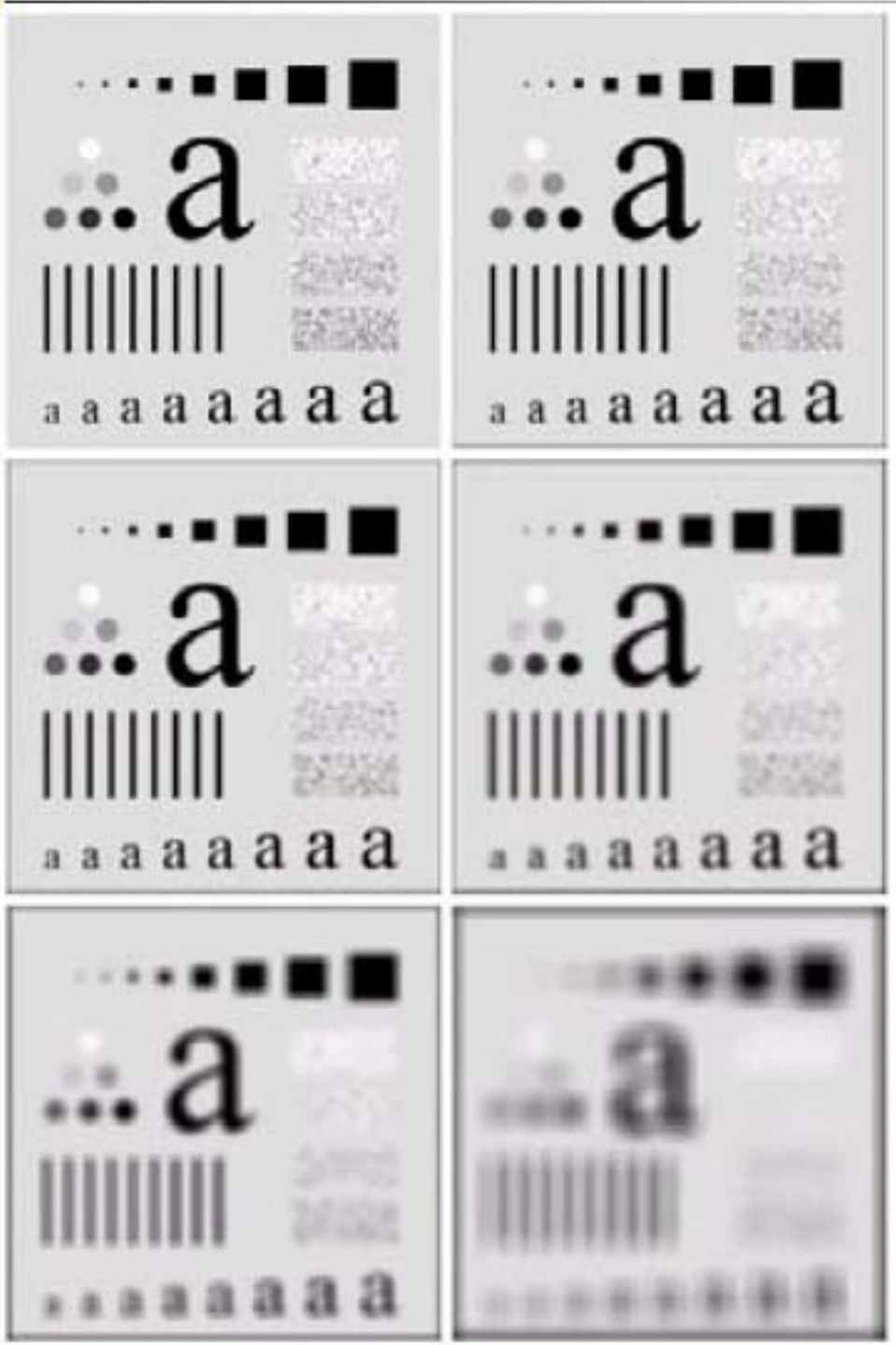
- **Señales espacio-tiempo, dimensiones**



Filtrado

Filtros

Filtro rect:
3x3,5x5,9x9,15x15, 35x35

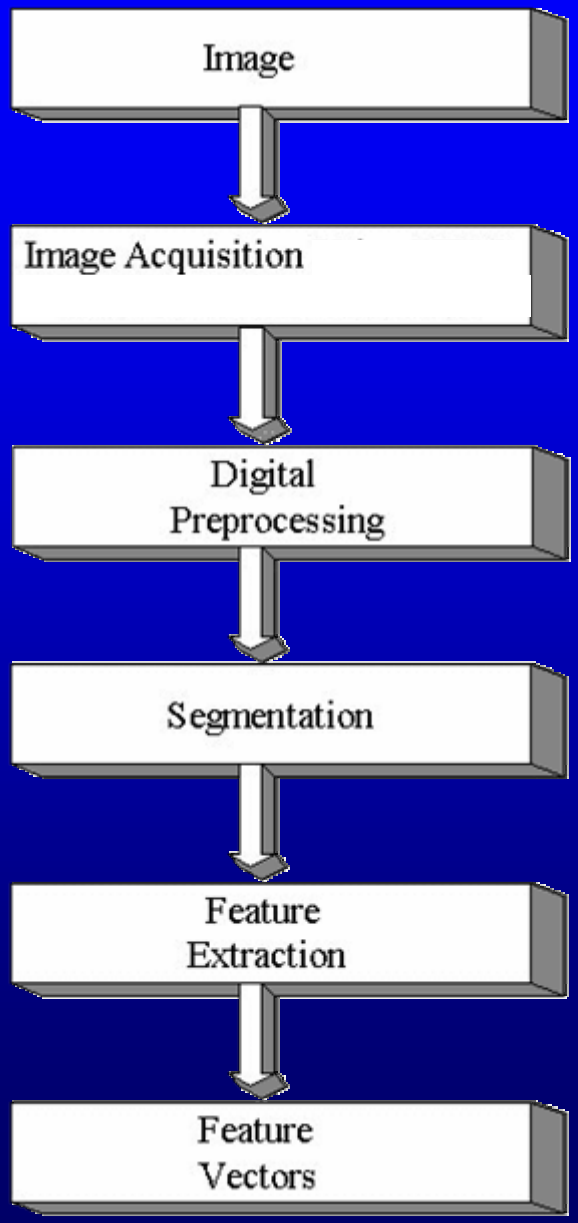


Sistemas de Visión Artificial:

* Complejidad – Motor de desarrollo
* Éxito en dominios restringidos

Guía de vehículos

Conceptos Básicos (2)



Aplicaciones:

* Sondeo remoto
* Tx y comunicaciones con imágenes
    * fax, video, TV digital, monitoreo de seguridad, etc.
* Medicina: R-x, TAC, MRI, US, Endoscopía, etc
* Radar – sonar
* Robótica
* Industria editorial/arte gráfico
* Síntesis de imágenes/animación

Adquisición de Imágenes

- **Sensores**
  - Cámaras estándares, barrido progresivo, barrido de línea
  - Analógica/digital

- **Frame Grabber**

- **Preprocesamiento**
  - **Mejoras**
  - **Eliminación de ruido**
- **Operaciones entre puntos v=f(u)**
- **Operaciones espaciales**

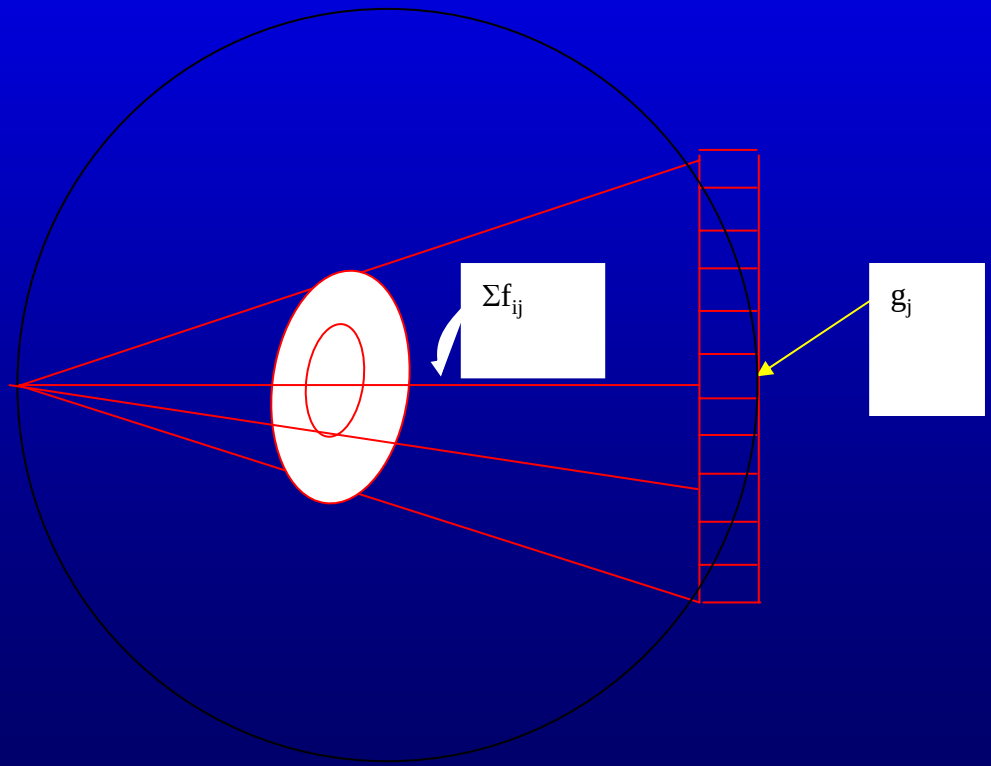
Conceptos Básicos

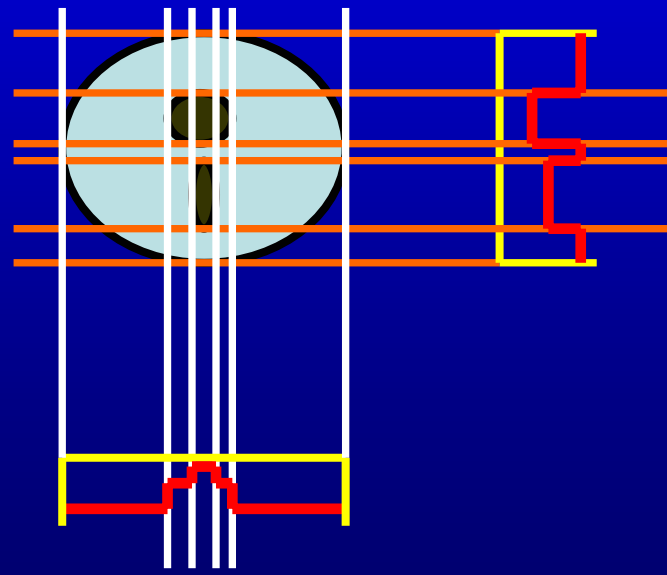
- **Sistemas para procesamiento de imágenes**
- **Criterios de Segmentación**
- **Criterios para extracción de características**
- **Selección de características**
- **Vectores de características – Clases**
- **Niveles de abstracción – pixeles - símbolos**
- **Base de datos - Partición**

Reconstrucción de Imágenes

Reconstrucción Iterativa ART (Adaptive Reconstructruction Technique)

$$f_{ij}^{q+1} = f_{ij}^{q} + \frac{g_j - \sum_{i=1}^{N} f_{ij}^{q}}{N}$$





Reconstrucción de Imágenes

Reconstrucción Iterativa ART (Adaptive Reconstructruction Technique)

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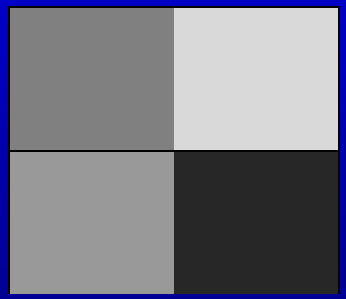
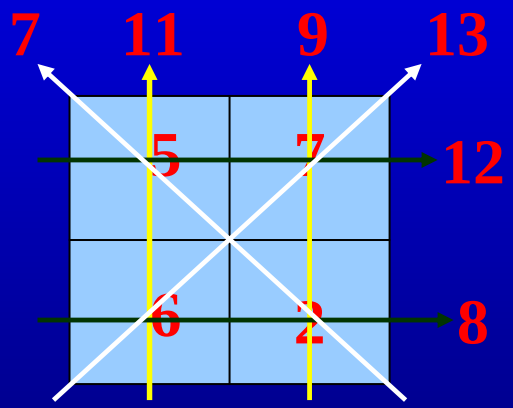


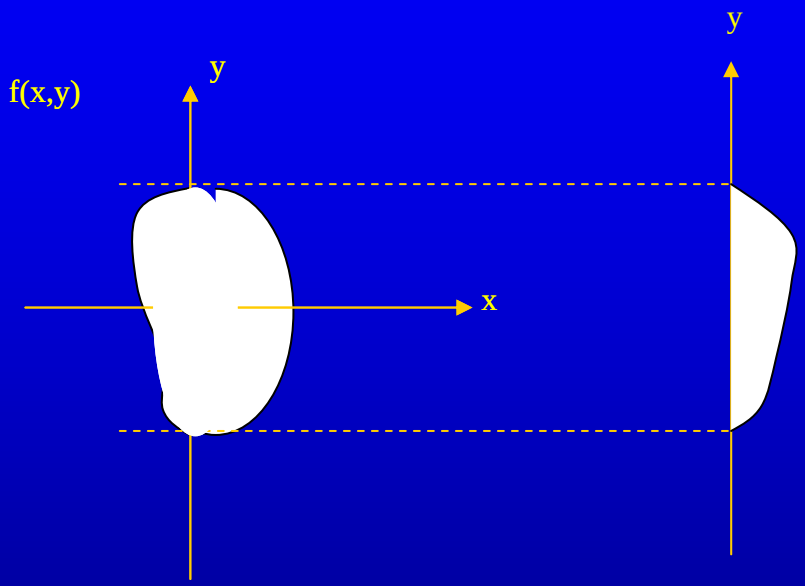
5	7
6	2



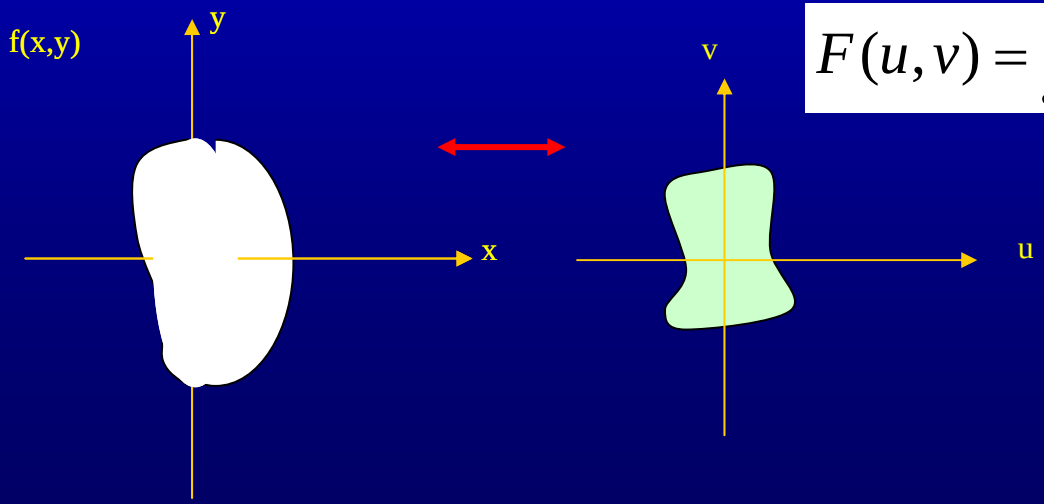
$f_1^0 = 0$	$f_2^0 = 0$	$f_1^1 = 5{,}5$	$f_2^1 = 4{,}5$	$f_1^2 = 6{,}5$	$f_2^2 = 5{,}5$	$f_1^3 = 5$	$f_2^3 = 7$
$f_3^0 = 0$	$f_4^0 = 0$	$f_3^1 = 5{,}5$	$f_4^1 = 4{,}5$	$f_3^2 = 4{,}5$	$f_4^2 = 3{,}5$	$f_3^3 = 6$	$f_4^3 = 2$

Reconstrucción de Imágenes

Reconstrucción Directa: T. de Fourier



$$g(y) = \int f(x,y)dx$$



$$F(u,v) = \iint f(x,y)e^{-j2\pi(ux+vx)}dxdy$$

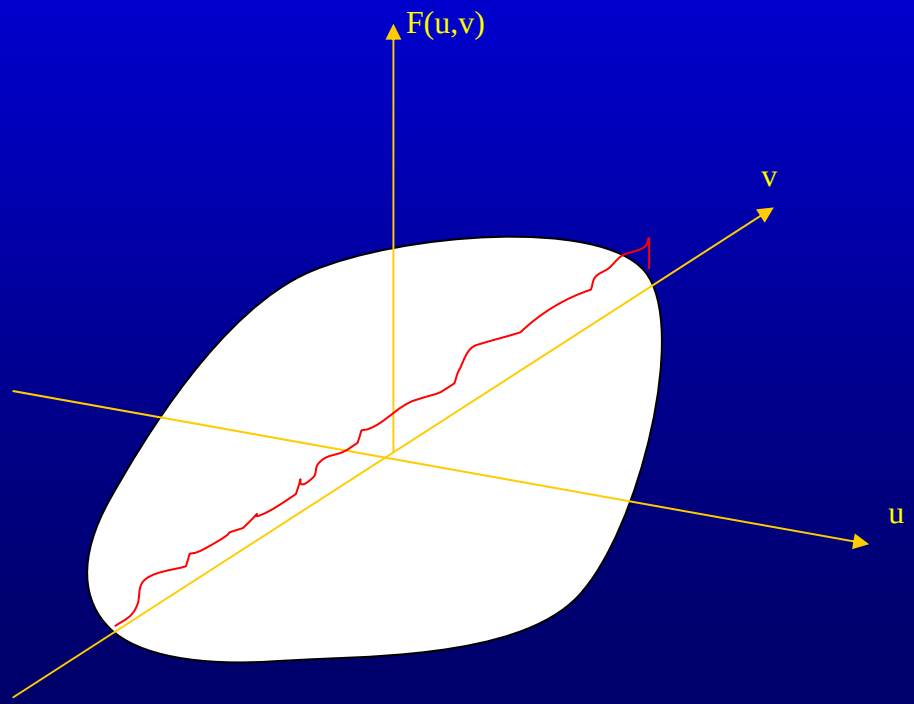
Reconstrucción de Imágenes

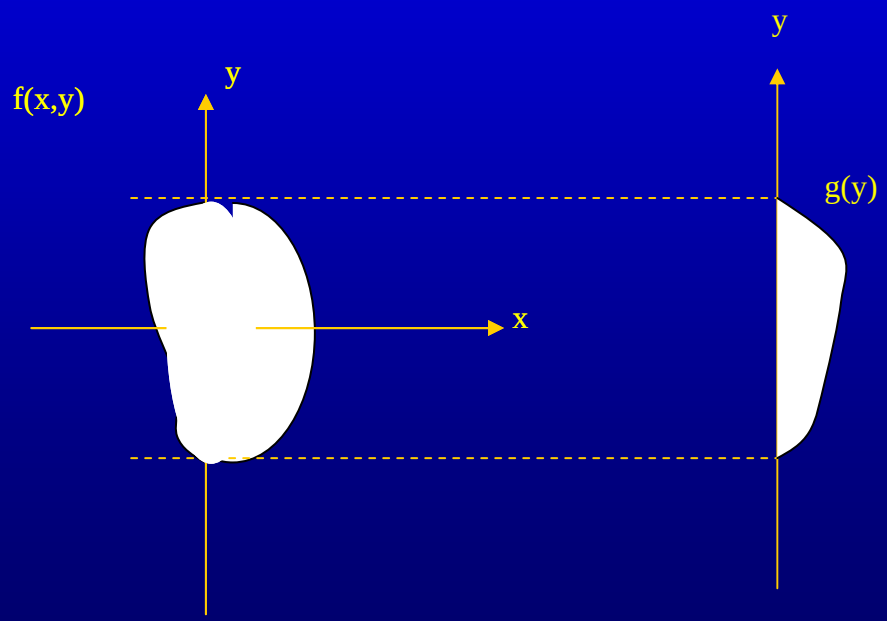
Reconstrucción Directa: T. de Fourier

Para u = 0

$$F(0,v) = \iint f(x,y)e^{-j2\pi vy}dxdy = \int\left[\int f(x,y)dx\right]e^{-j2\pi vy}dy = \int g(y)e^{-j2\pi vy}dy$$

$$= F_{1-D}\{g(y)\}$$

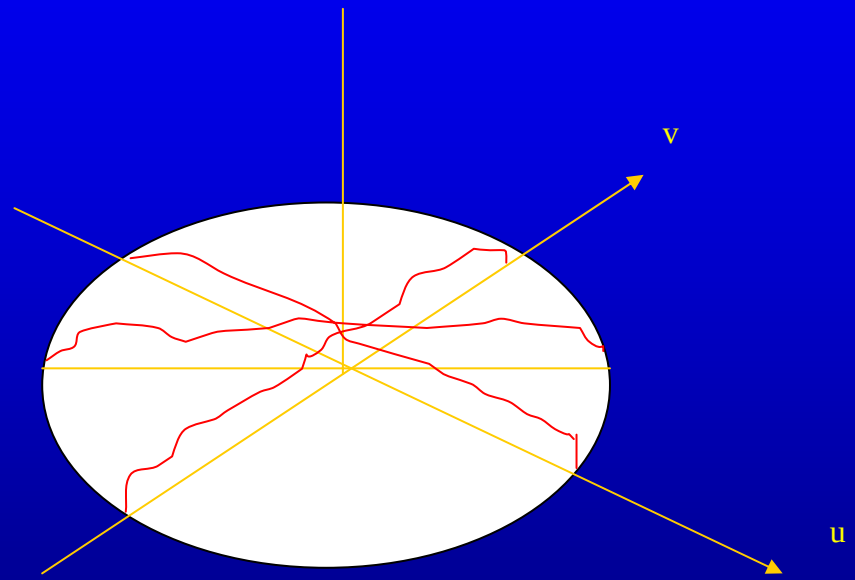




Reconstrucción de Imágenes

Reconstrucción Directa: T. de Fourier

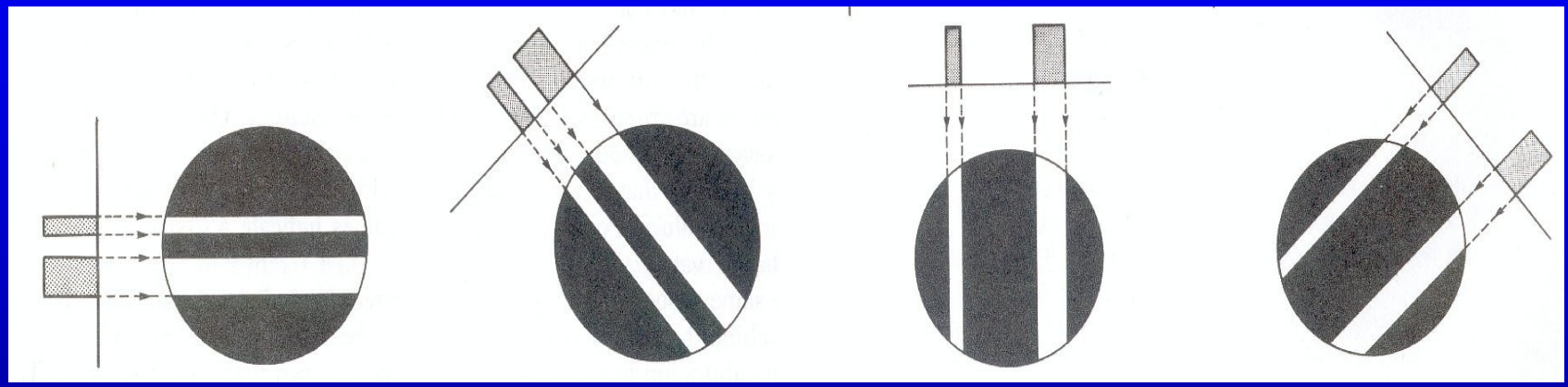
Para muchas proyecciones

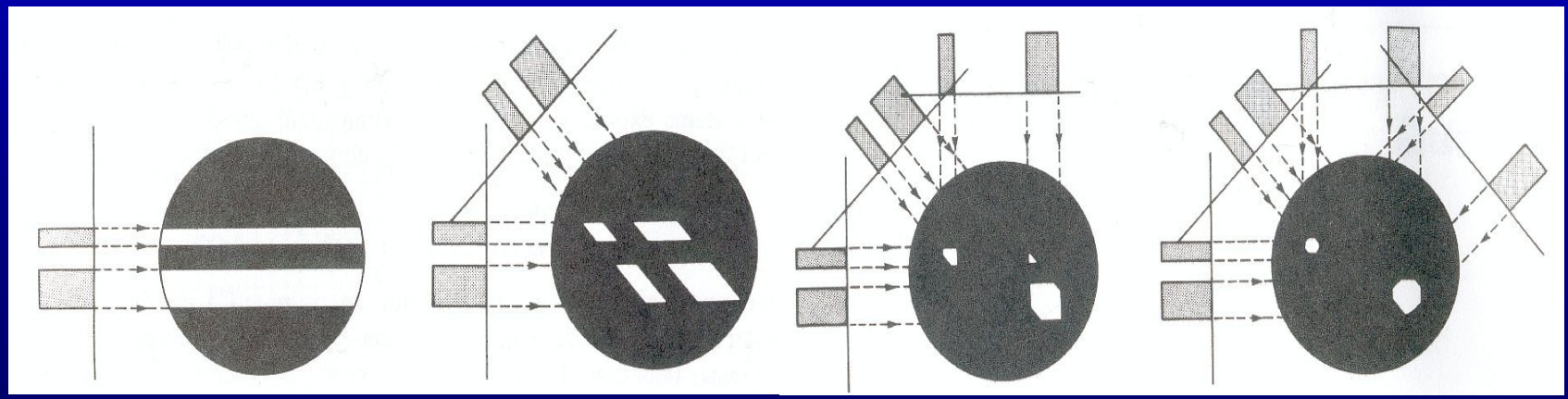


$$f(x,y) = F_{2-D}^{-1}\left\{F(u,v)\right\}$$

Reconstrucción de Imágenes

Retroproyección: Las medidas realizadas en cada proyección son proyectadas hacia atrás asignando el valor medido a cada línea.

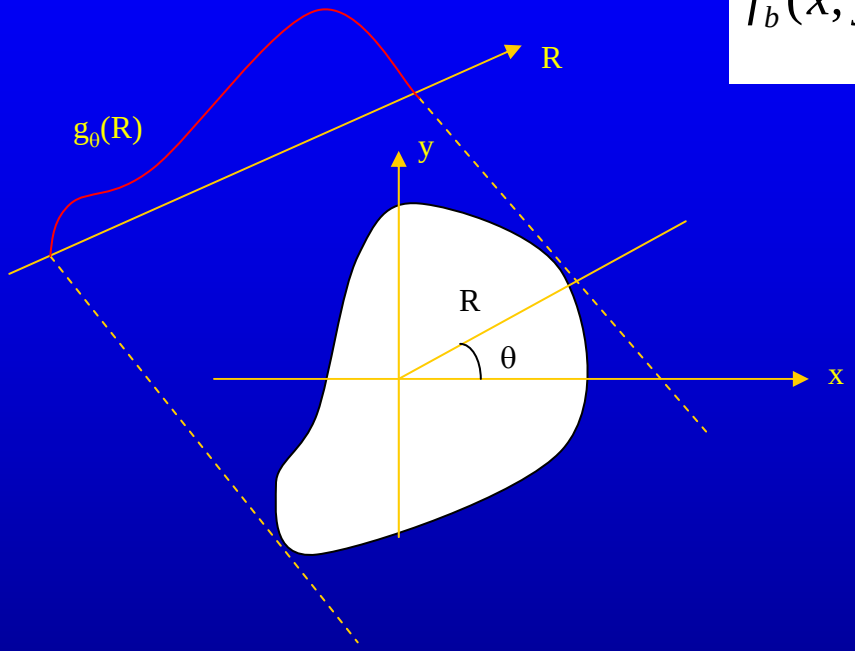




Reconstrucción de Imágenes

Retroproyección:

$$f_b(x,y) = \int_0^{\pi} \int_{-\infty}^{\infty} g_\theta(R)\,\delta(x\cos\theta + y\,\mathrm{sen}\,\theta - R)\,dR\,d\theta$$



se puede demostrar que la retroproyección de una función δ corresponde a la respuesta al impulso

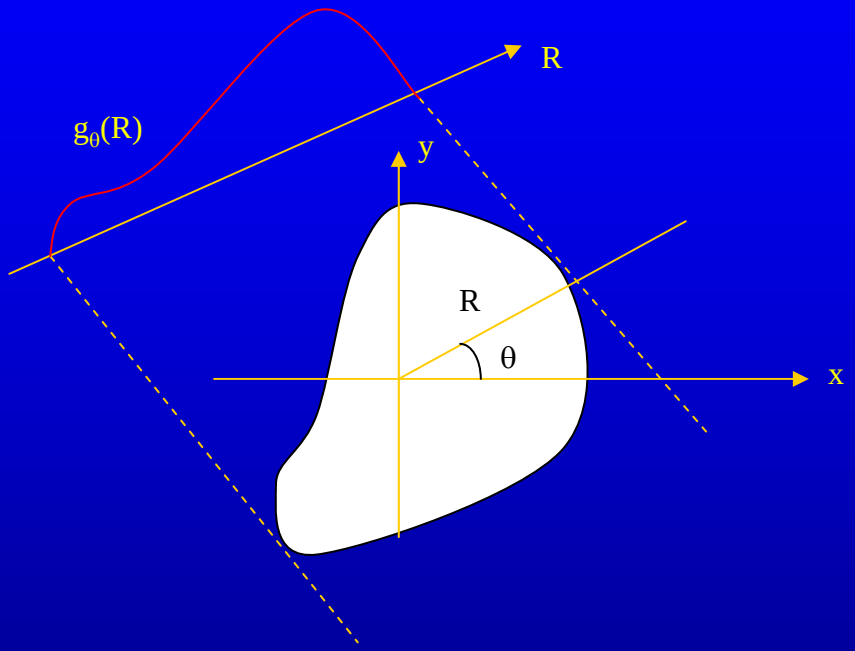
$$h_b(r) = \frac{1}{r}$$

$$\Rightarrow f_b(x,y) = f(x,y) * \frac{1}{r} \quad \leftrightarrow \frac{F(\rho,\theta)}{\rho}$$

$$f(x,y) \approx F_{2-D}^{-1}\left\{F_b(\rho,\theta)\rho\right\}$$

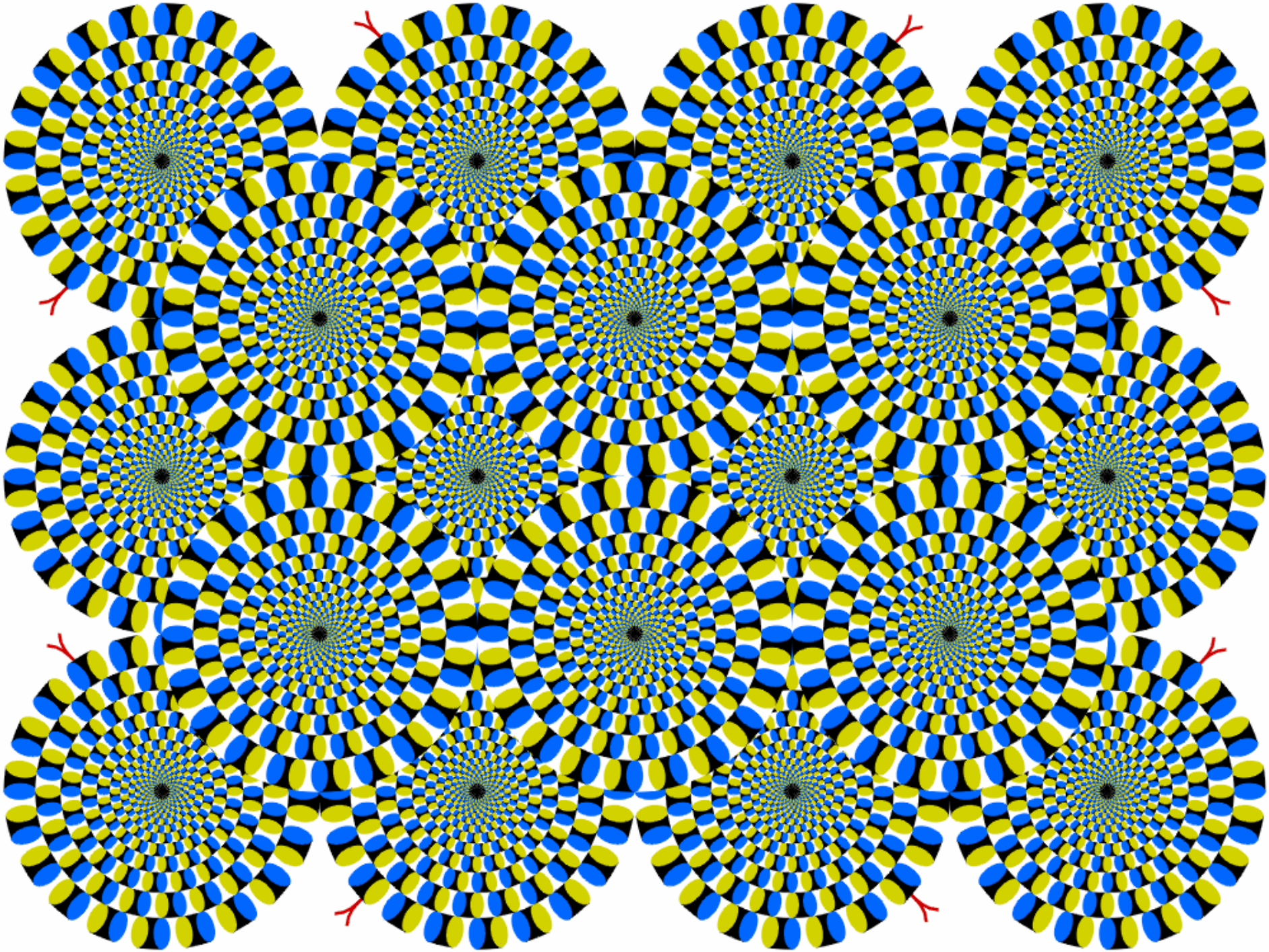
Reconstrucción de Imágenes

Retroproyección Filtrada:

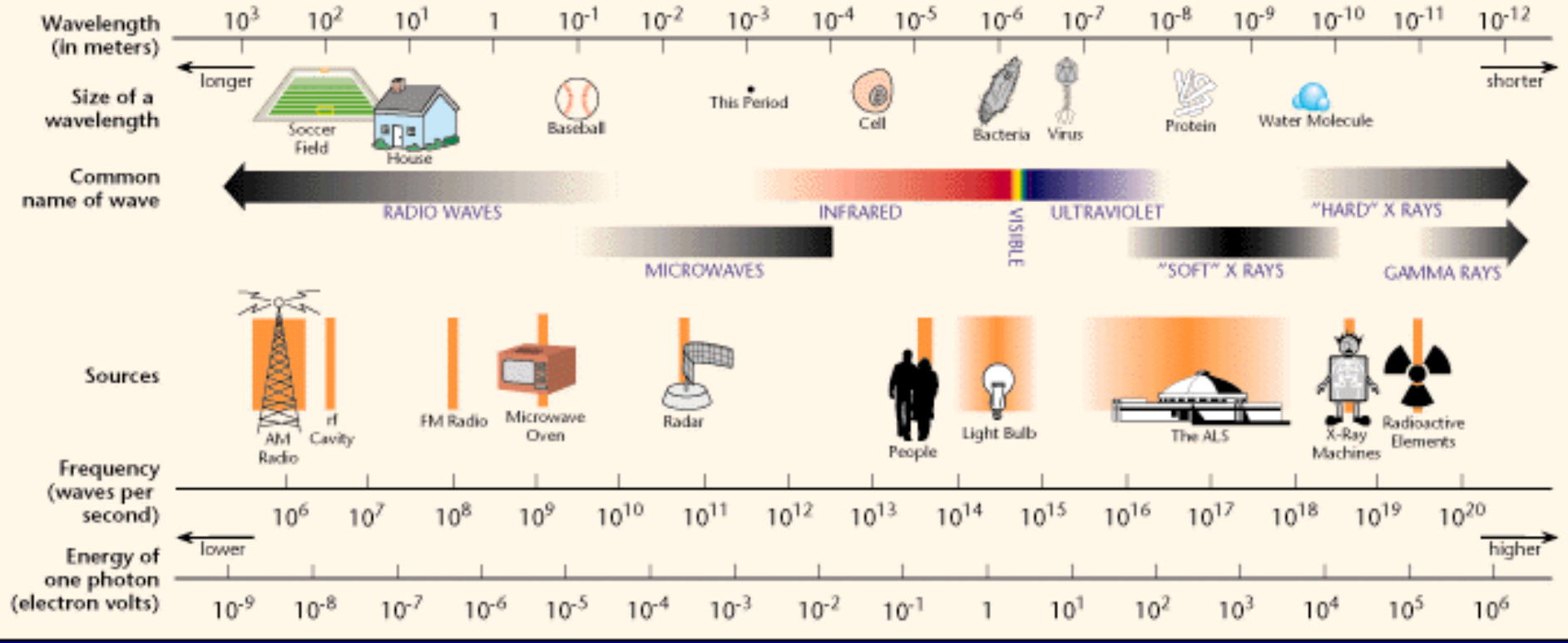


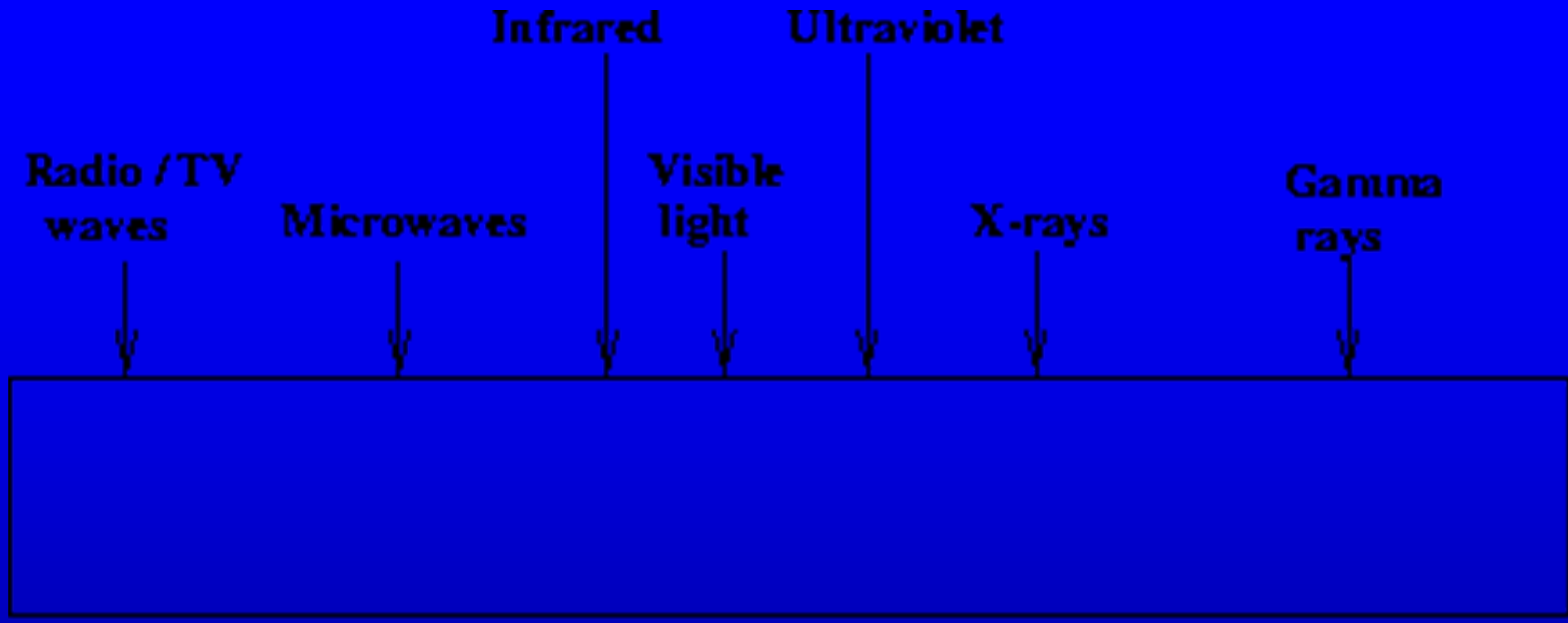
$$f(x,y) \approx F_{2-D}^{-1}\left\{F_b(\rho,\theta)\rho\right\}$$

Cada proyección se transforma individualmente se pondera por |ρ| y se hace la T inversa y luego se retroproyecta.



THE ELECTROMAGNETIC SPECTRUM





10 10^{-2} 10^{-7} 10^{-10} 10^{-13}

(wavelength in meters)

10^{7} 10^{10} 10^{15} 10^{18} 10^{21}

(frequency in Hz)

The Eye's Neural Network

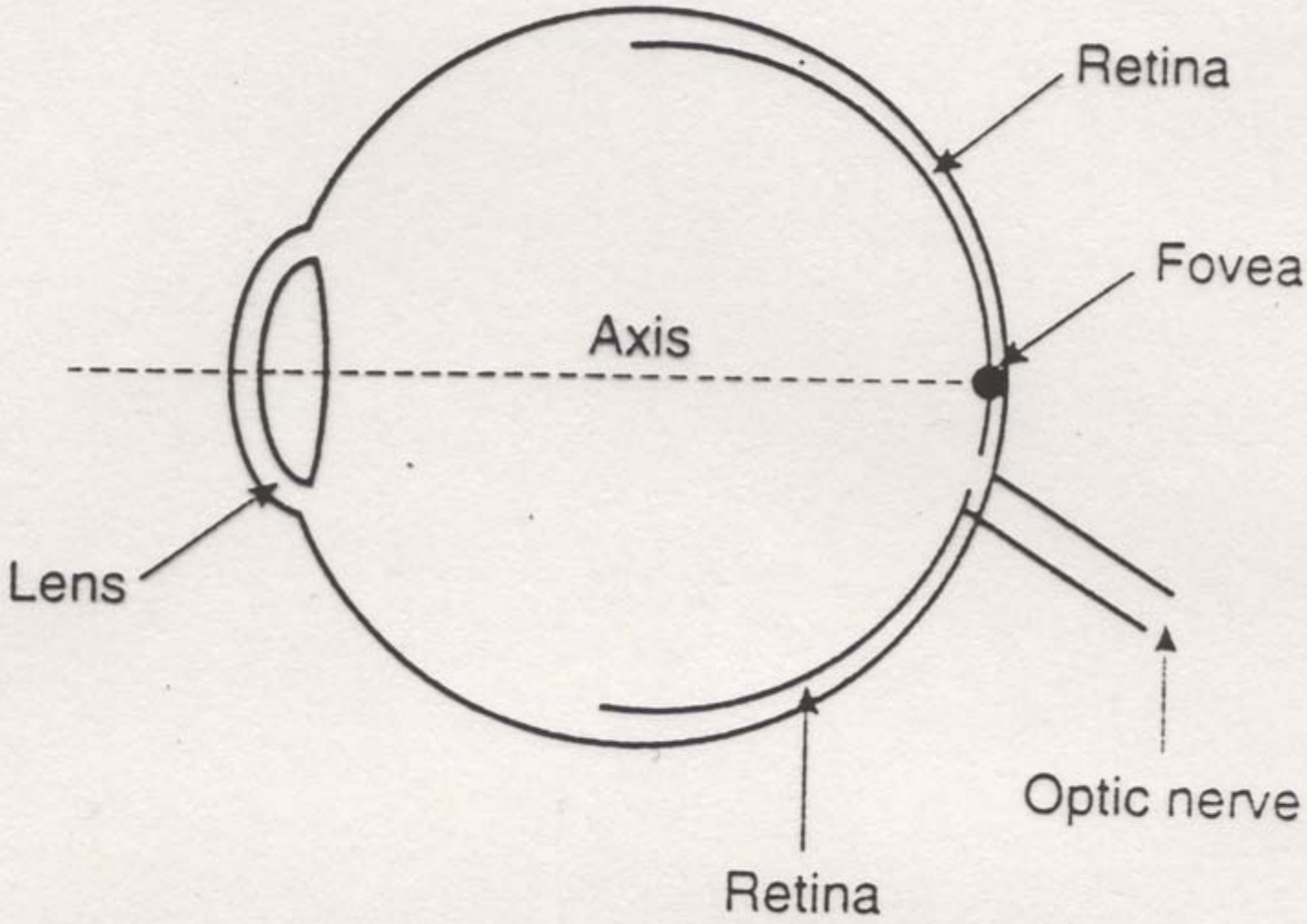
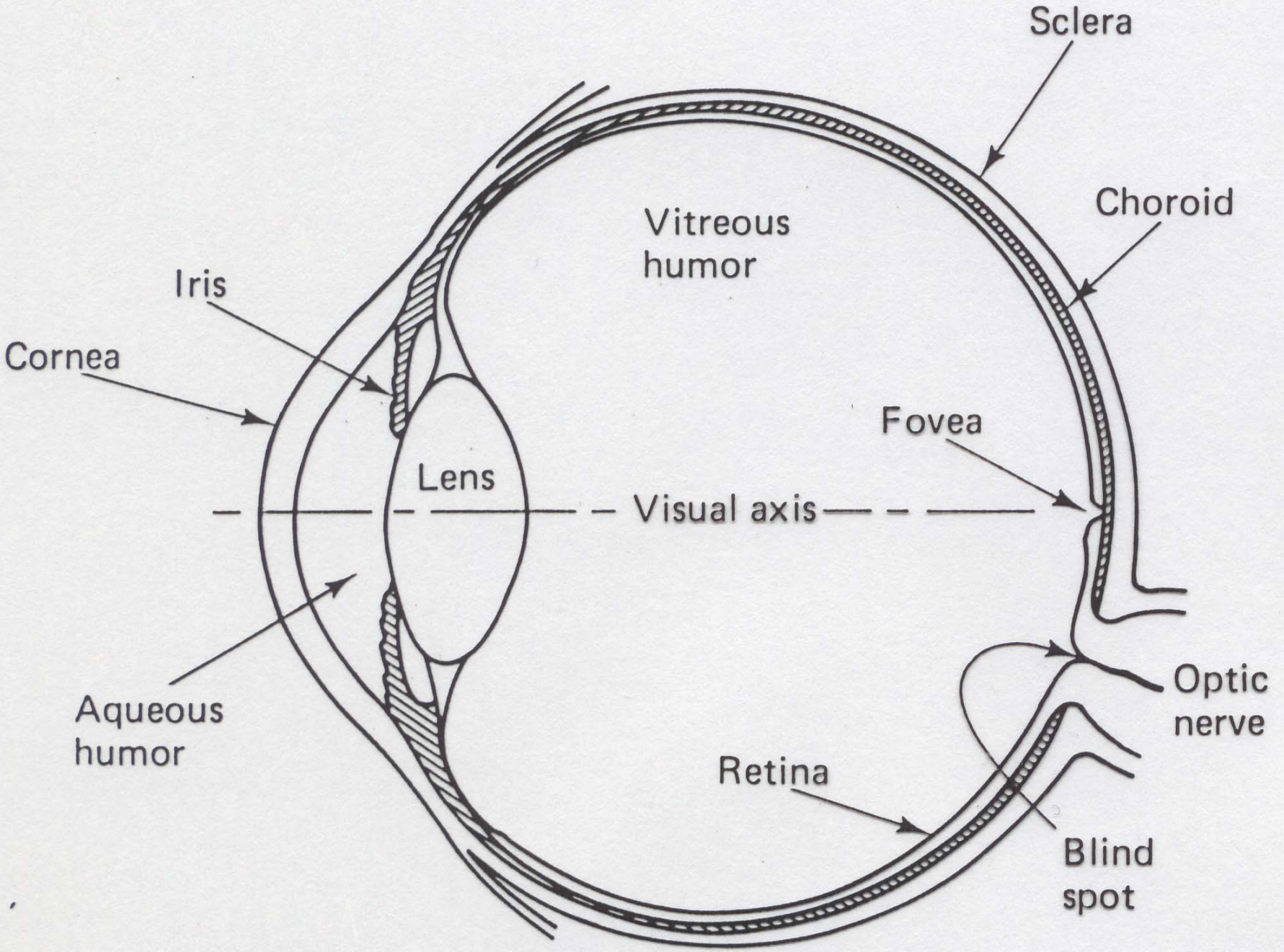
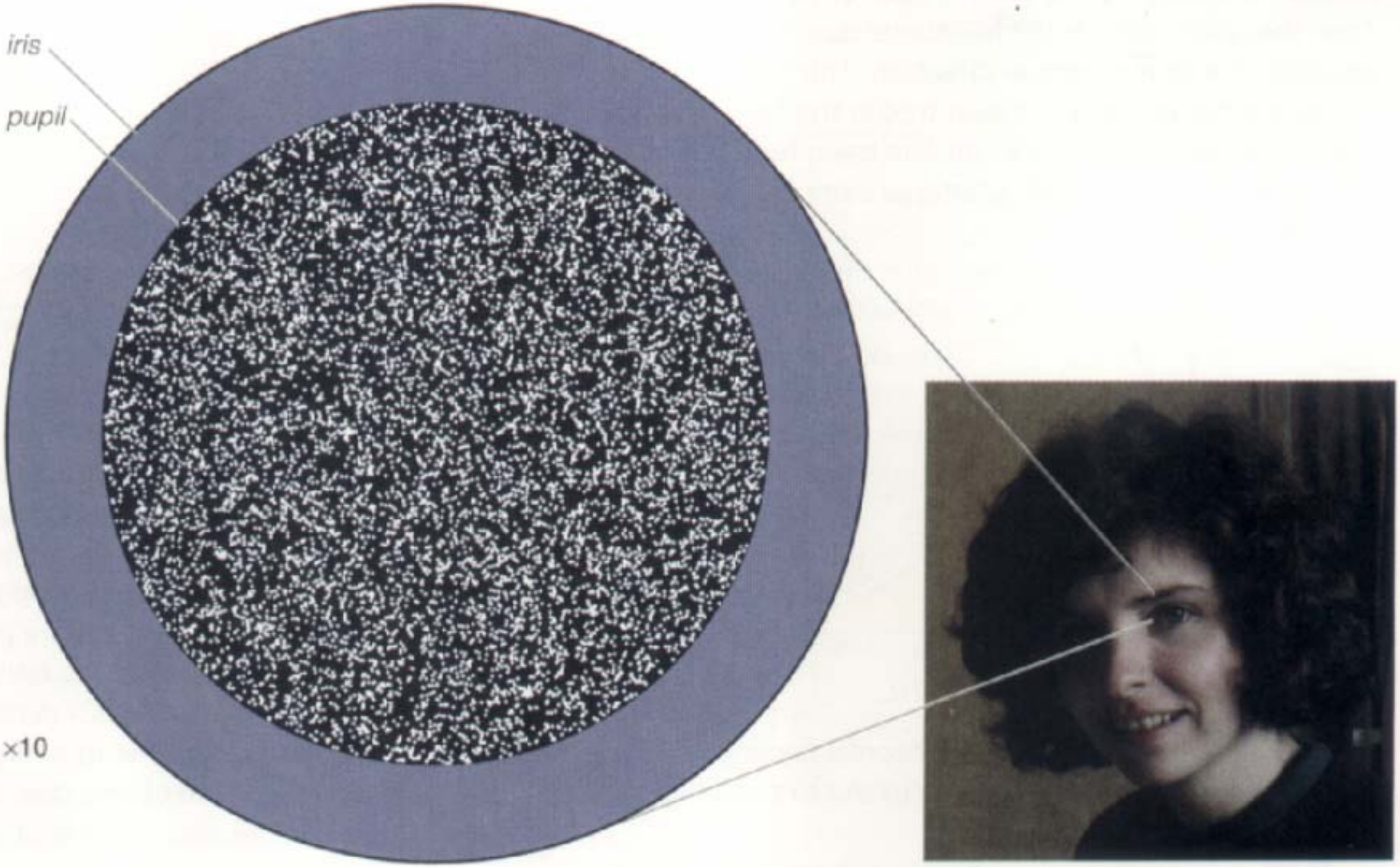
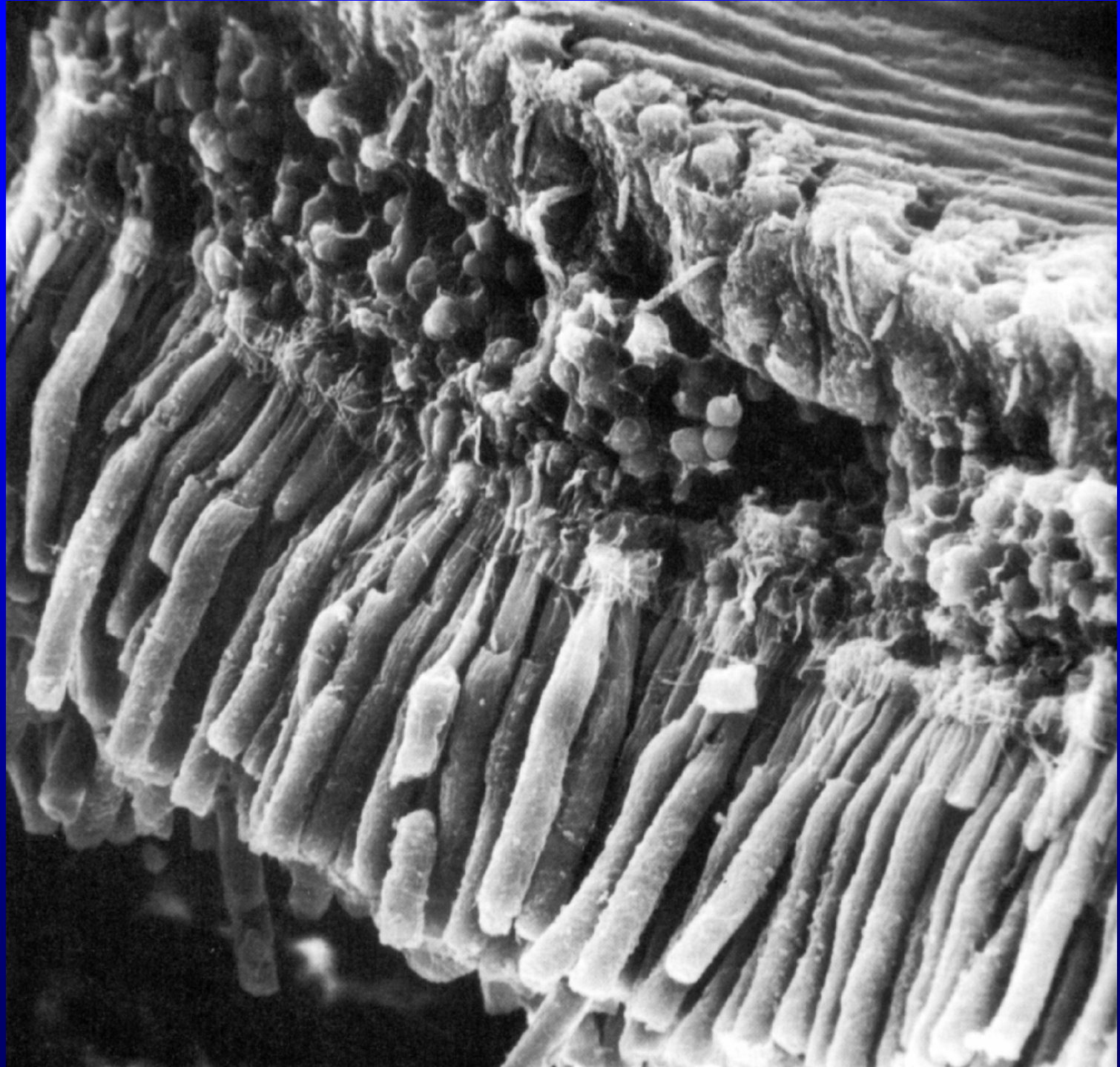


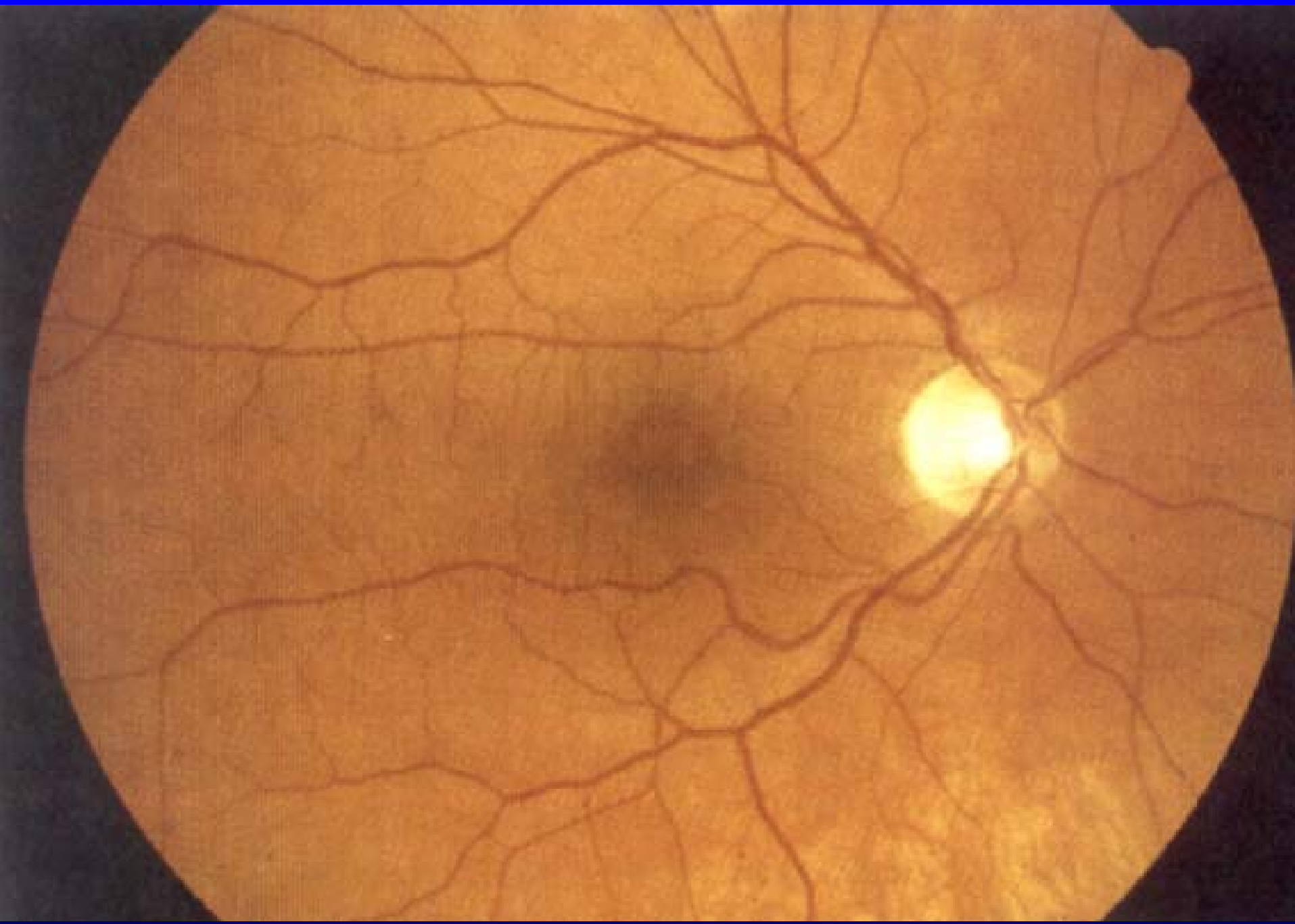
Figure 1-8 Simplified cross section of the eye.

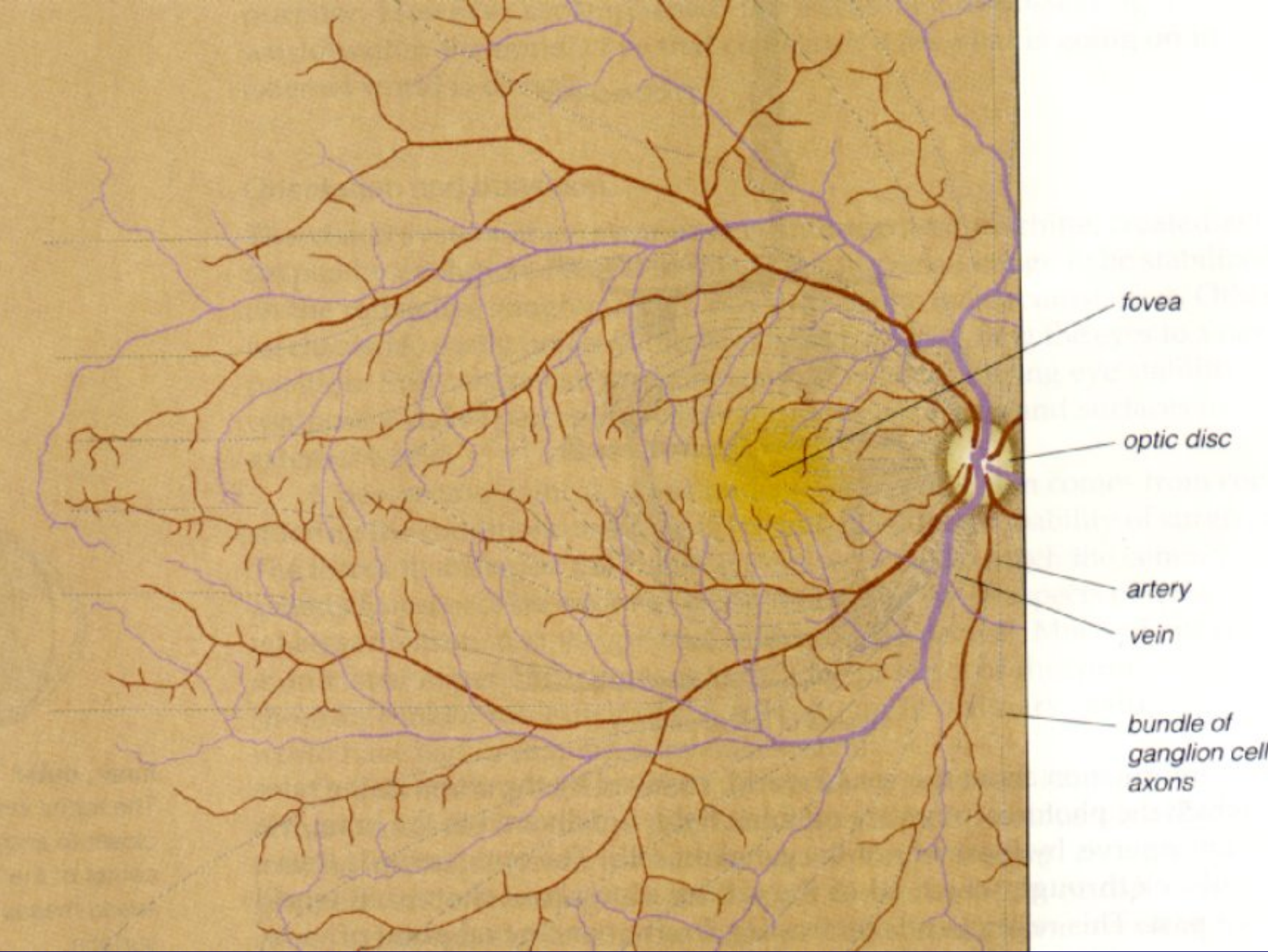

Sclera
Choroid
Vitreous humor
Iris
Cornea
Fovea
Lens
Visual axis
Optic nerve
Aqueous humor
Retina
Blind spot



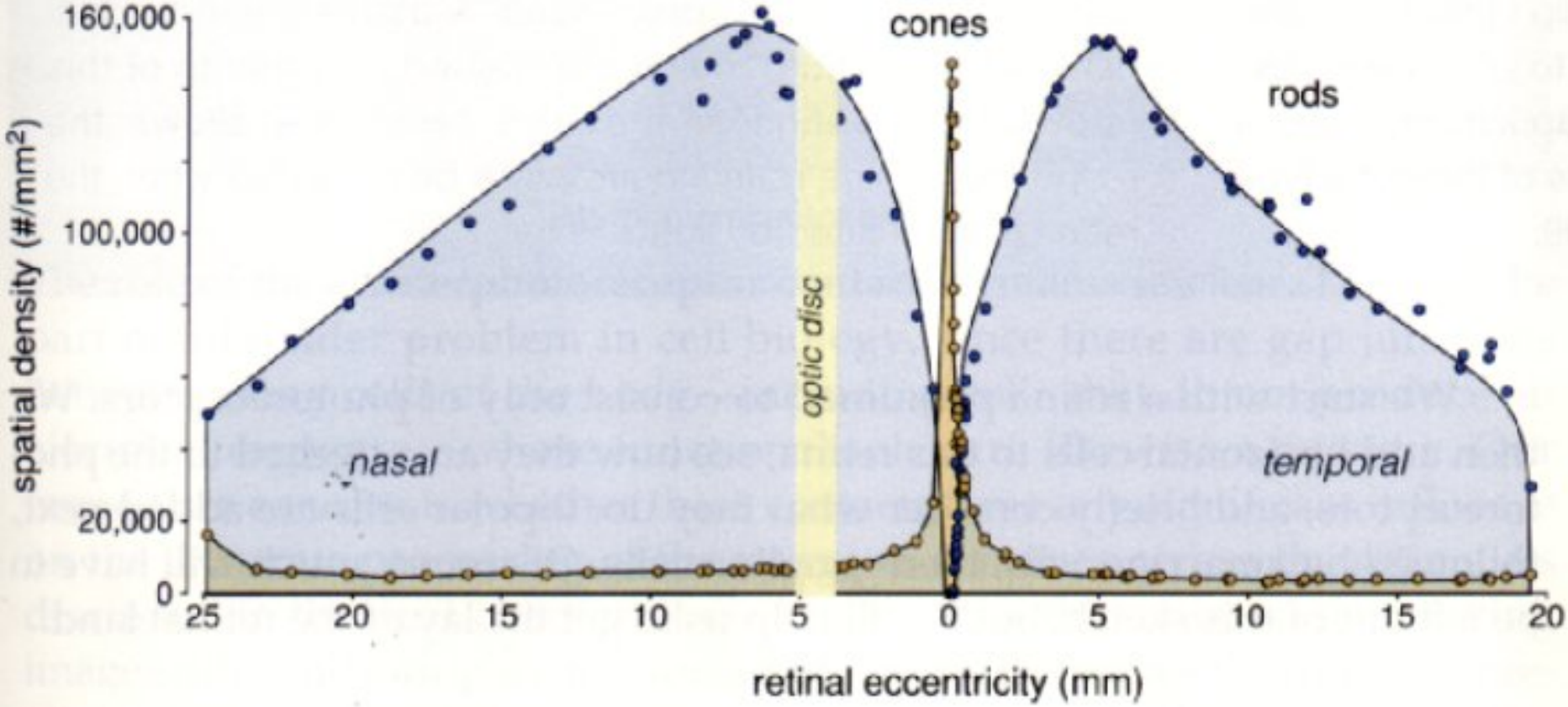
9,400 photons in plane of pupil

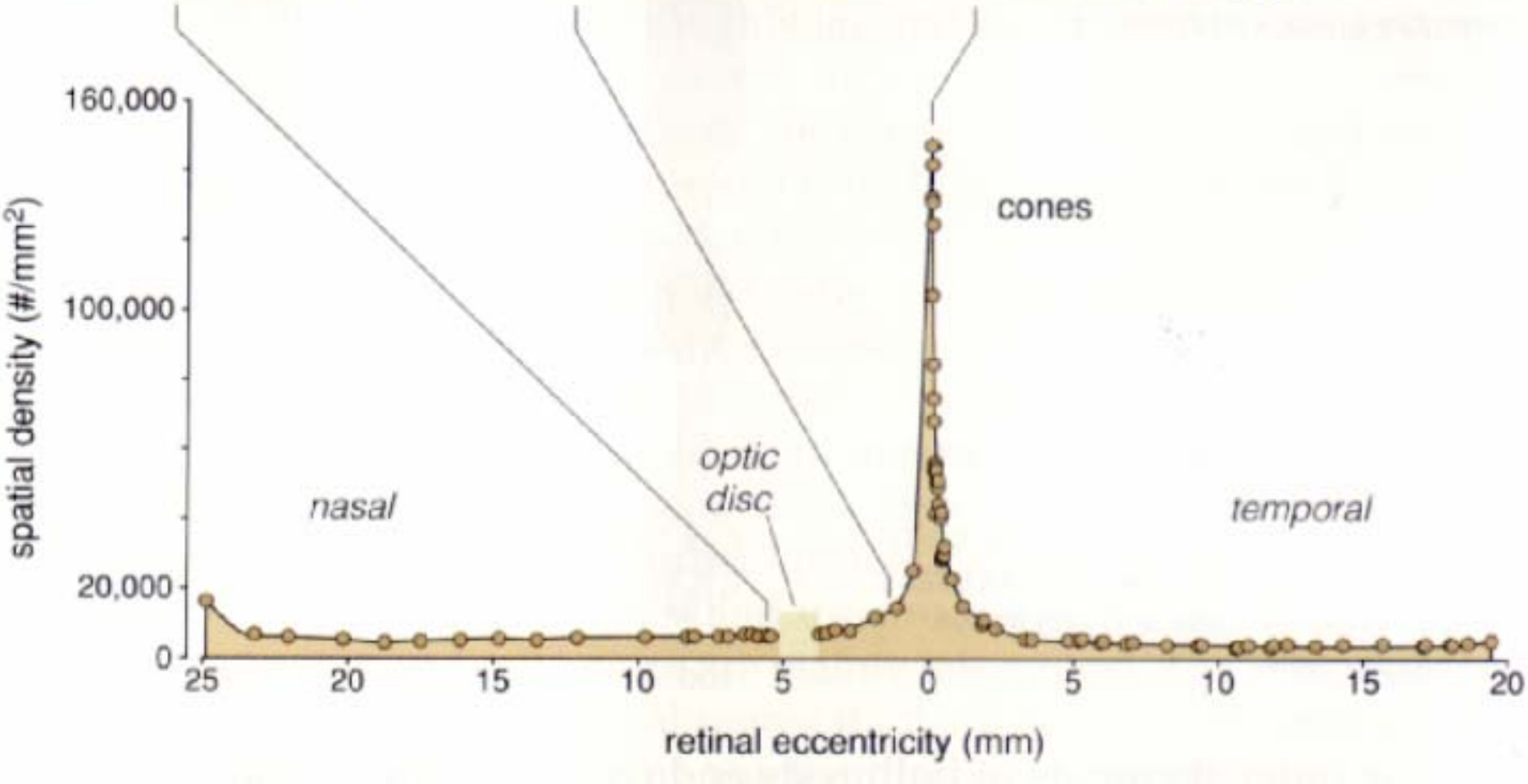


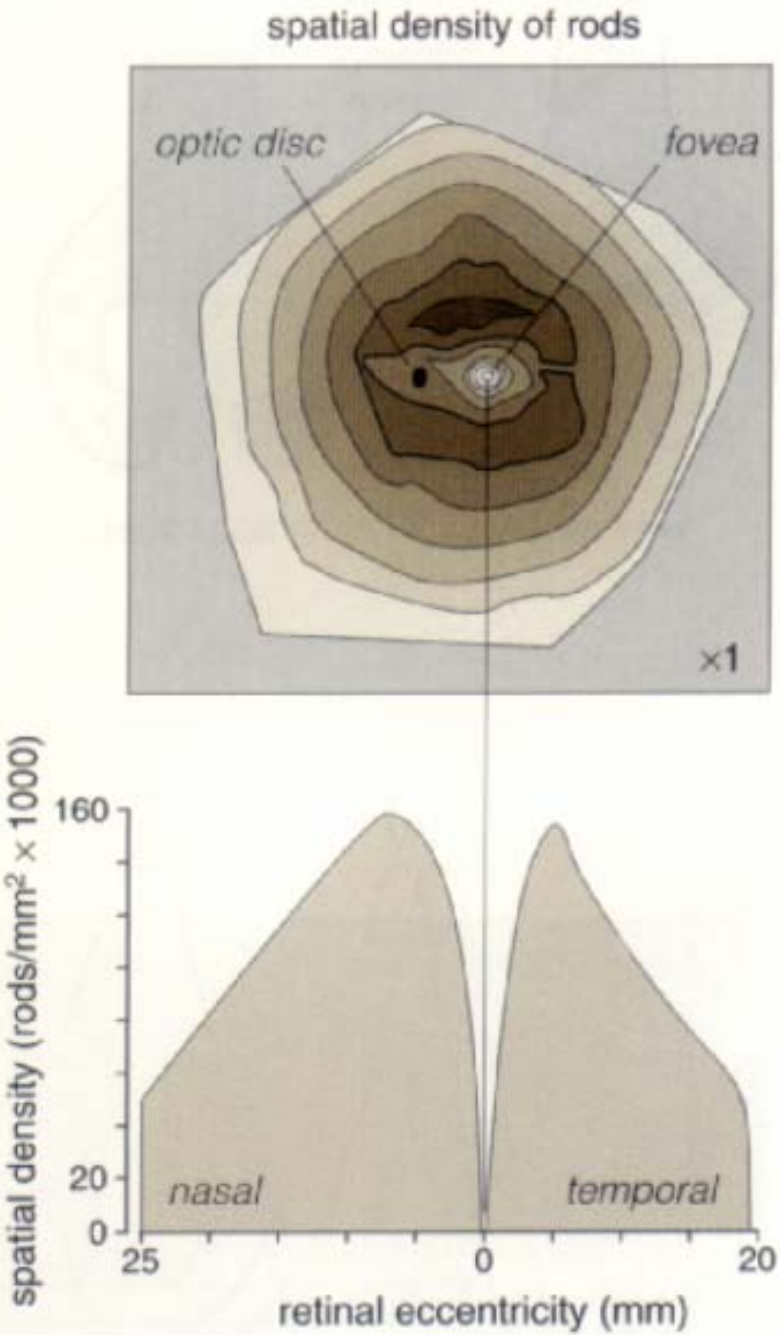



fovea
optic disc
artery
vein
bundle of
ganglion cell
axons

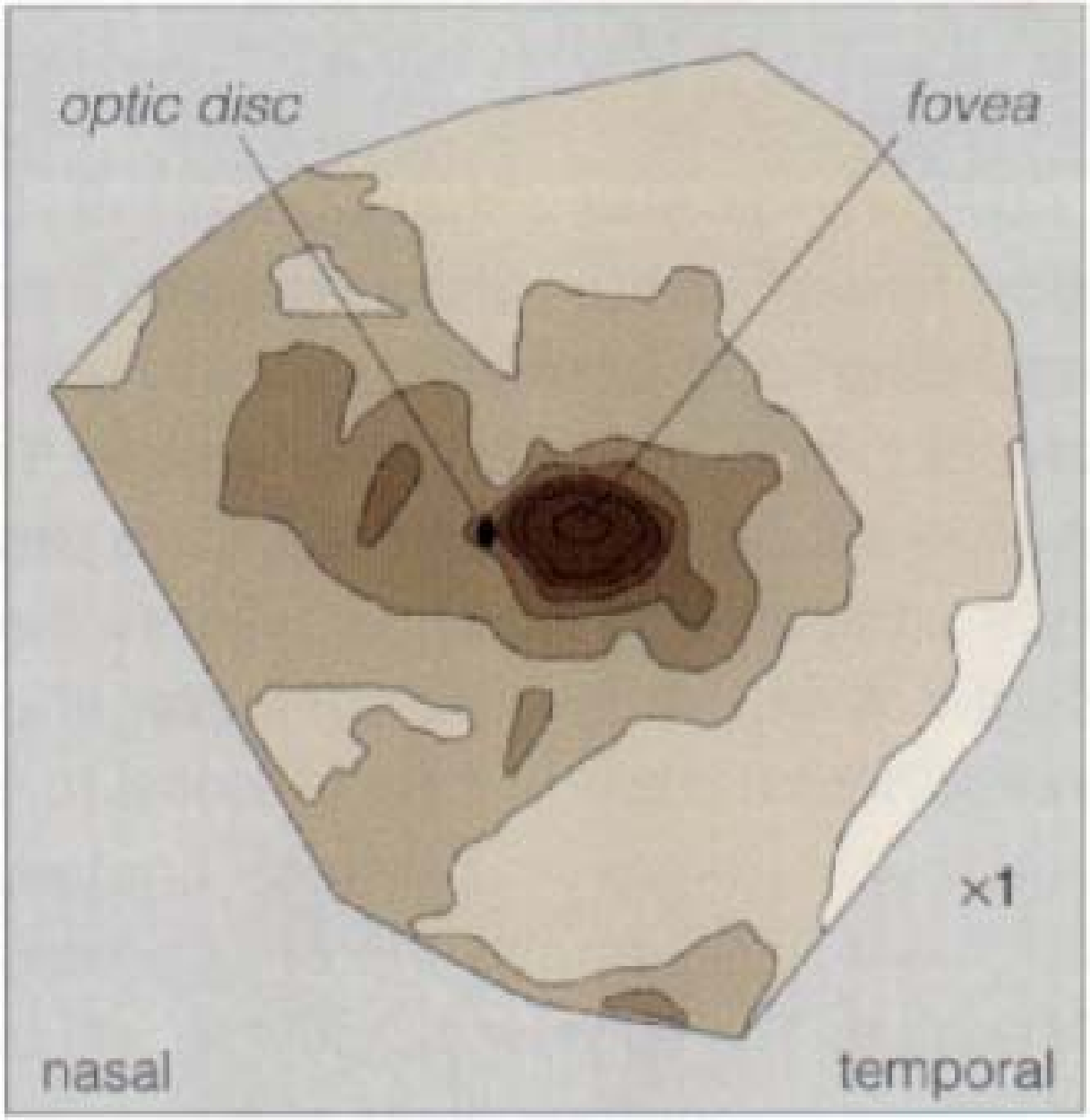
This diagram shows the spatial density of rods superimposed upon that of cones:

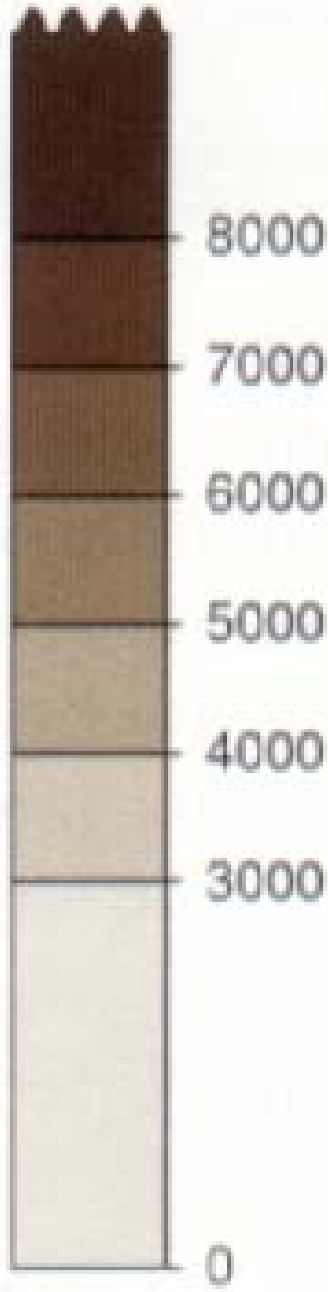



×1000
160,000
100,000
20,000
0
spatial density (#/mm²)
cones
optic
disc
nasal
temporal
25
20
15
10
5
0
5
10
15
20
retinal eccentricity (mm)

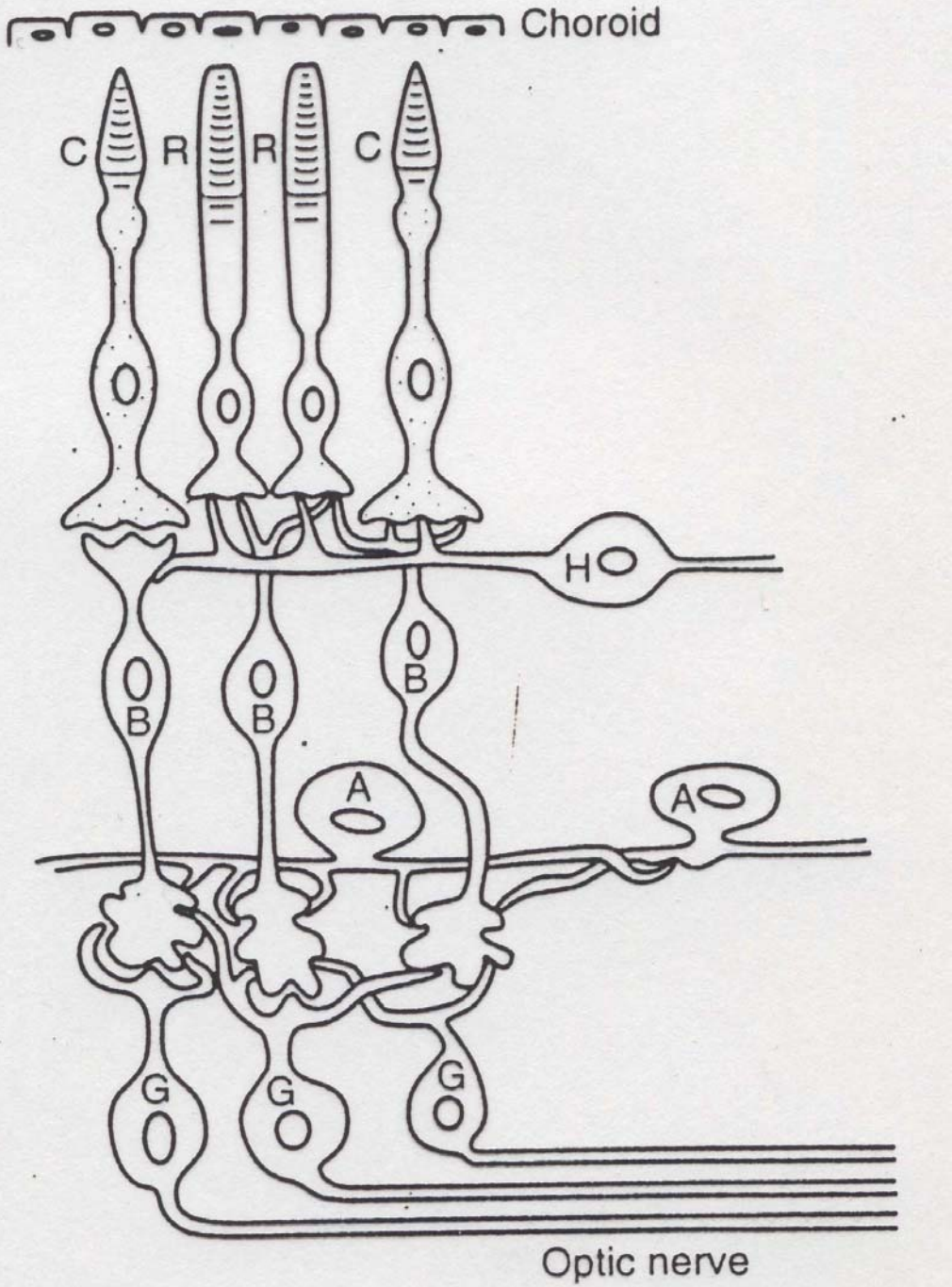


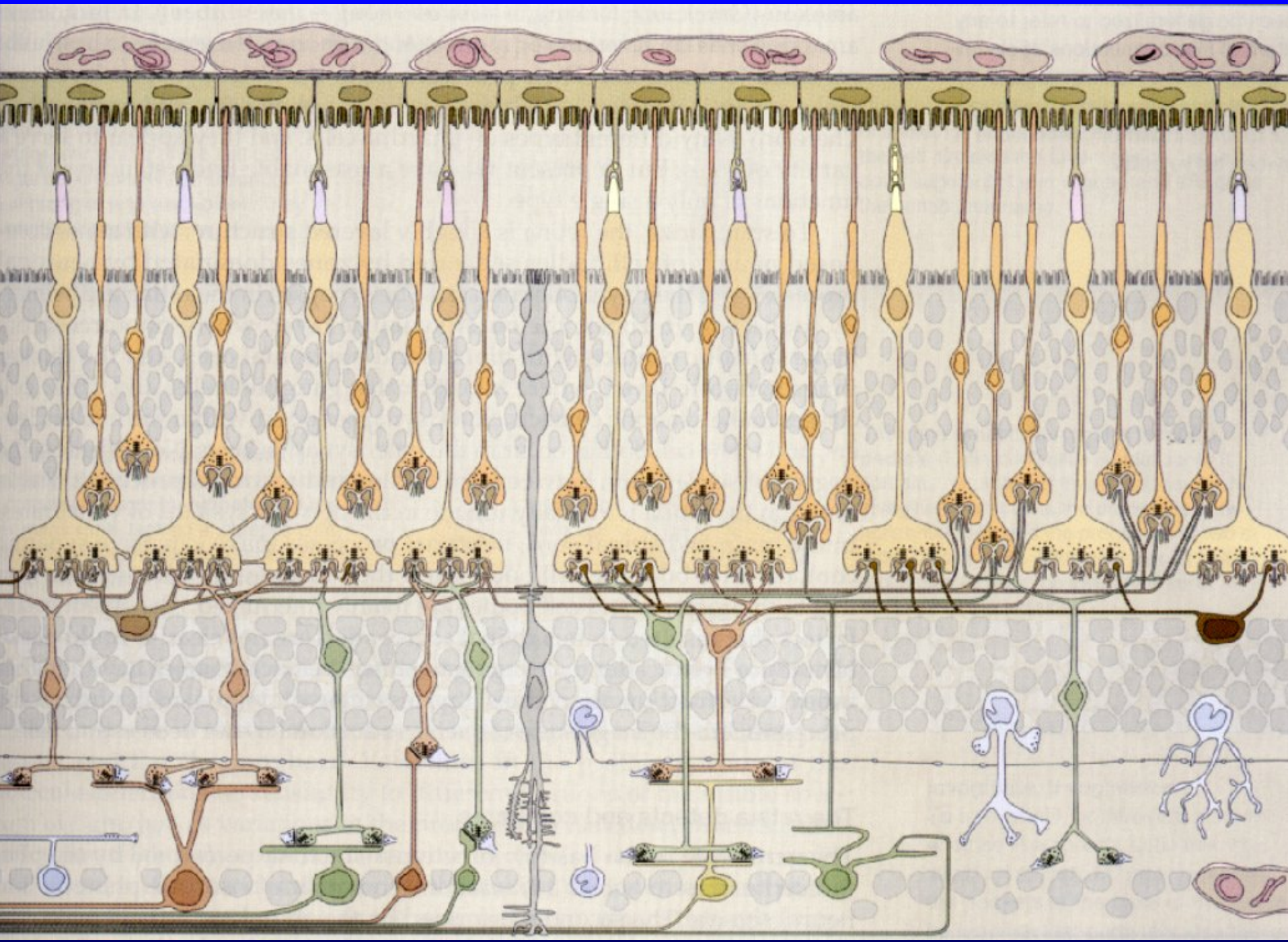
after Curcio et al., 1990

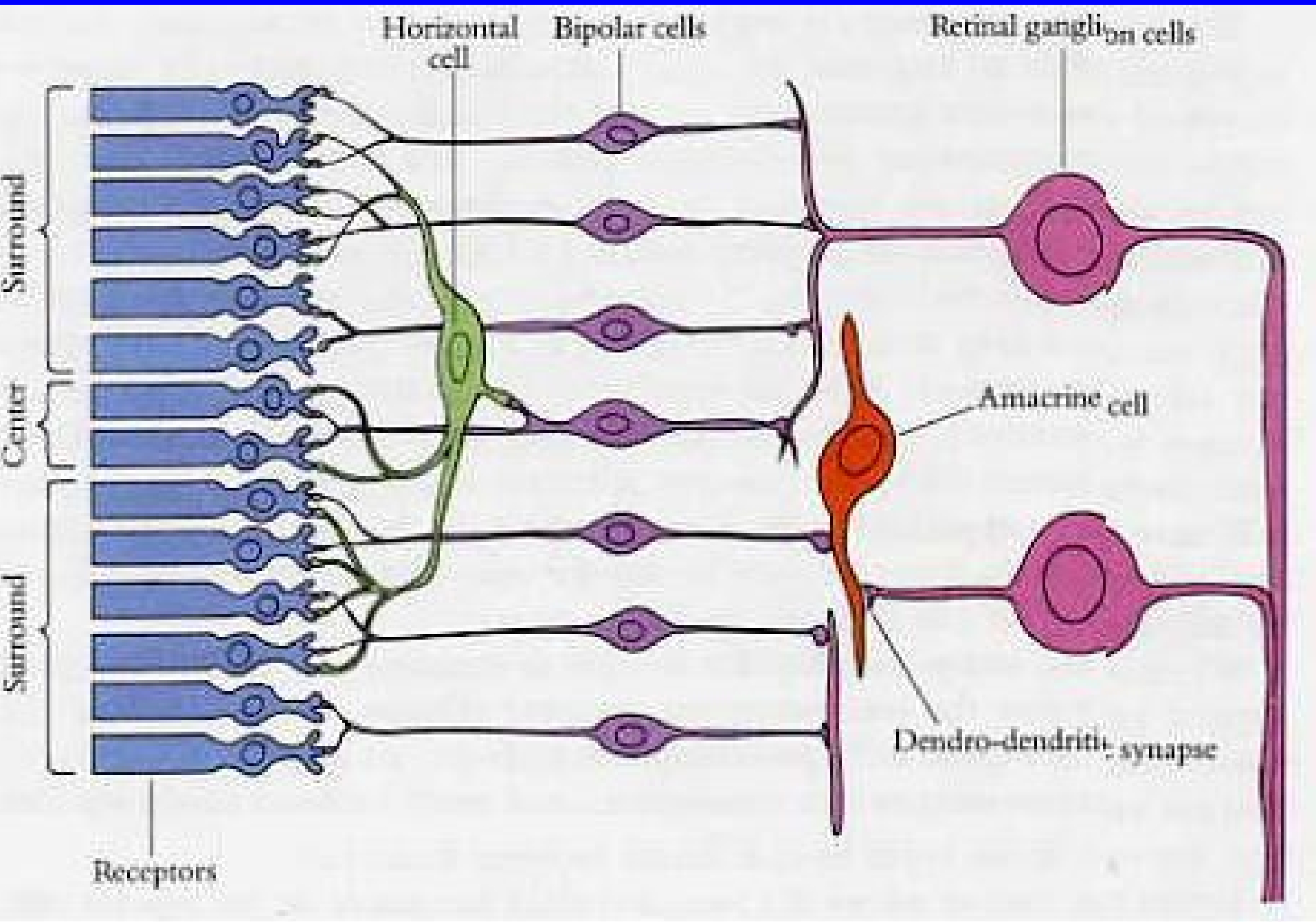


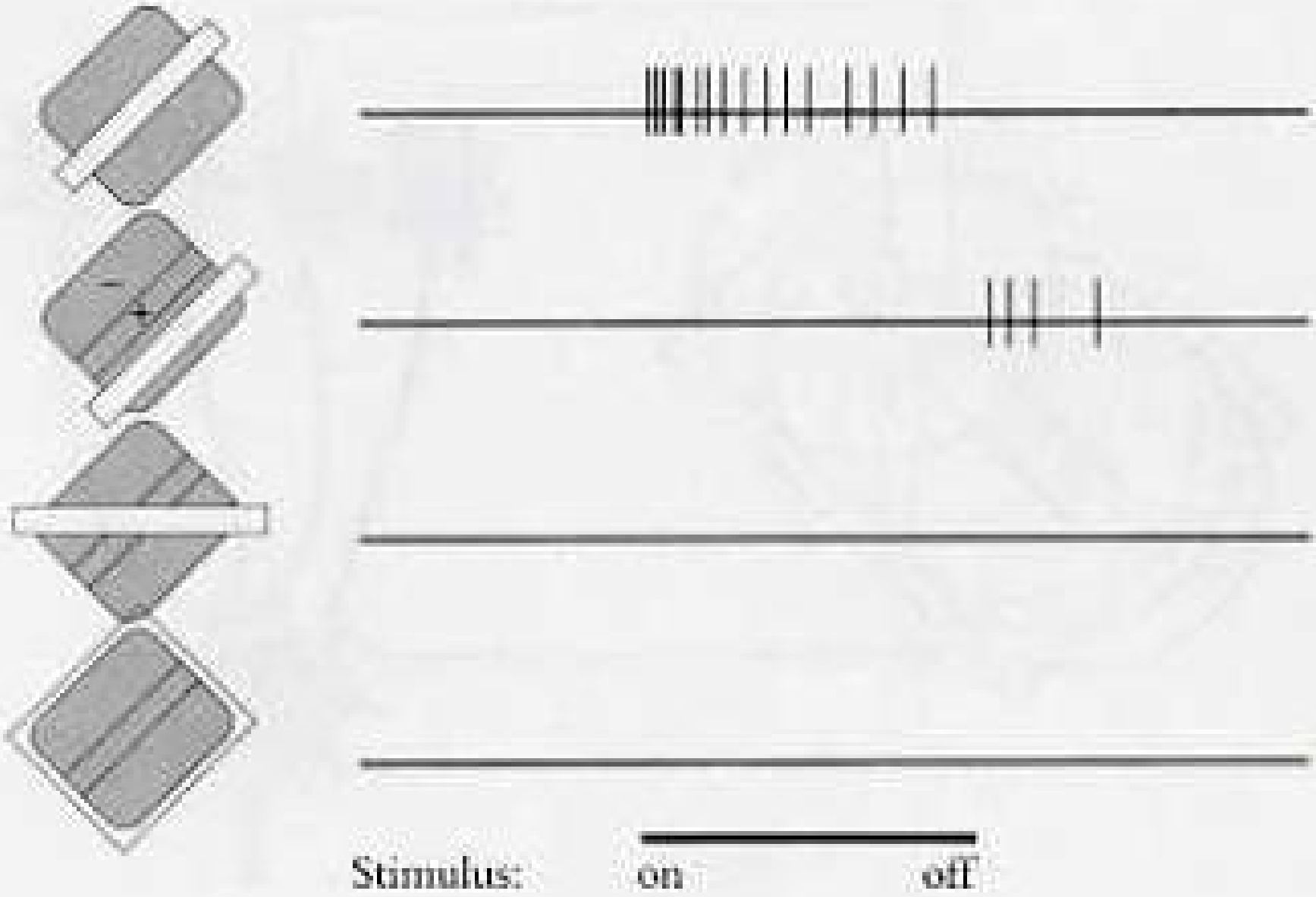


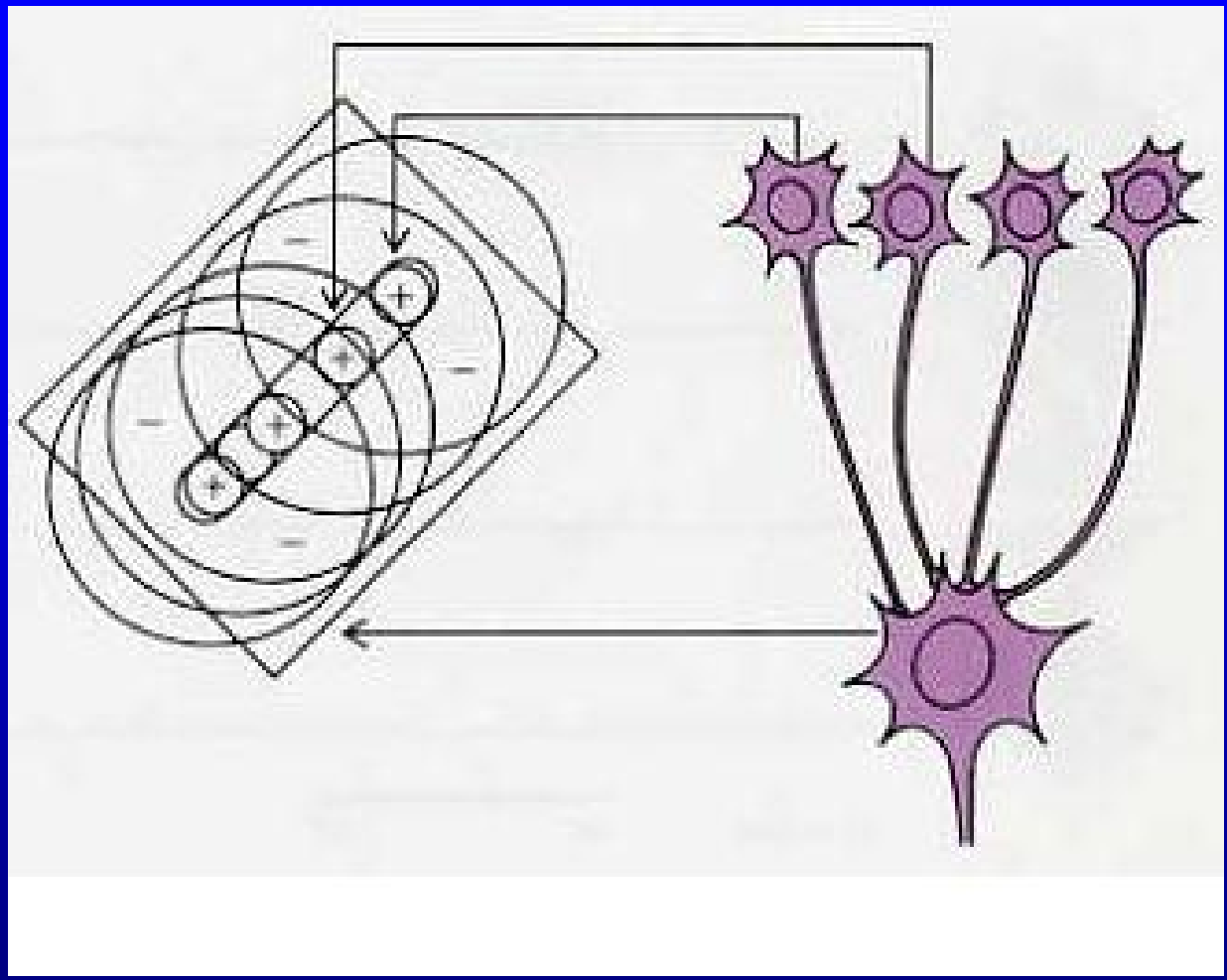
spatial density of cones


Choroid
C
R
R
C
H
B
B
B
A
A
G
G
G
Optic nerve

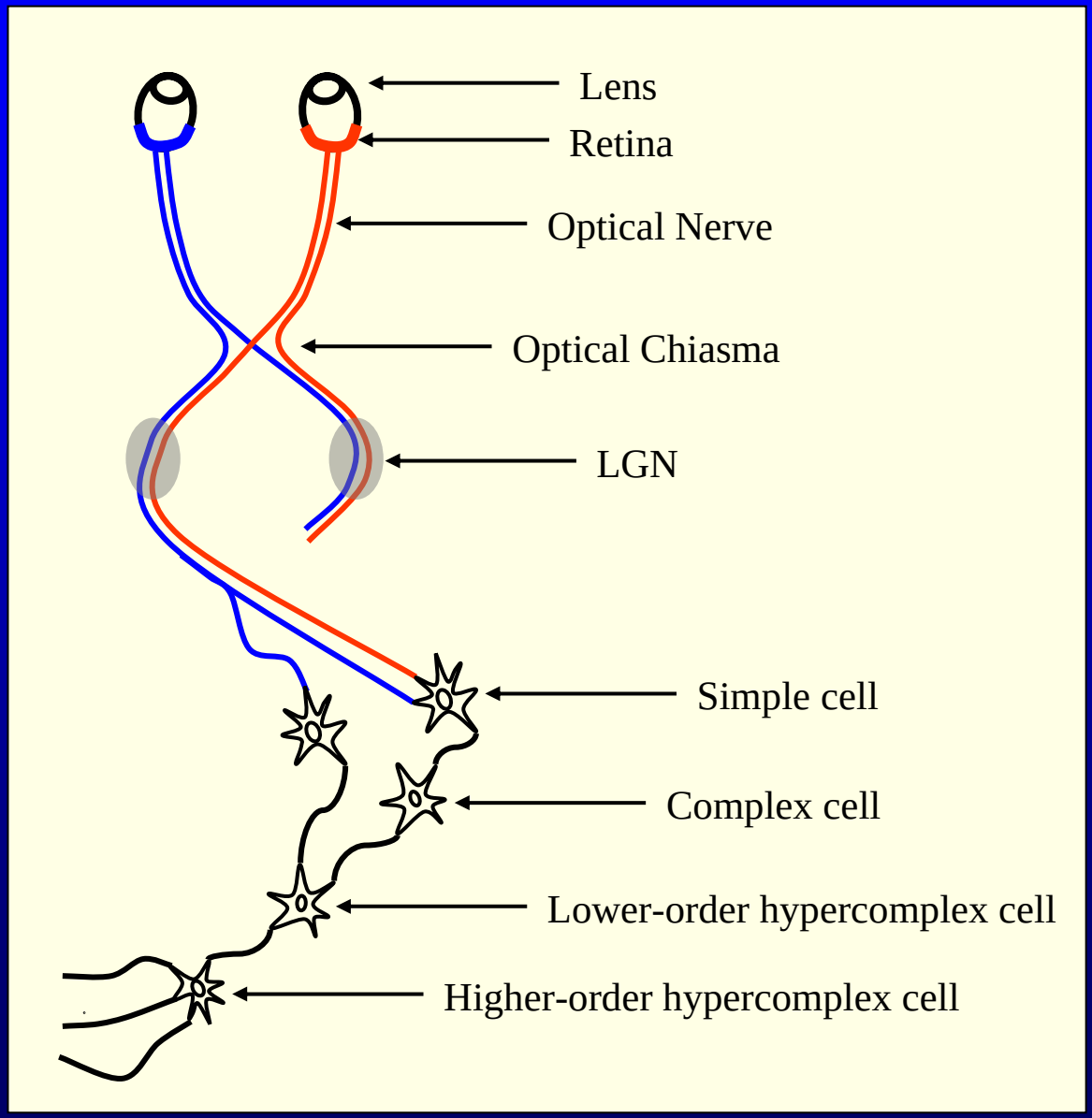



Horizontal cell
Bipolar cells
Retinal ganglion cells
Surround
Center
Surround
Amacrine cell
Dendro-dendritic synapse
Receptors

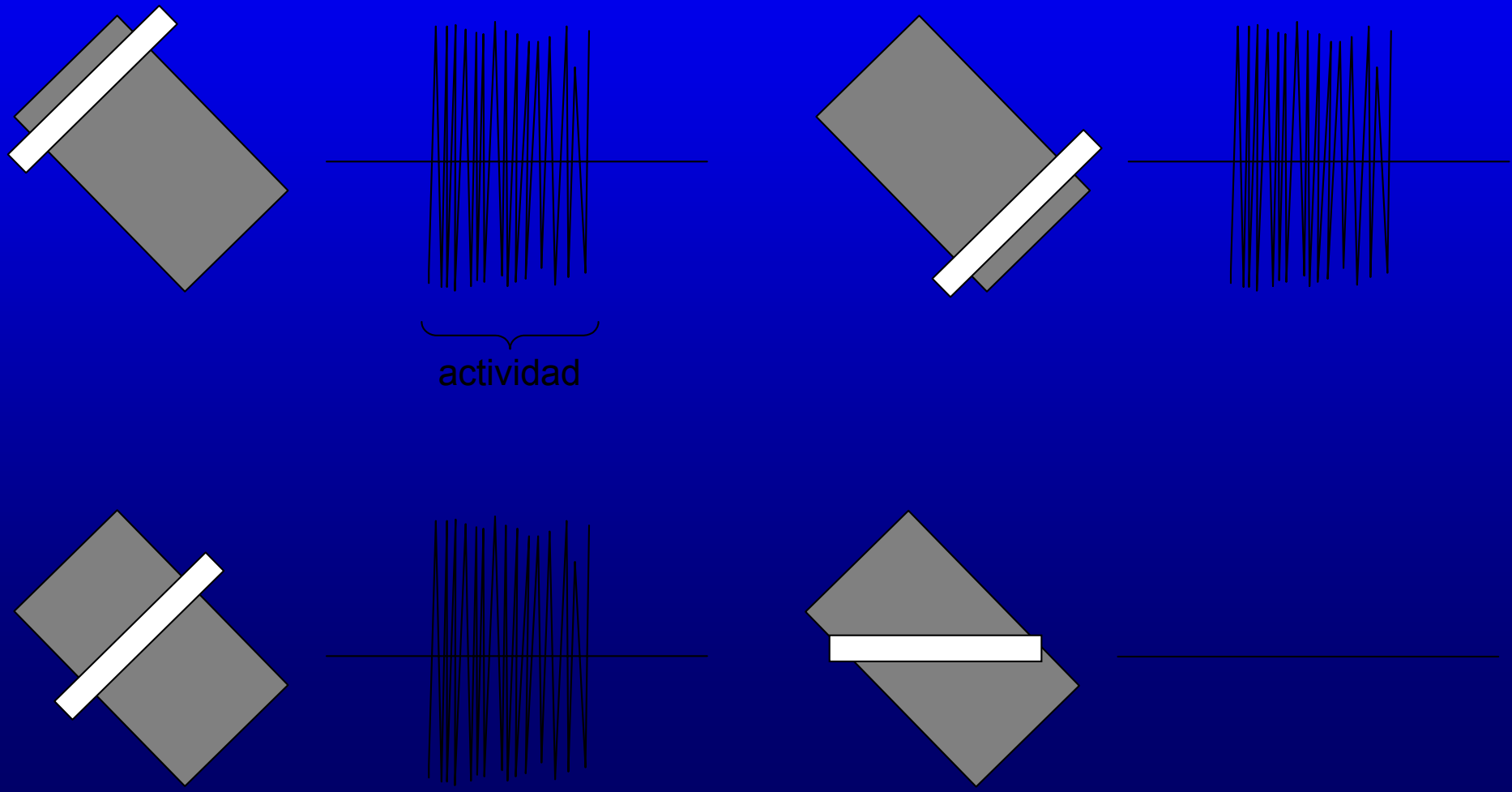

Stimulus:
on
off



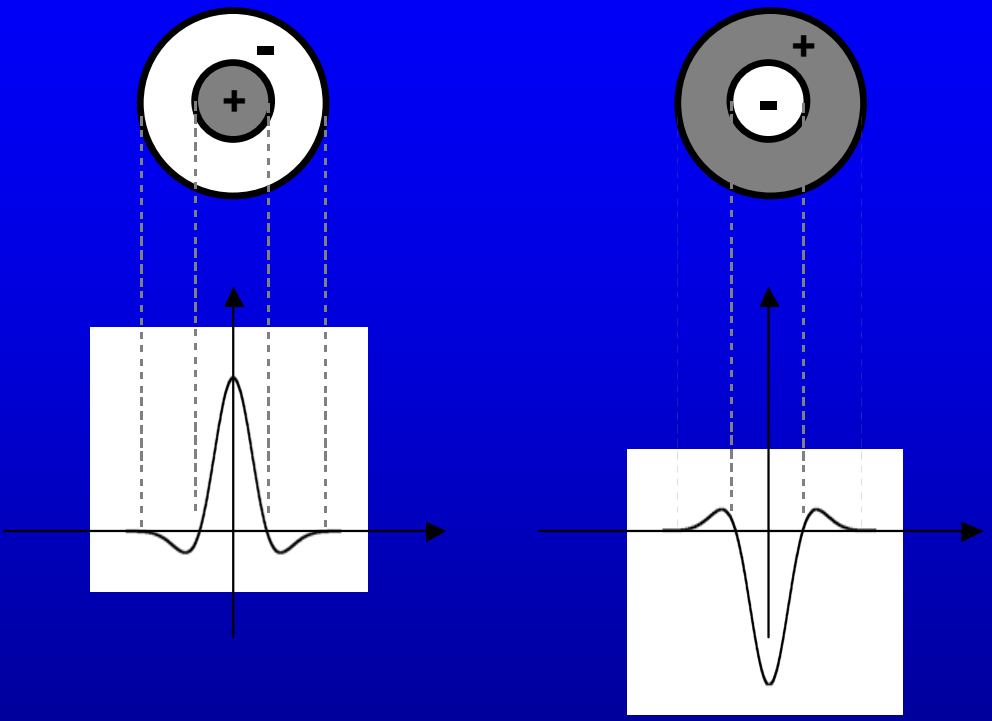
Introduction:Visual Path in Mammals

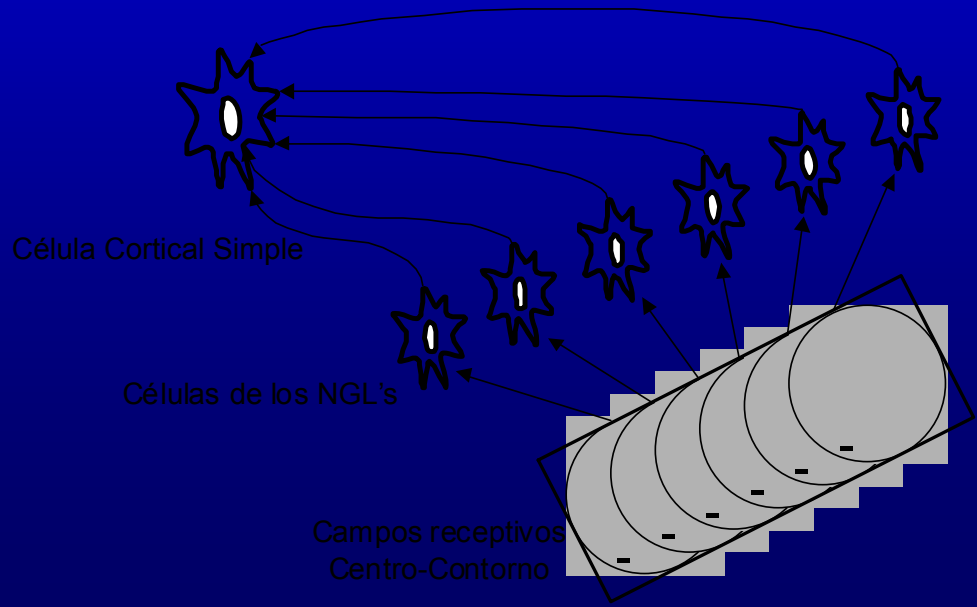


Introduction: Visual Cortex Receptive Field

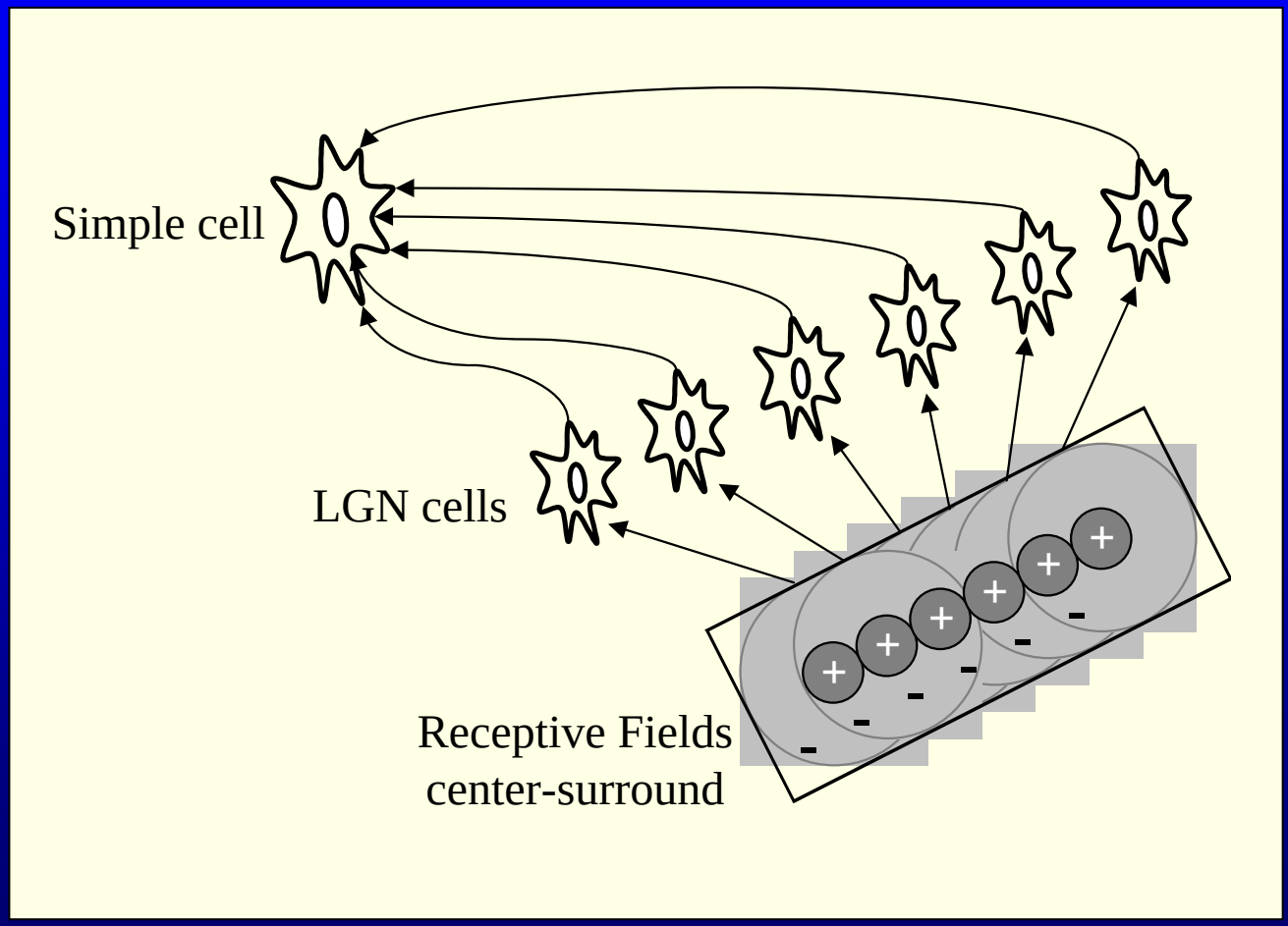


Introduction: Visual Path in Mammals

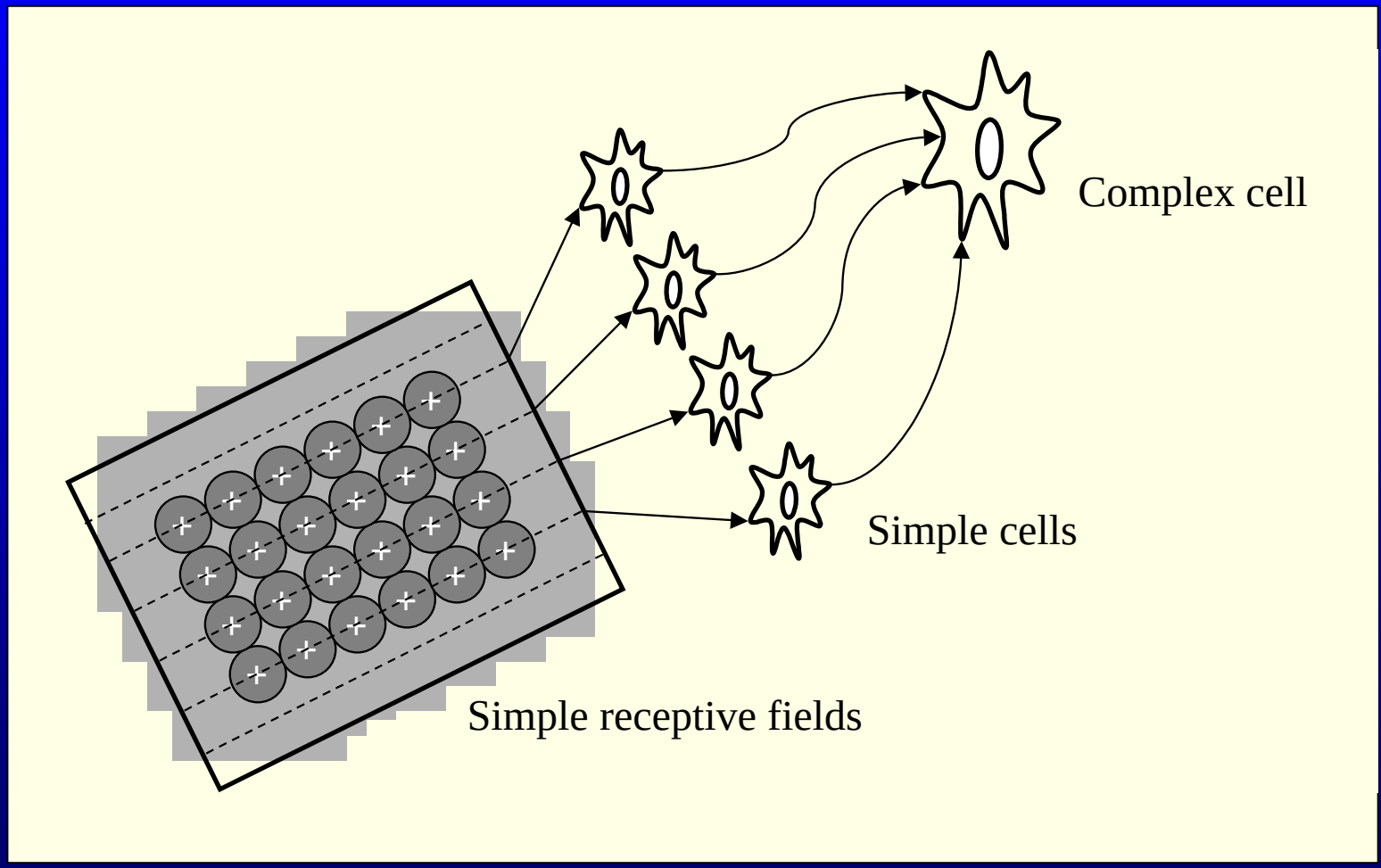




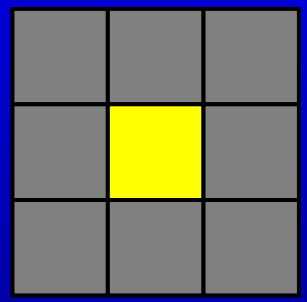
Introduction: Simple Cell Receptive Field



Introduction: Complex Cell Receptive Field

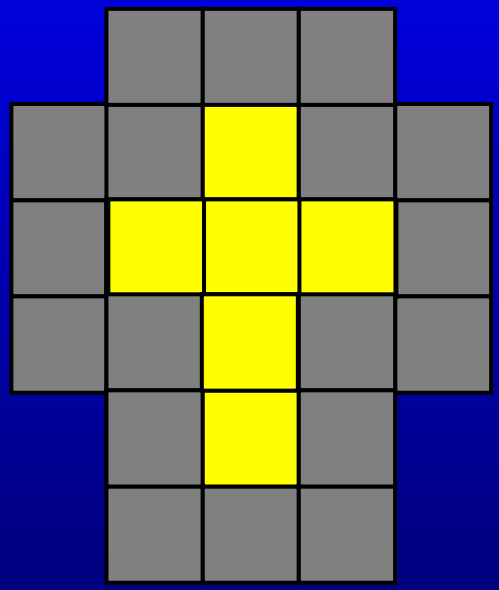


Introd.:Mathematical Representation of Receptives Fields Center-Surround



-1	-1	-1
-1	8	-1
-1	-1	-1

Introd.: “Cross” Detector using Center-Surround Receptives Fields



0	-1	-1	-1	0
-1	-3	5	-3	-1
-1	5	4	5	-1
-1	-4	4	-4	-1
0	-2	7	-2	0
0	-1	-1	-1	0

Complex Receptive Field

-1	-1	-1
-1	8	-1
-1	-1	-1

Simple Receptive Field

Introd.:Numeric example of correlation using the "Cross" detector

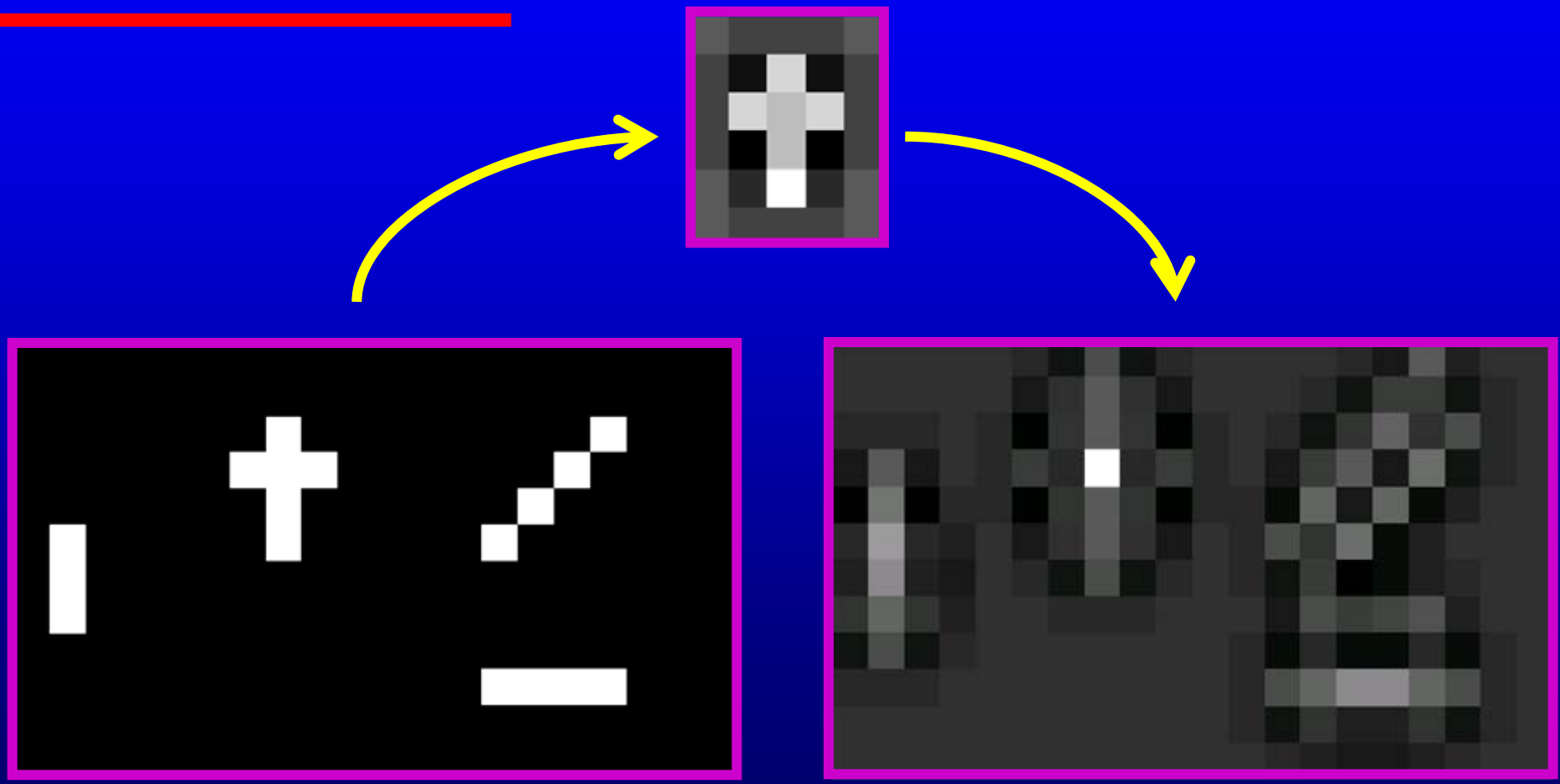
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0
0	0	0	1	0	0	1	1	1	0	0
0	0	0	1	0	0	0	1	0	0	0
0	0	0	1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0

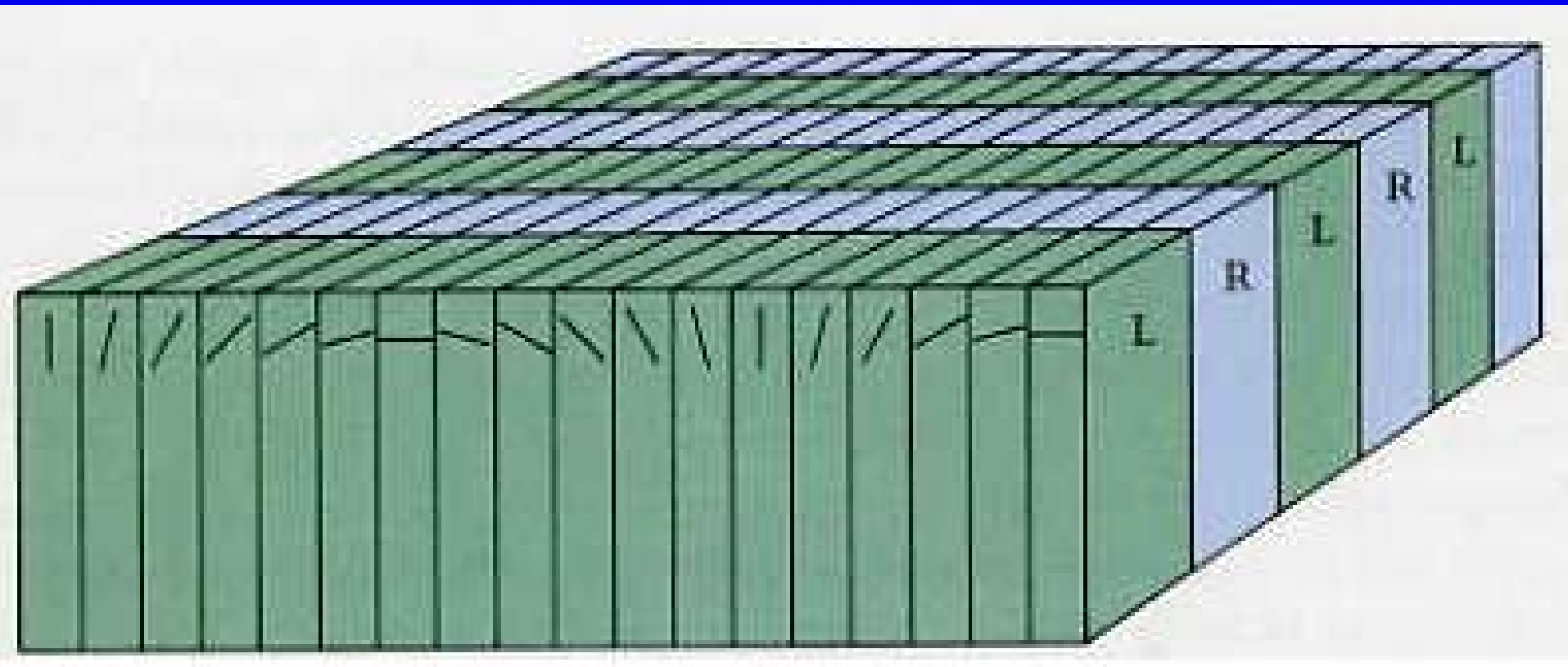
0	-1	-1	-1	0
-1	-3	5	-3	-1
-1	5	4	5	-1
-1	-4	4	-4	-1
0	-2	7	-2	0
0	-1	-1	-1	0

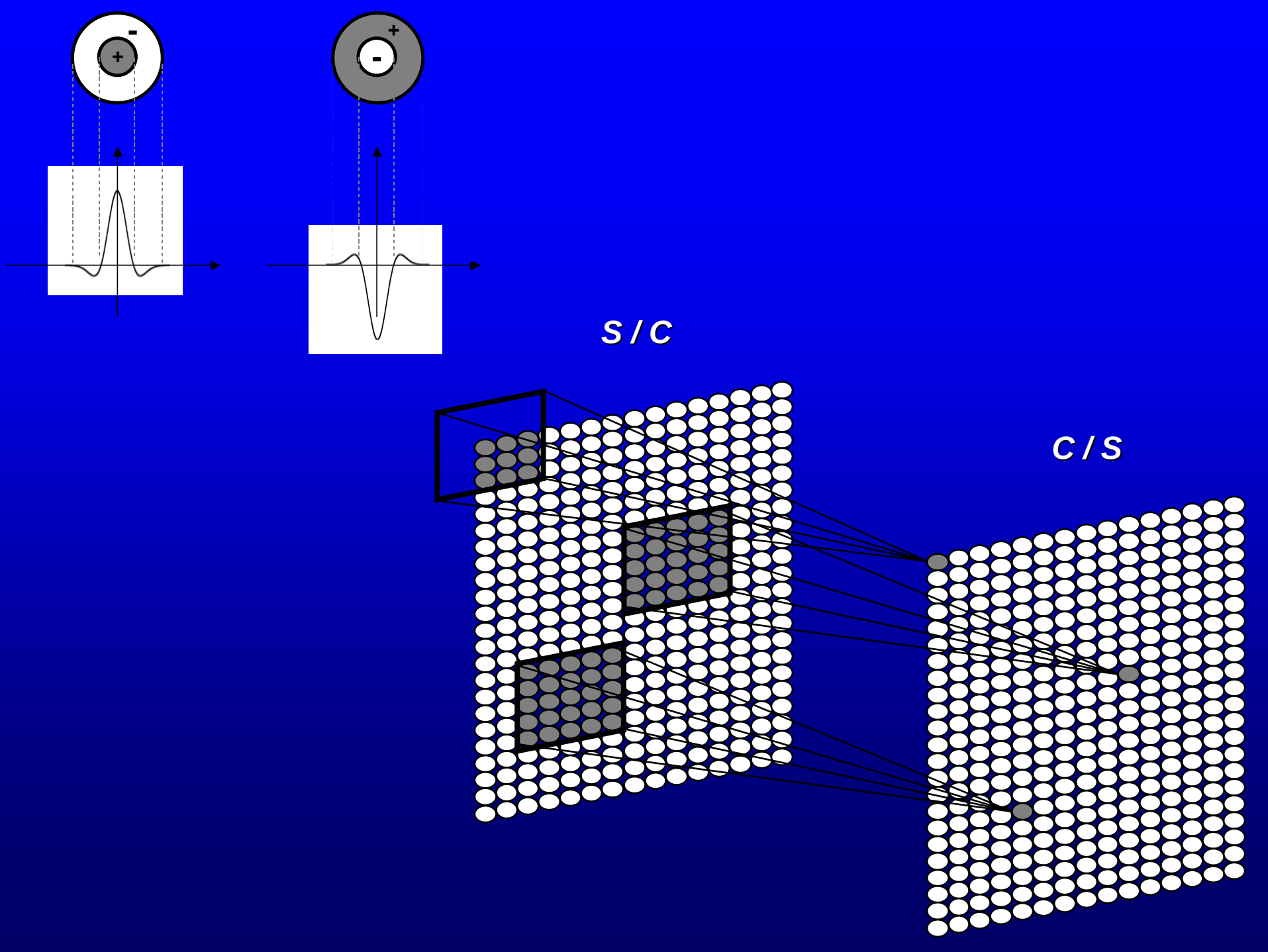
Maximum

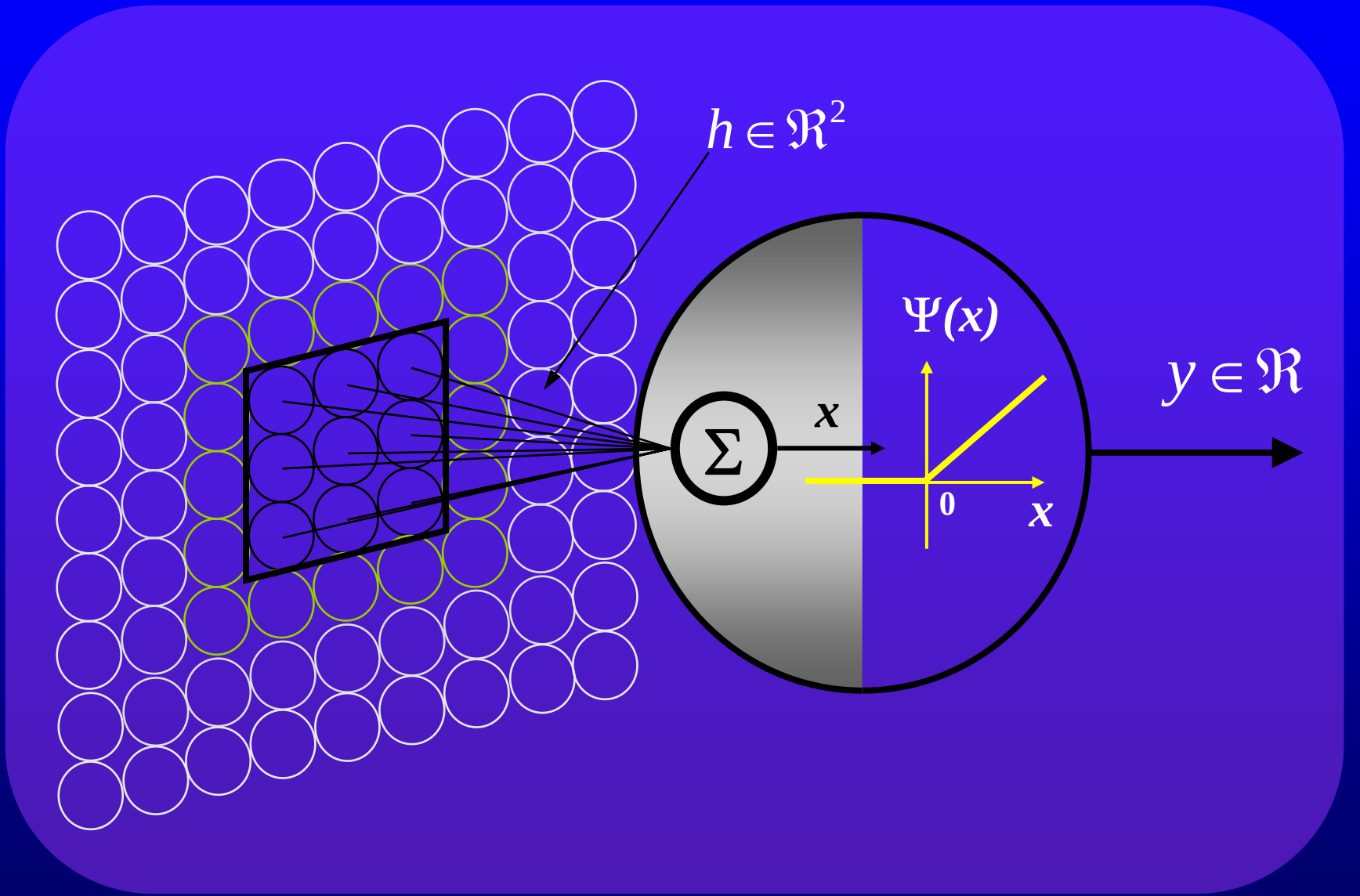
0	0	-3	6	-3	-1	-4	4	-4	-1	0
0	-1	-7	10	-7	-4	0	6	0	-3	0
0	-2	-2	14	-3	-8	1	6	1	-6	-1
0	-3	-4	20	-5	-1	-1	30	-1	2	-1
0	-3	-3	12	-4	-9	1	6	1	-6	-1
0	-2	1	8	1	-5	0	6	0	-3	0
0	-1	-4	4	-4	-2	-4	4	-4	-1	0

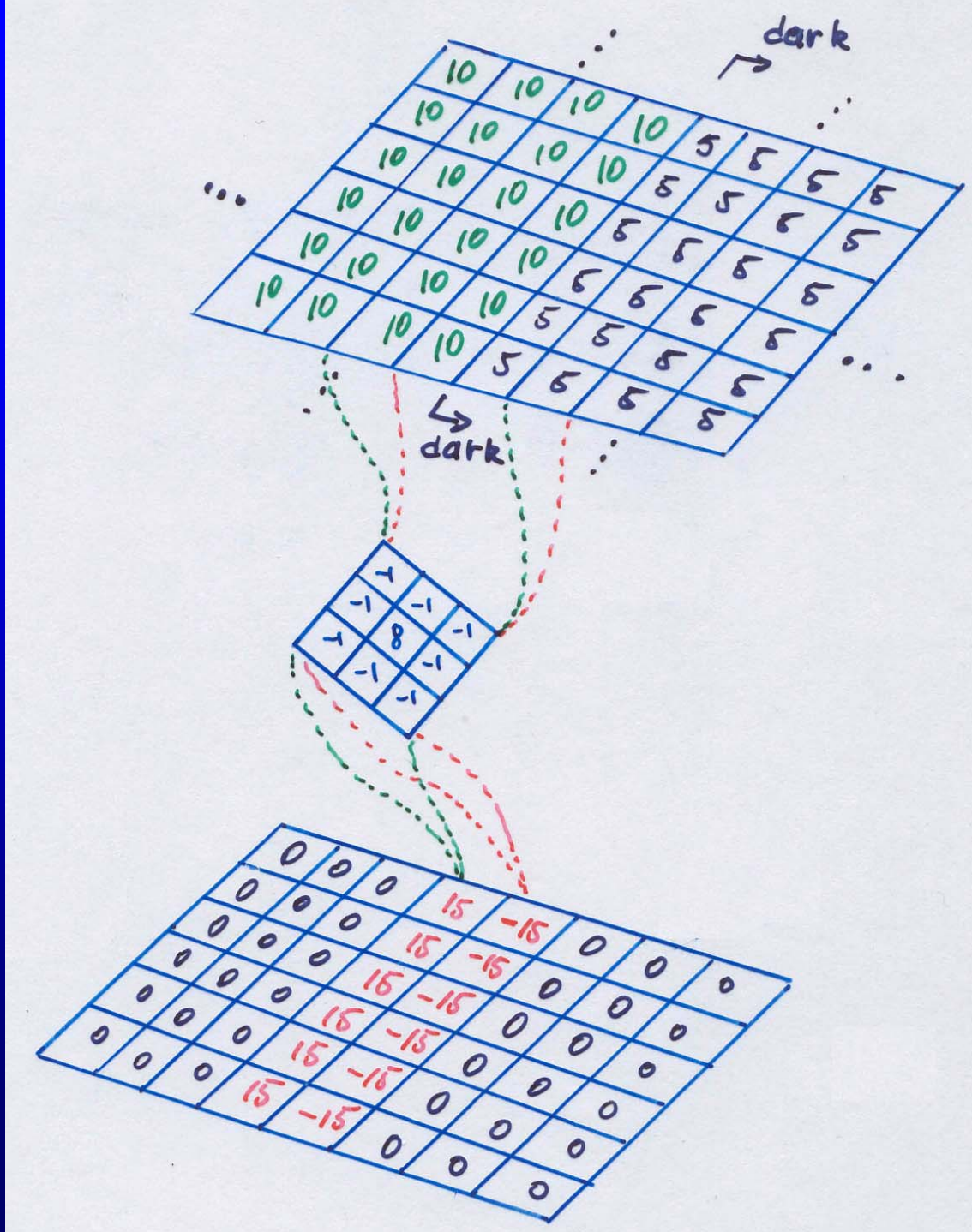
Introduction: “Cross” Detector



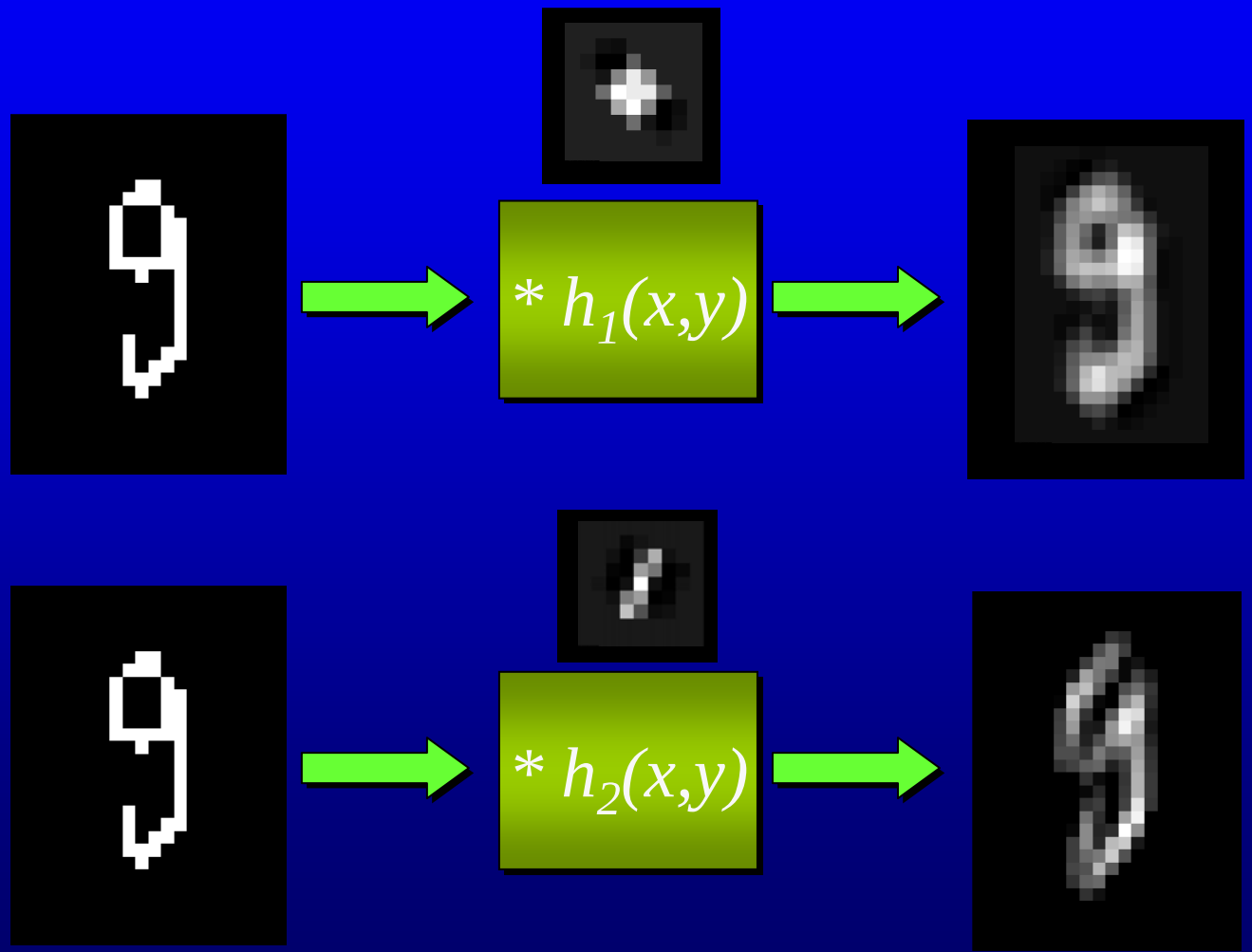

L
R
L
R
L


S / C
C / S

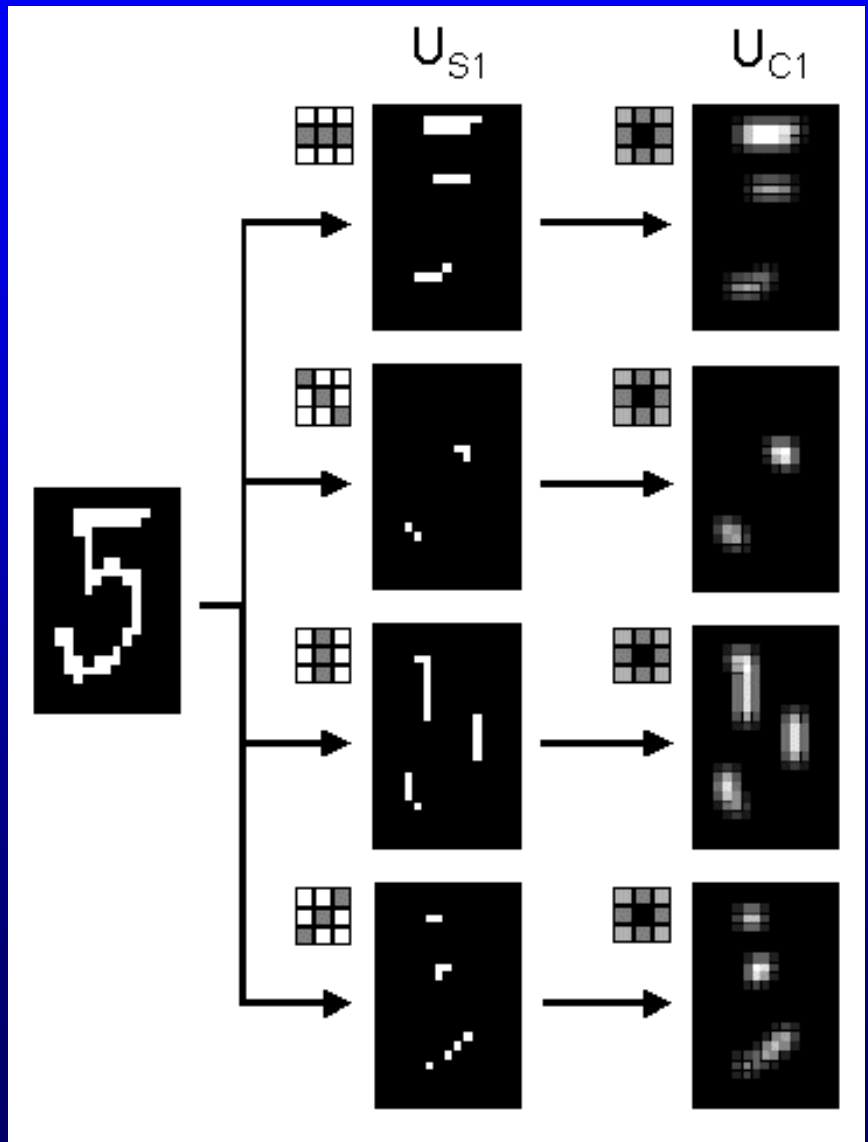

$h \in \Re^2$
$\Psi(x)$
$y \in \Re$
Σ
x
0
x

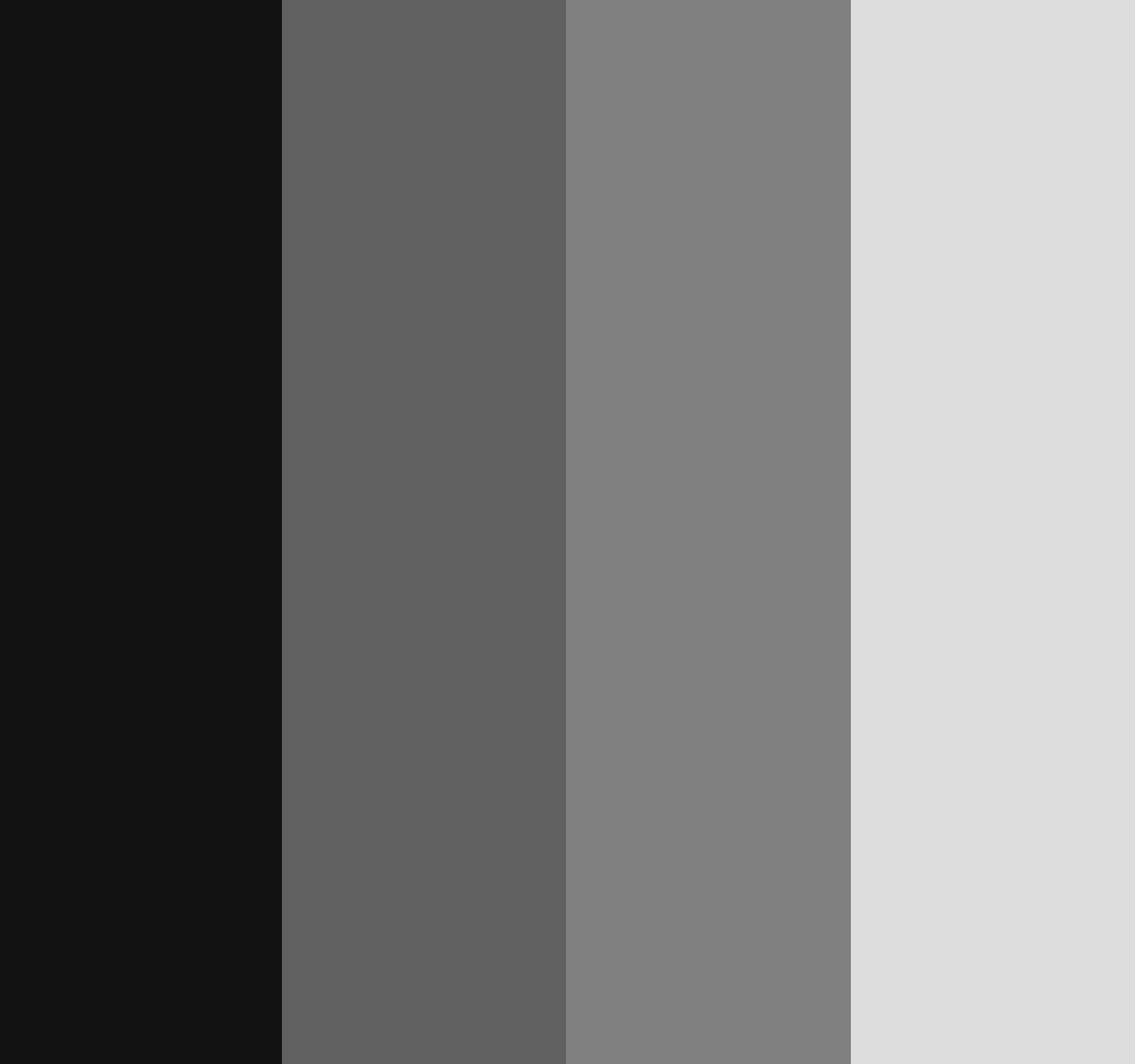

dark
dark

Receptive fields as filters



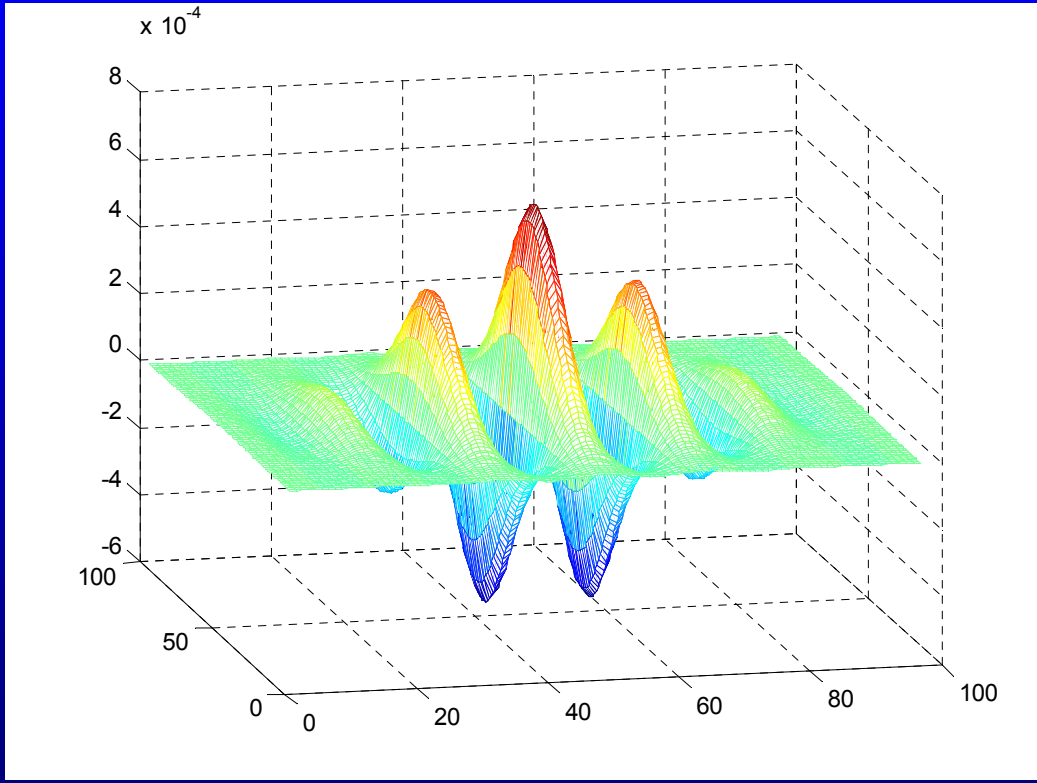
Introduction: Non-Linear Filters





Filtros Gabor

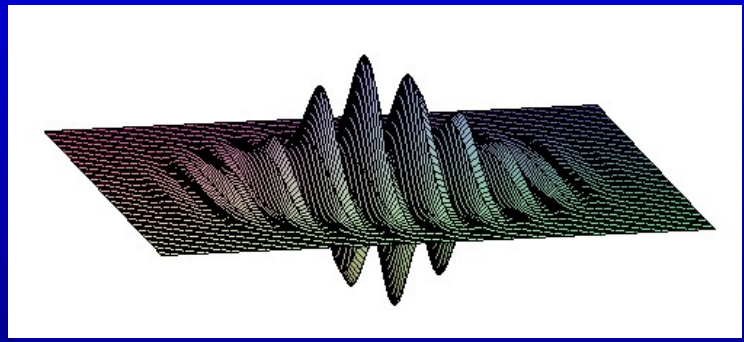
- Sinusoide modulada por una Gaussiana



$$h(x, y; \sigma, \omega_0, \phi) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{1}{2} \frac{x^2 + y^2}{\sigma^2} \right) \left[\exp\left(j\omega_0 \left(x\cos\phi + y\sin\phi \right) \right) \right]$$

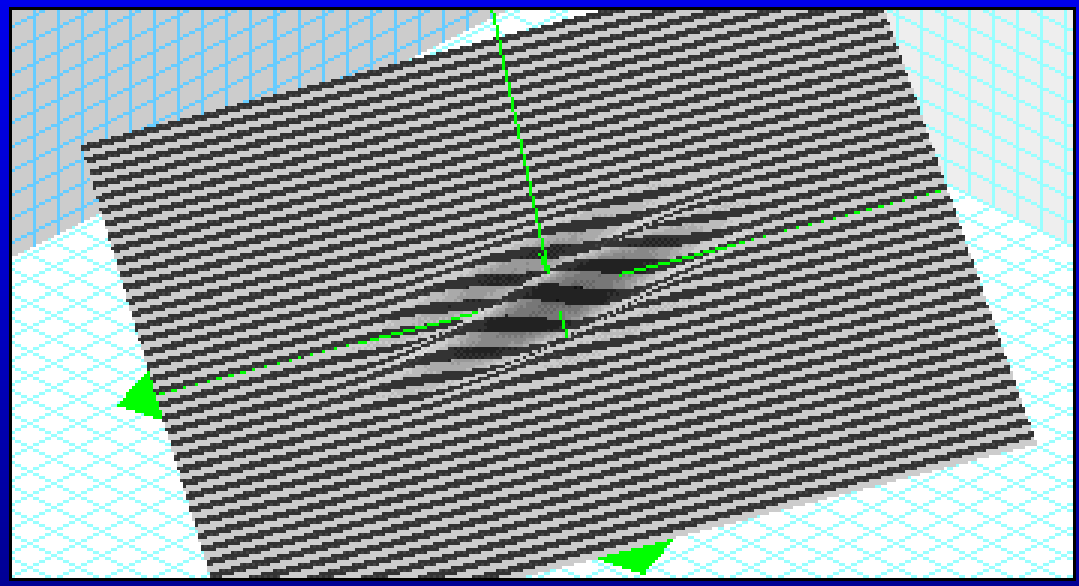
Wavelet Gabor

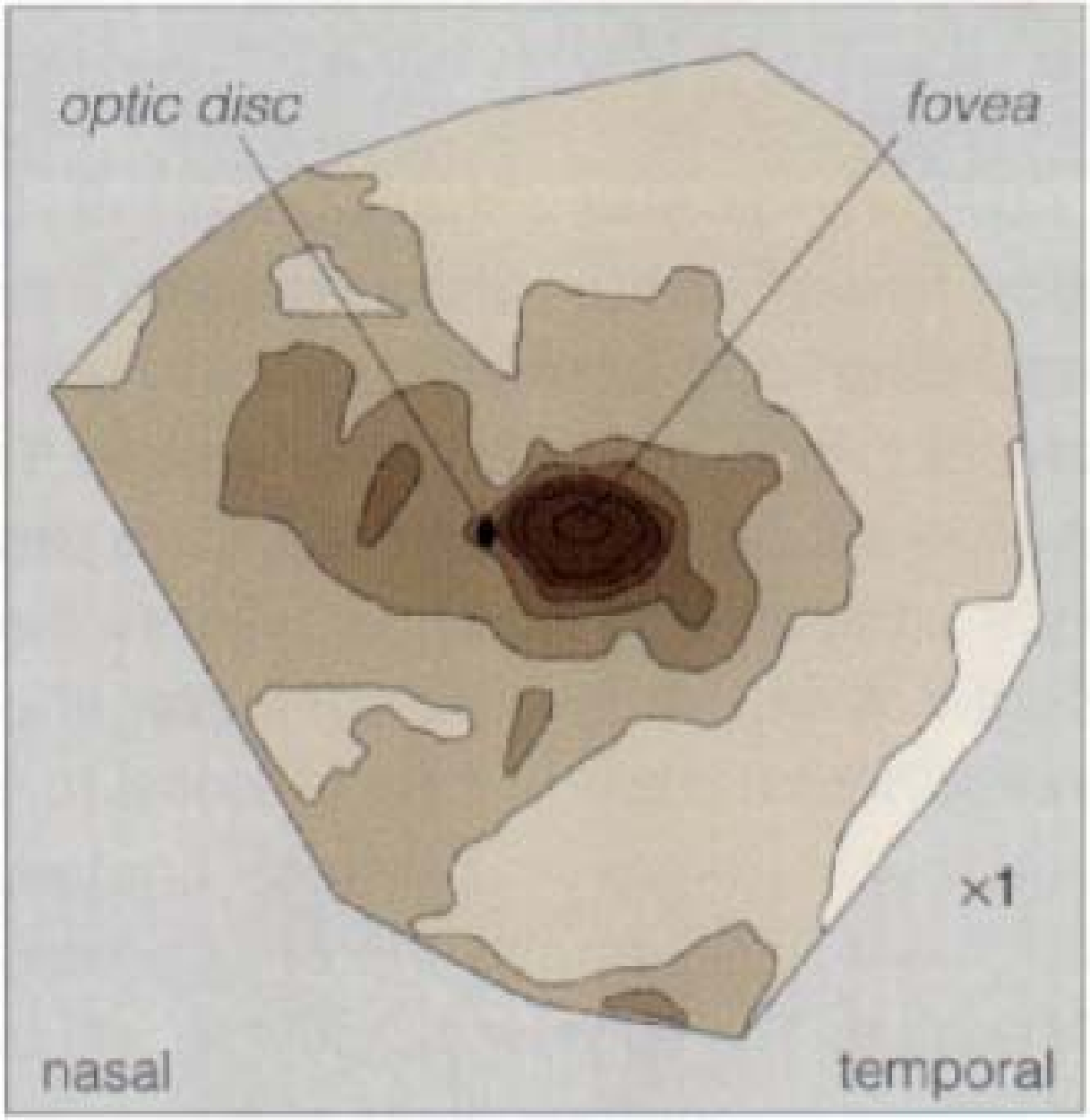
- Gabor Jet: Conjunto de funciones Gabor 2-D complejas que coinciden en posición y longitud de onda (λ), pero difieren en orientación

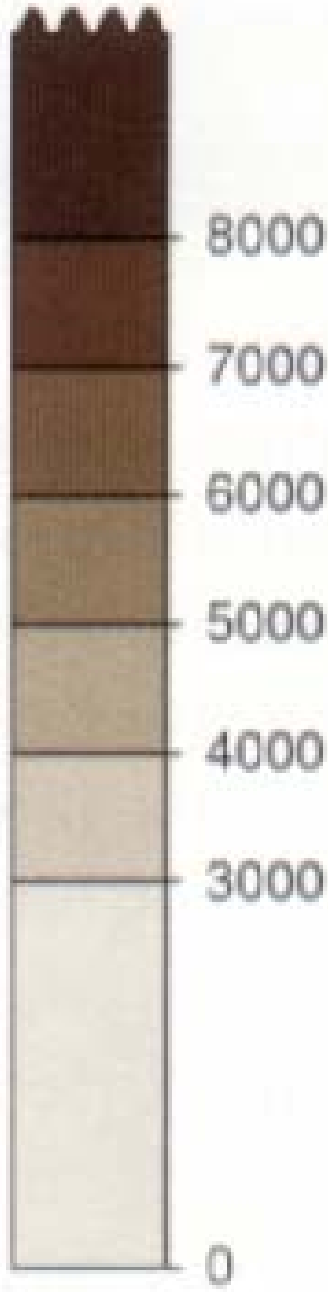


$$h(x, y; \sigma, \omega_0, \phi) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{1}{2} \frac{x^2 + y^2}{\sigma^2} \right) \cos\left(\omega_0 \left(x \cos\phi + y \sin\phi\right)\right)$$

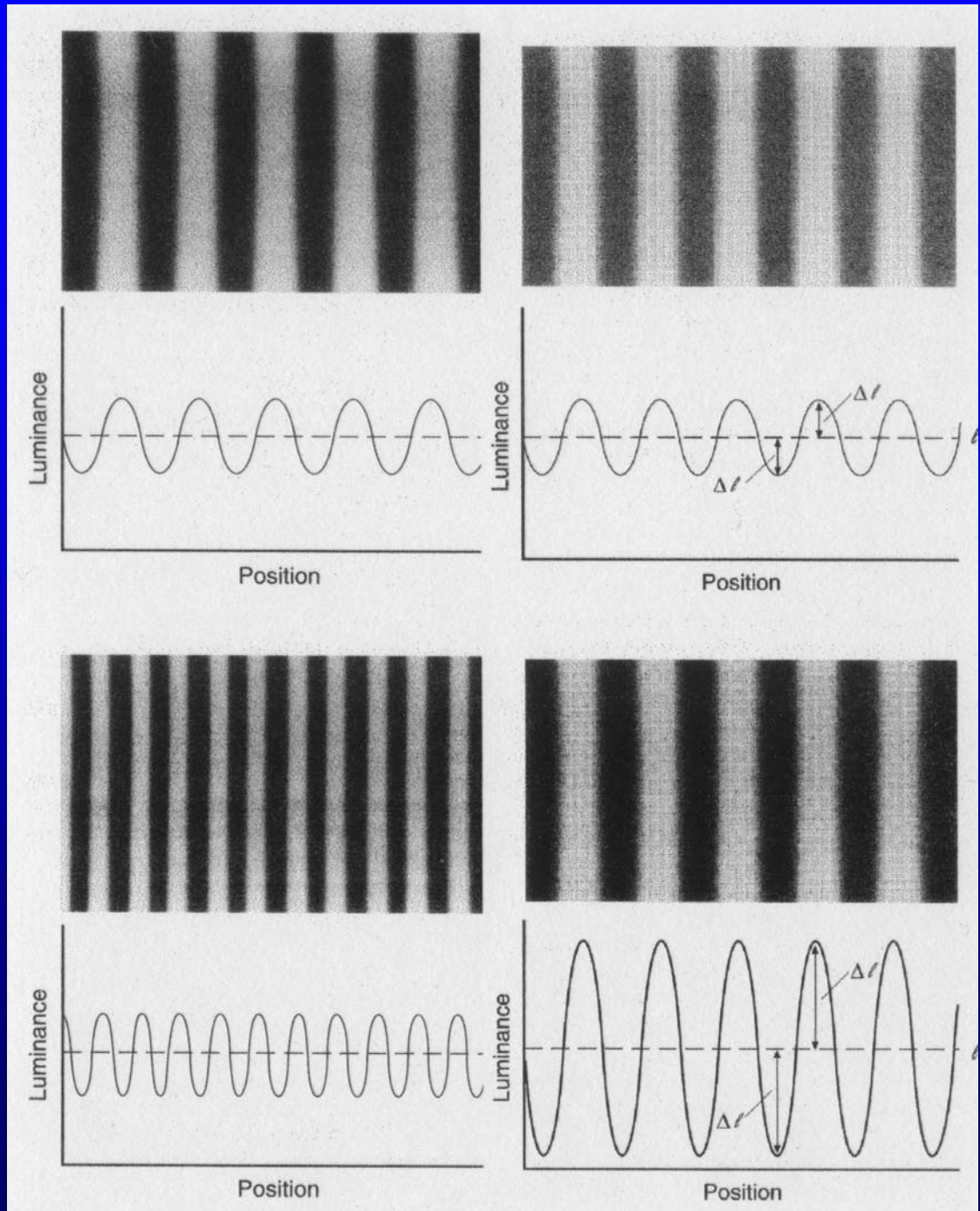
Oriented Filters are steerable

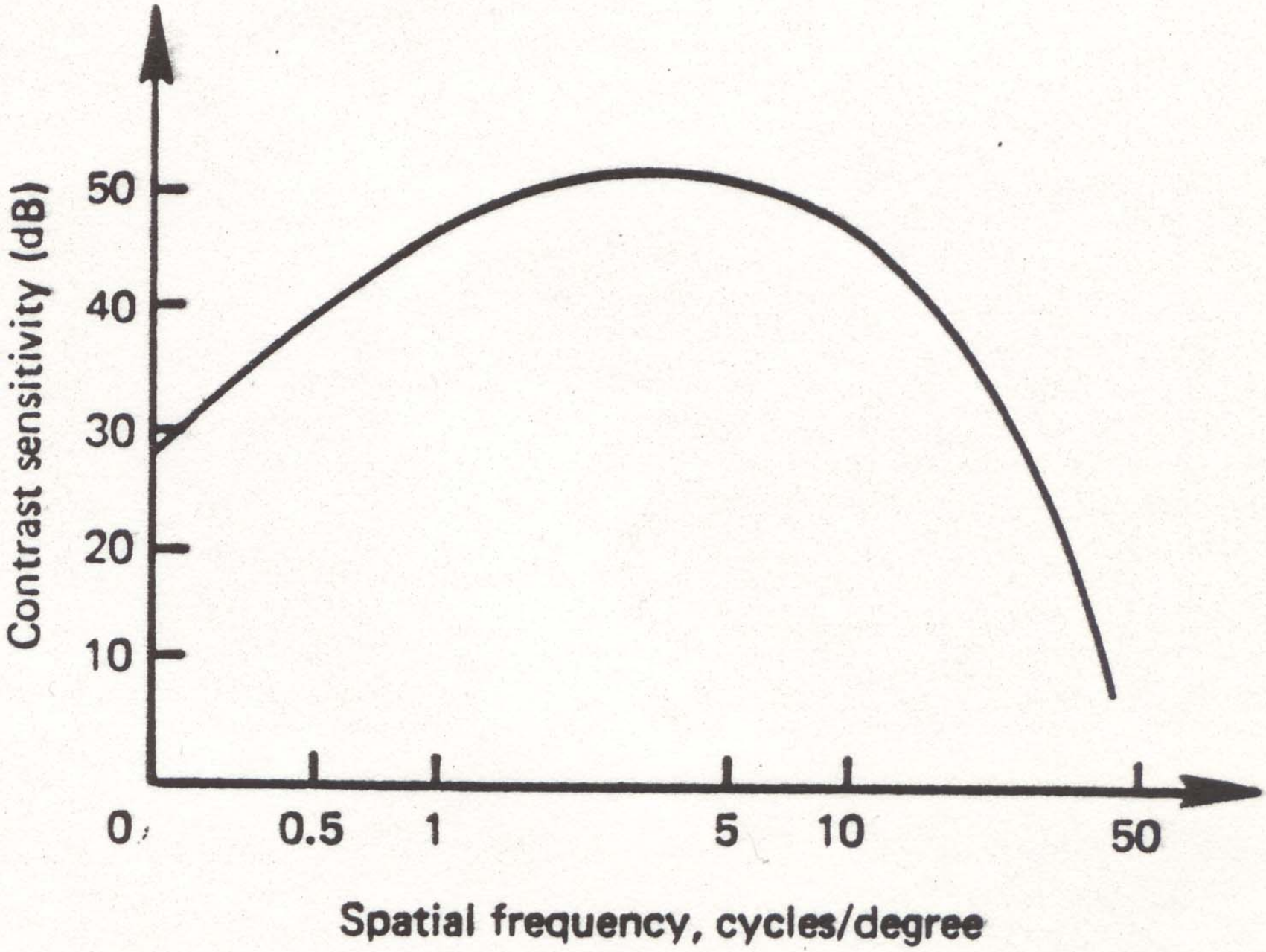




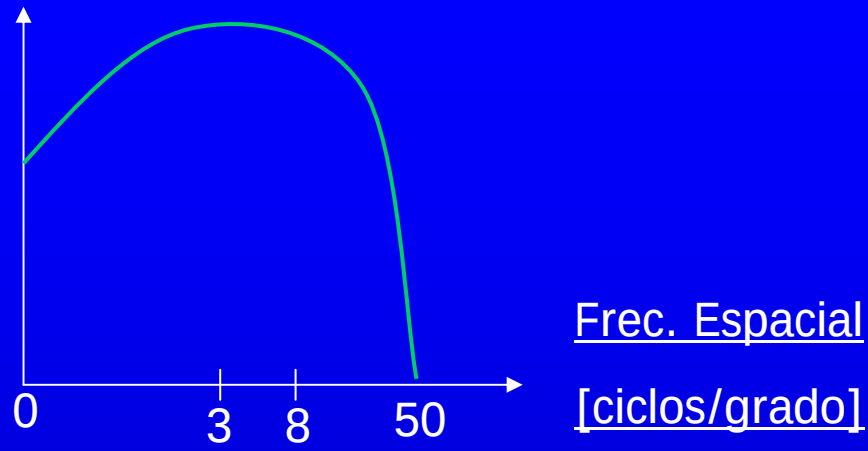


spatial density of cones

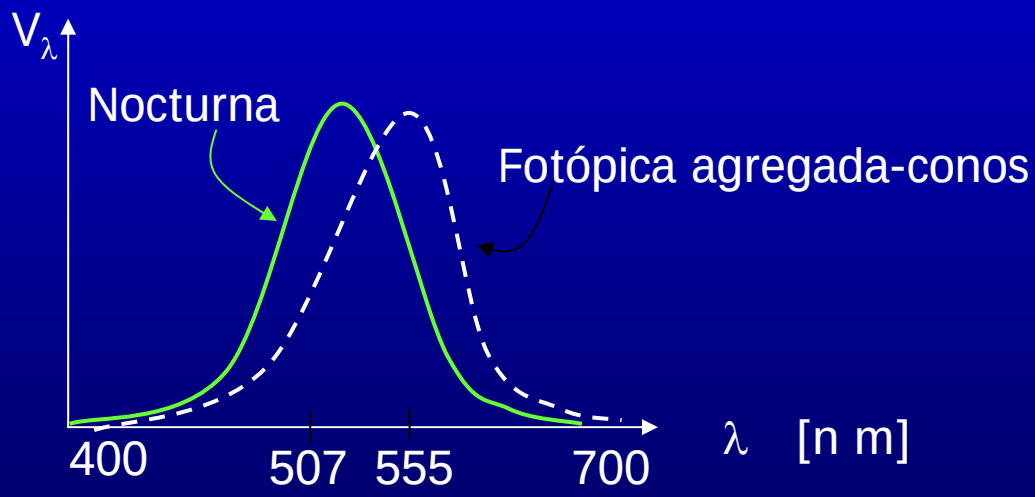

Luminance
Position
Luminance
Position
Luminance
Position
Luminance
Position


Contrast sensitivity (dB)
50
40
30
20
10
0
0.5
1
5
10
50
Spatial frequency, cycles/degree

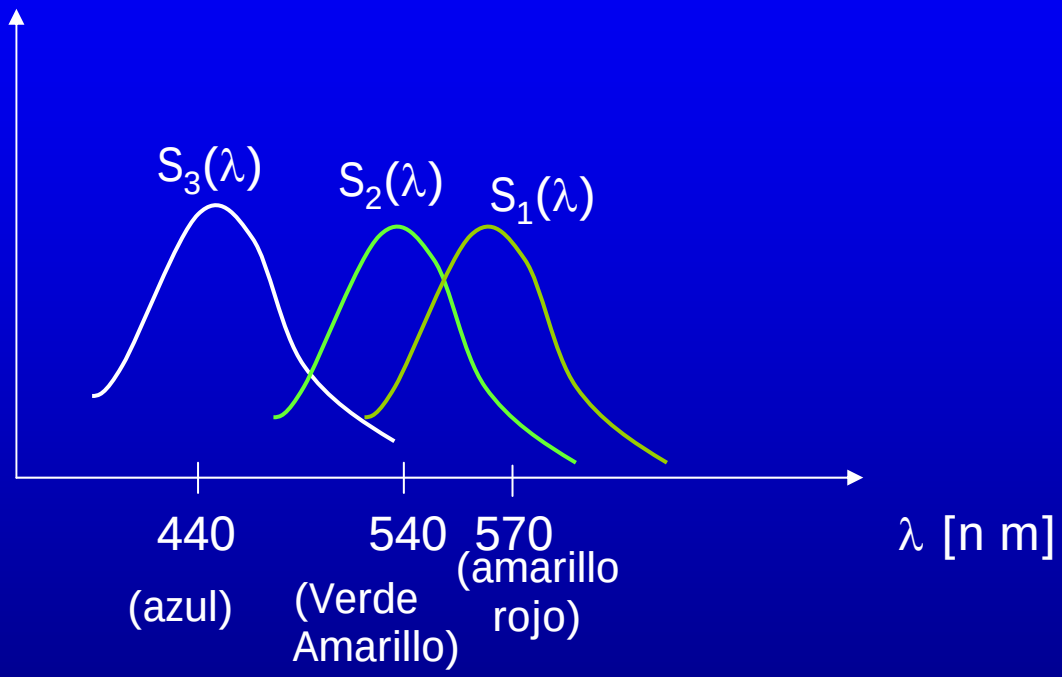
- Sensibilidad al Contraste

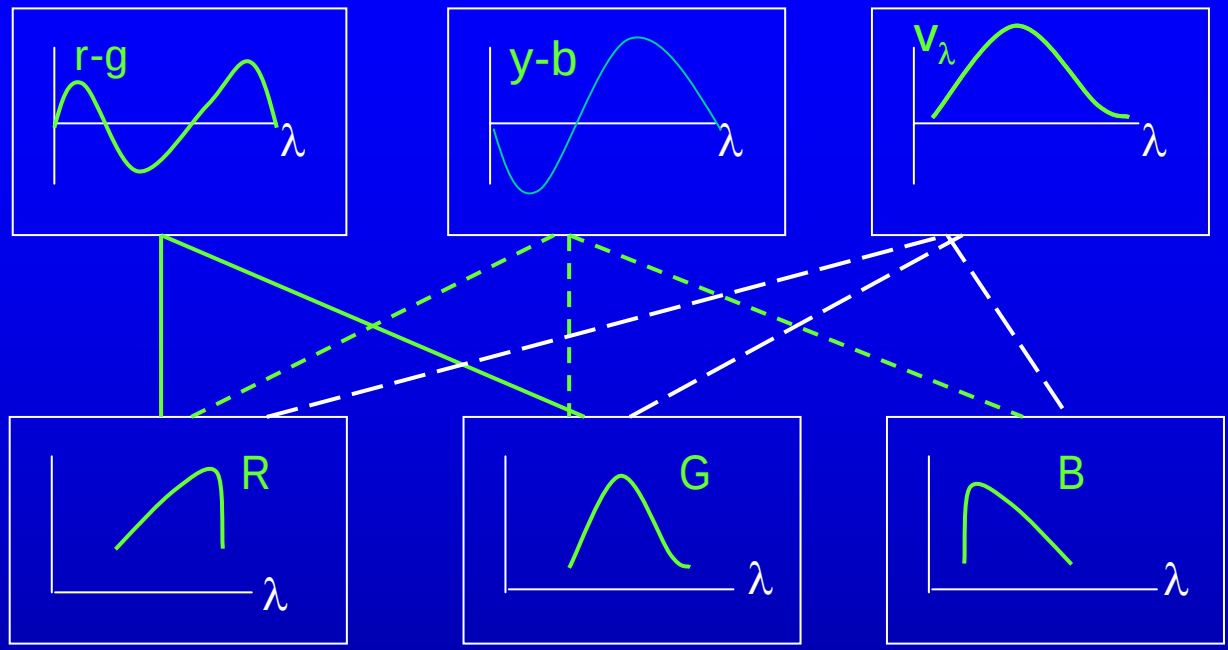


- Función eficiencia luminosa relativa

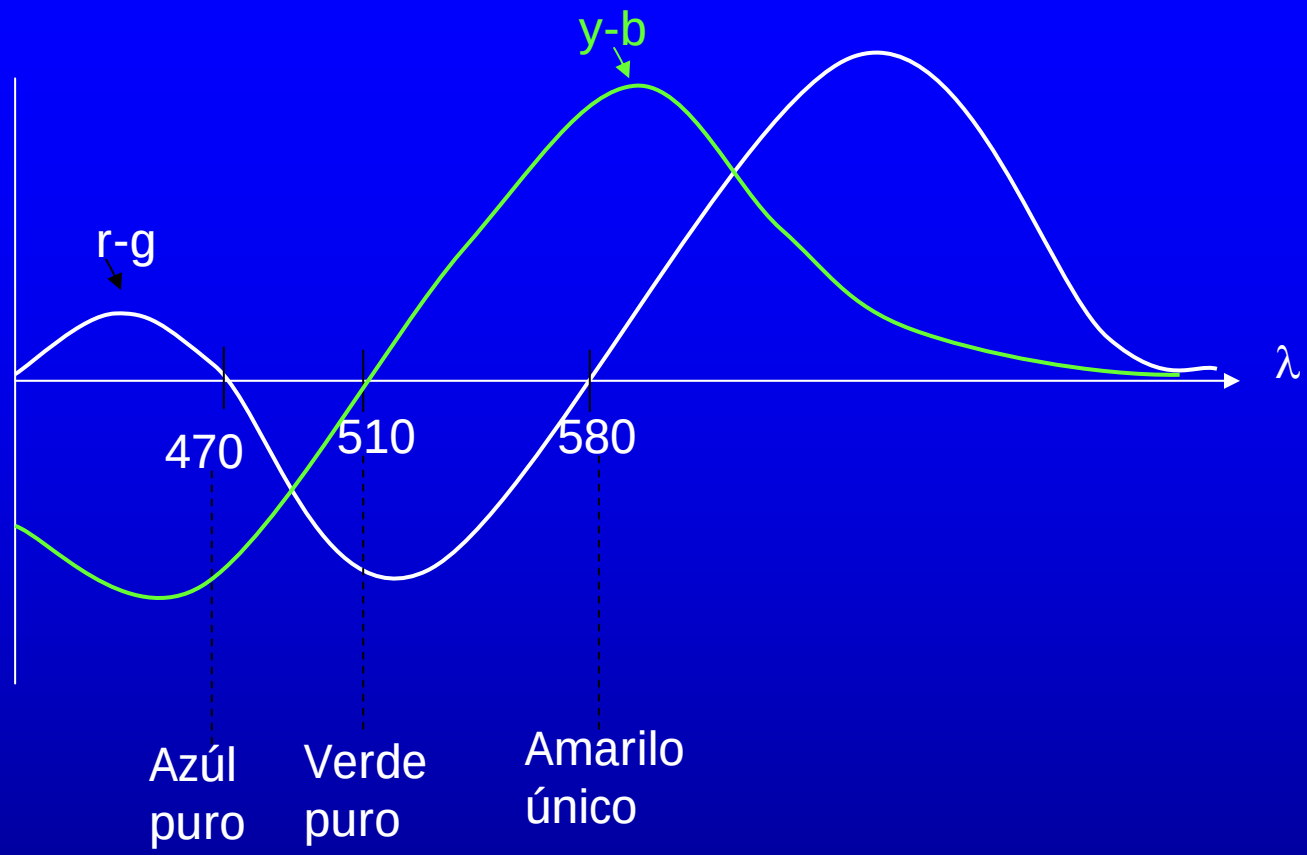


- Sensibilidad - Conos

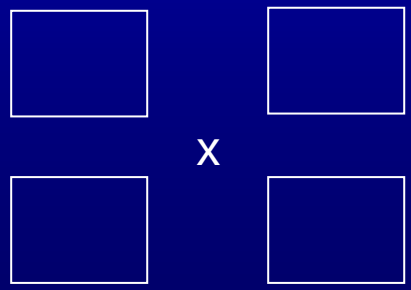


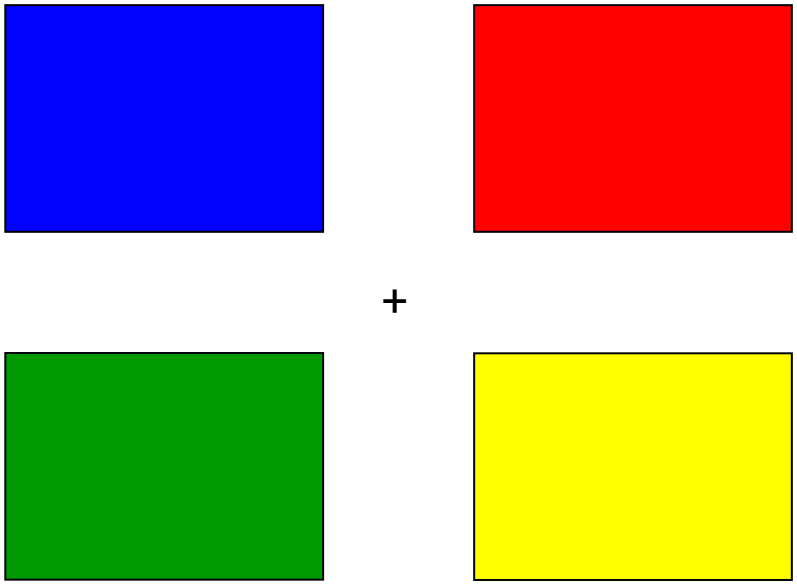


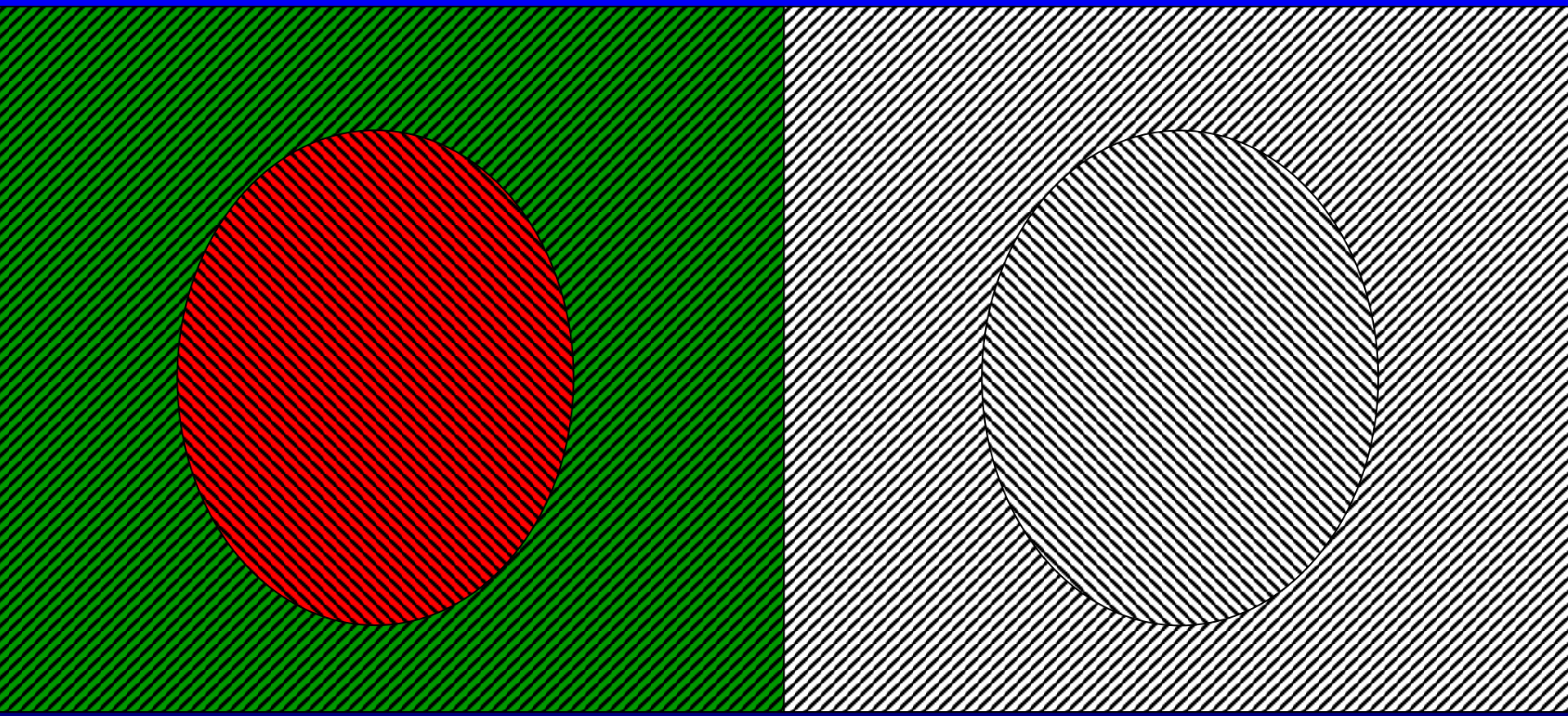
$$\begin{bmatrix} r-g \\ y-b \\ v_\lambda \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$



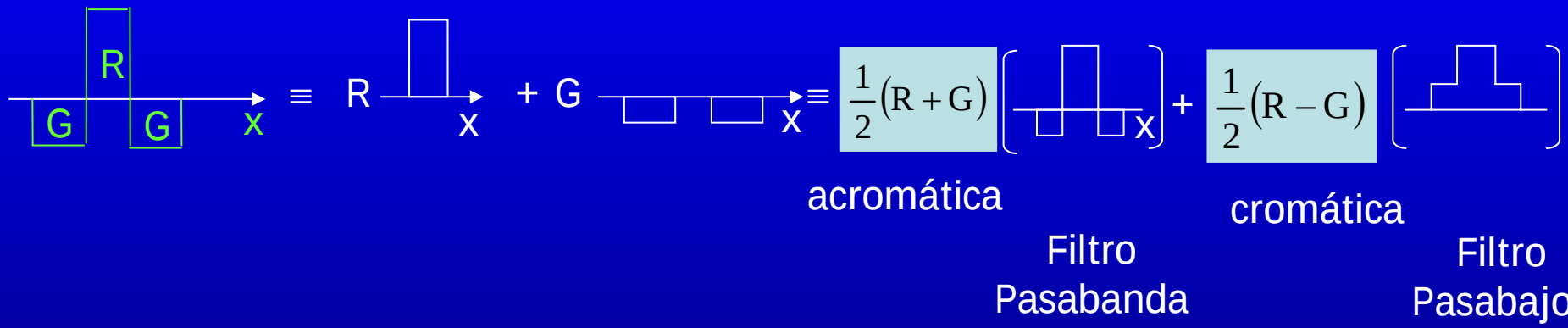
- Experimento







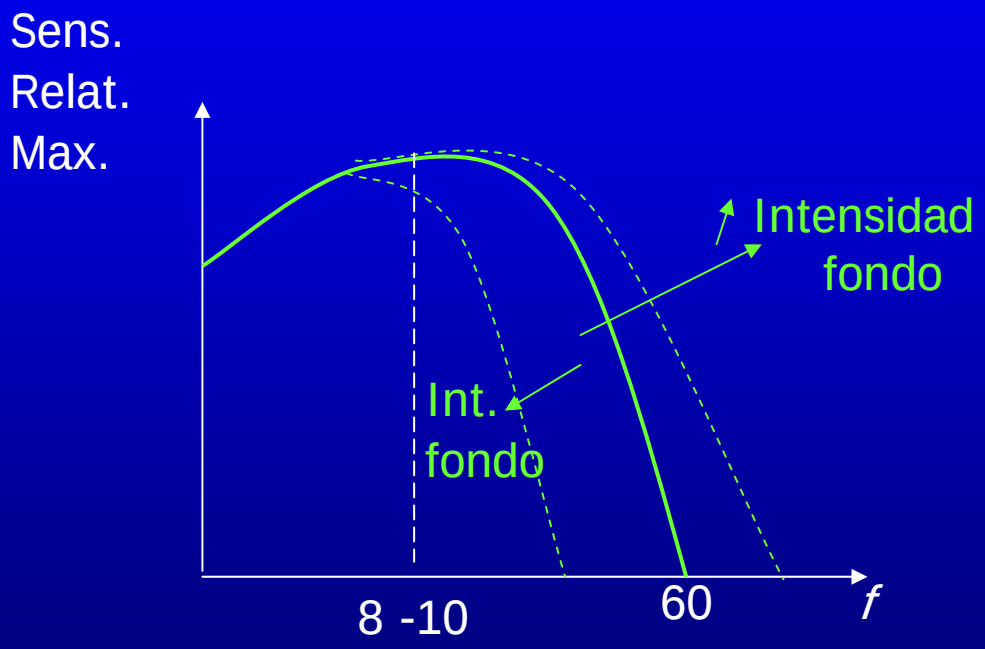
- Descomposición campo receptivo

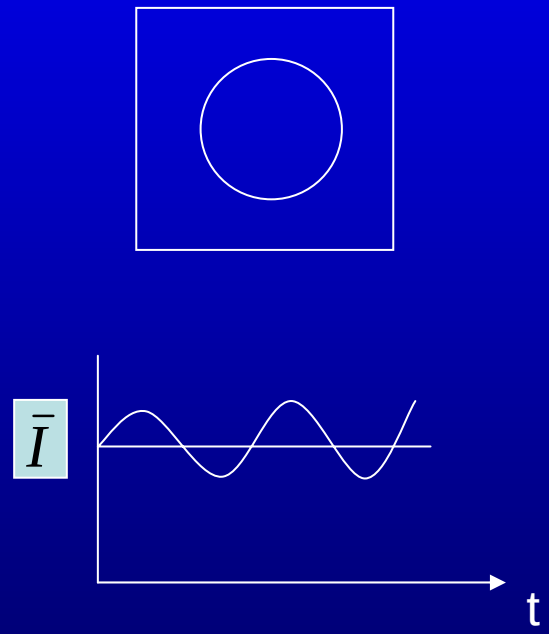


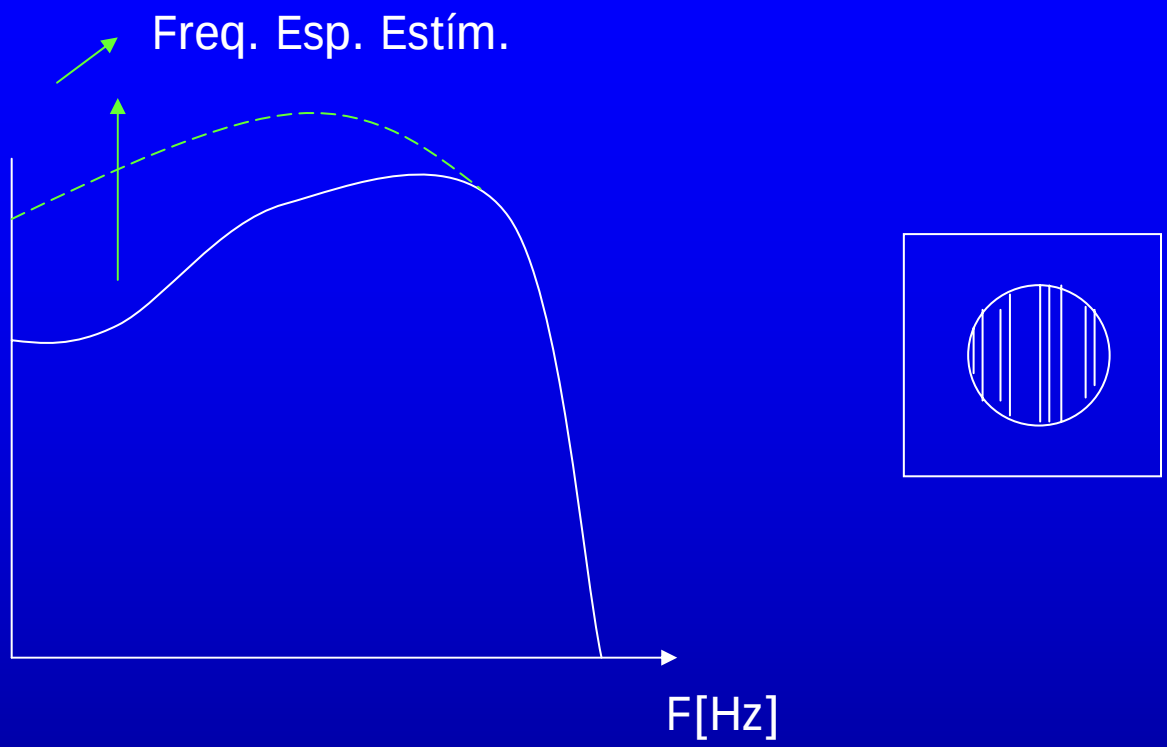
- Propiedades Temporales

  • Frec. Crítica de Fusión

  • Función de Sensibilidad a la variación de contraste temporal

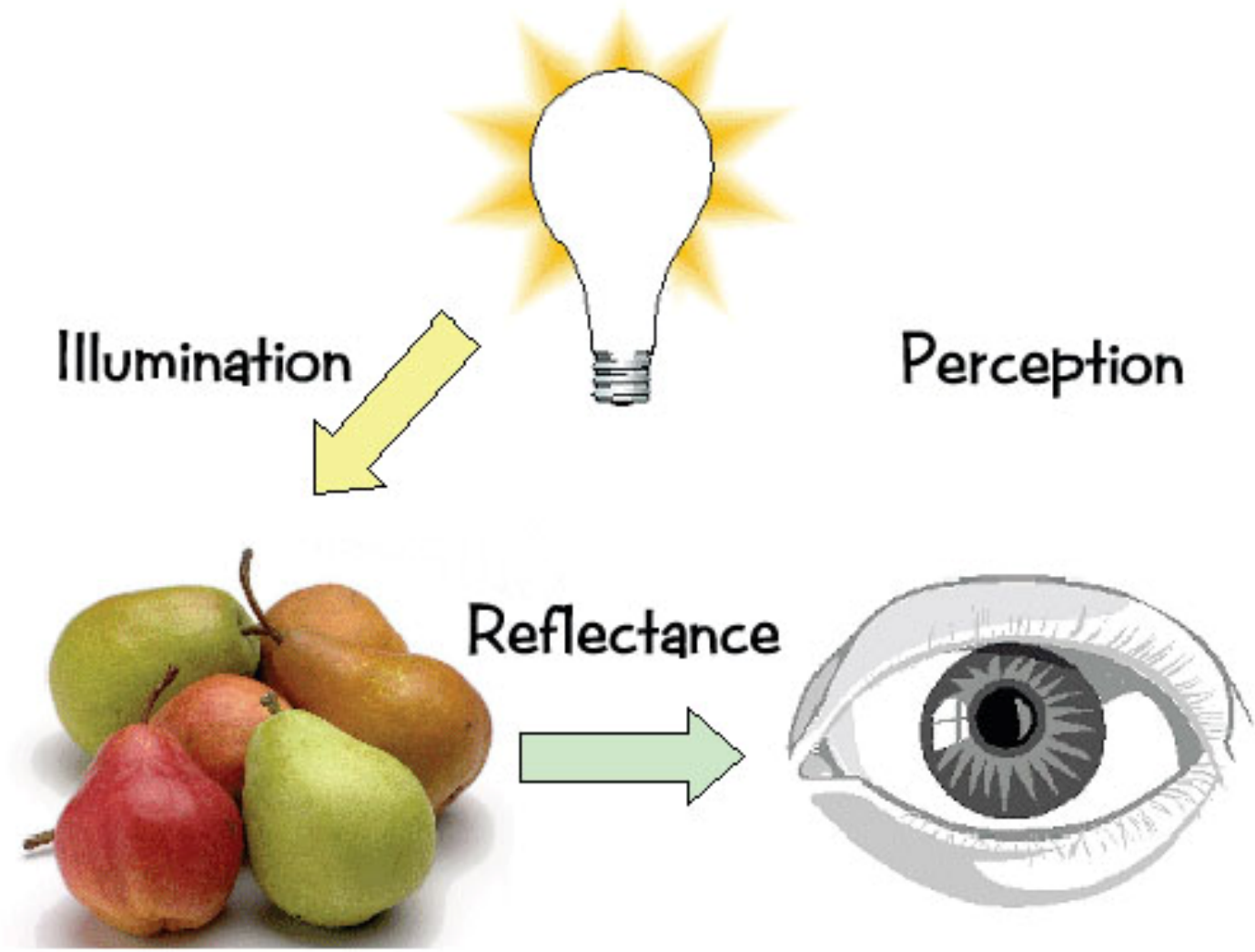





Freq. Esp. Estím.
F[Hz]

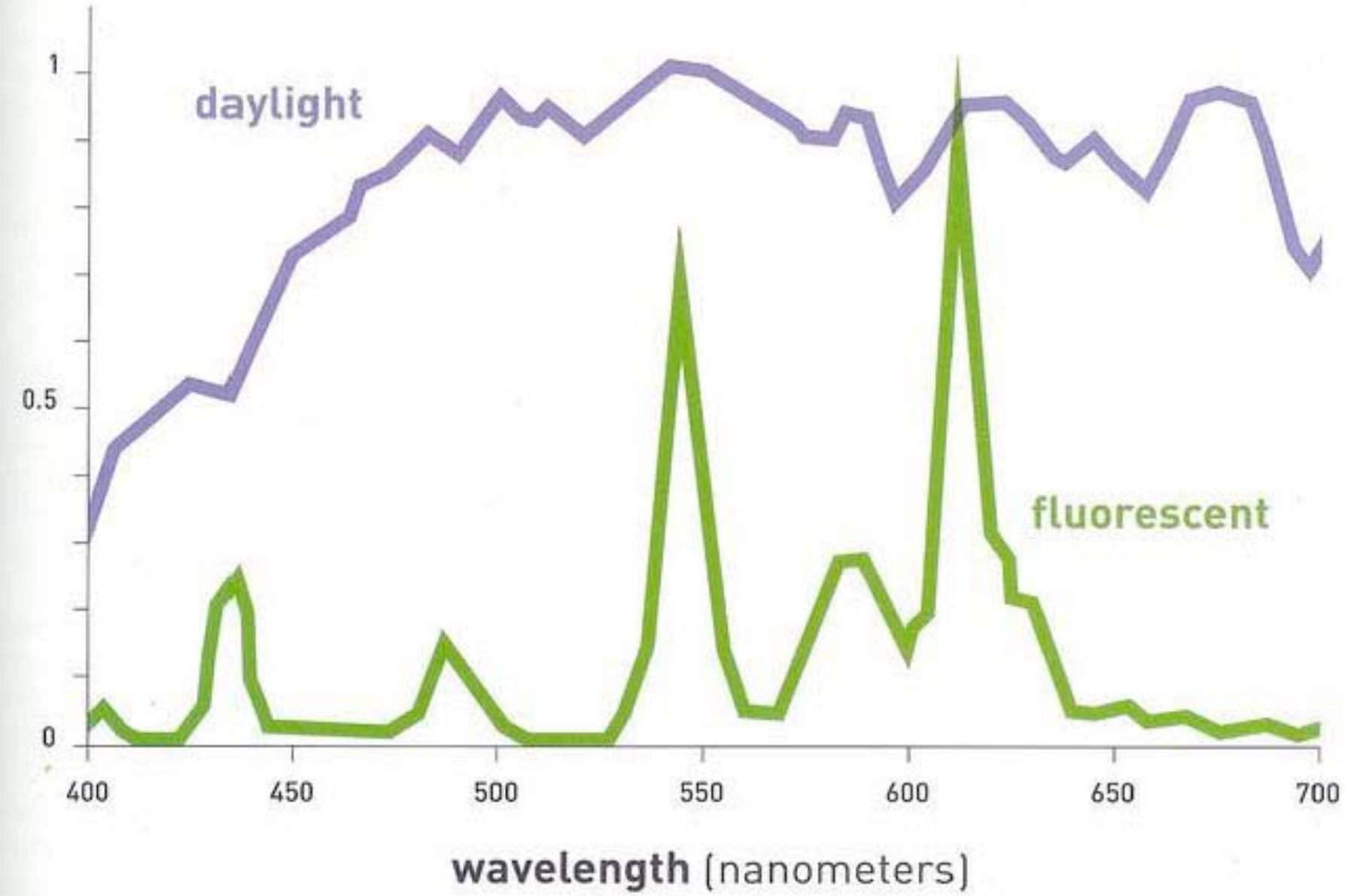
The perception of color teaches us a lot about ourselves; We universally believe that objects *look* colored because they *are* colored. Nothing could be further from the truth. Color is a *psychological* property of our visual experience, not a *physical* property.

Physics of Color




INCIDENT BEAM
REFLECTED
ABSORBED

VAVELENGTHS IN DAYLIGHT AND FLUORESCENT LIGHT

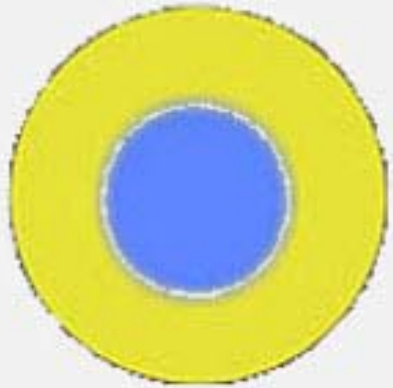


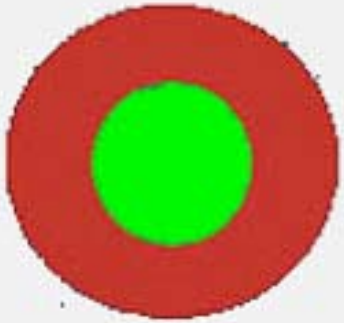
Color opponent ganglion cells

red ON/green OFF

red OFF/green ON

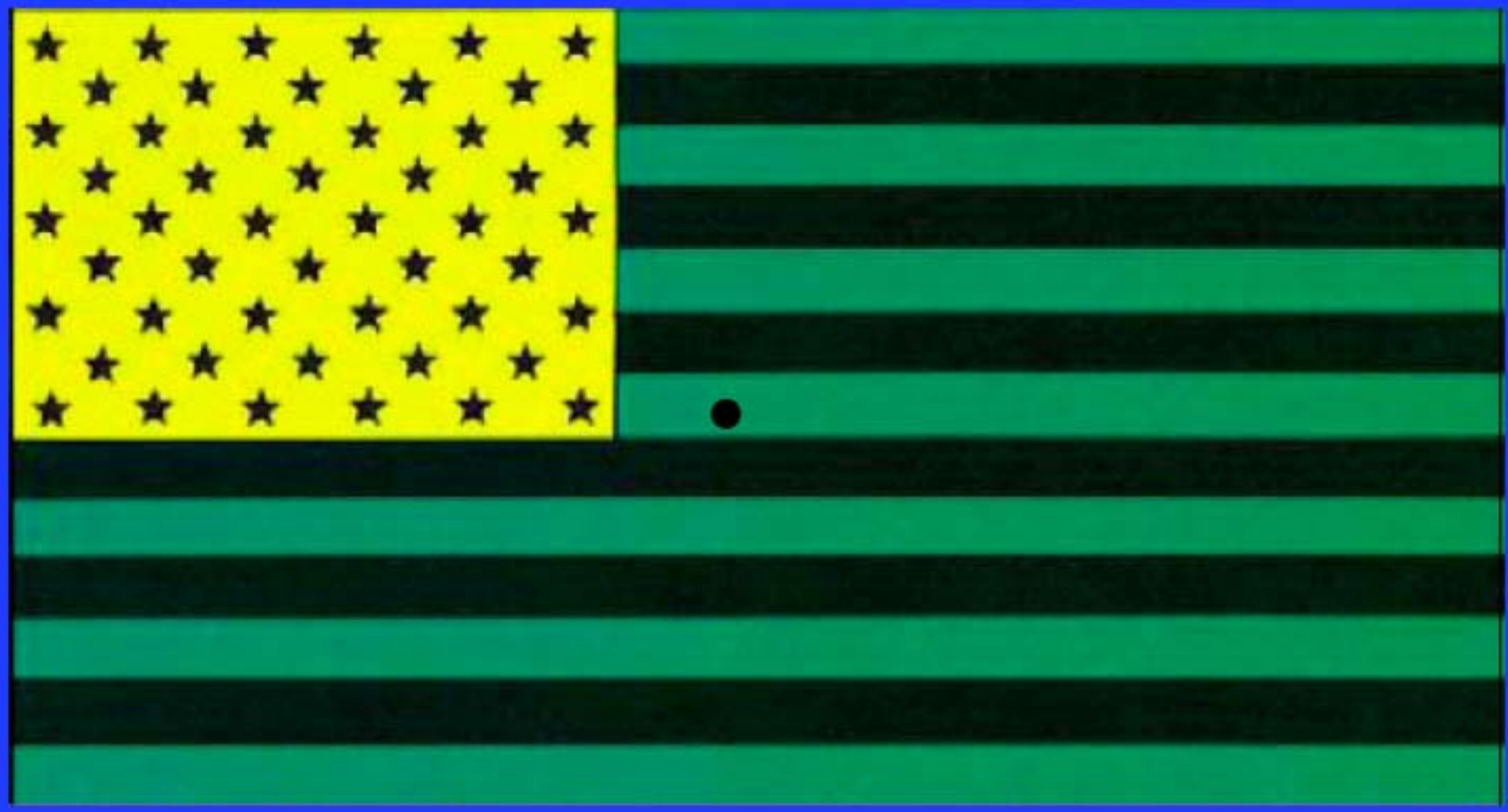
blue ON/yellow OFF

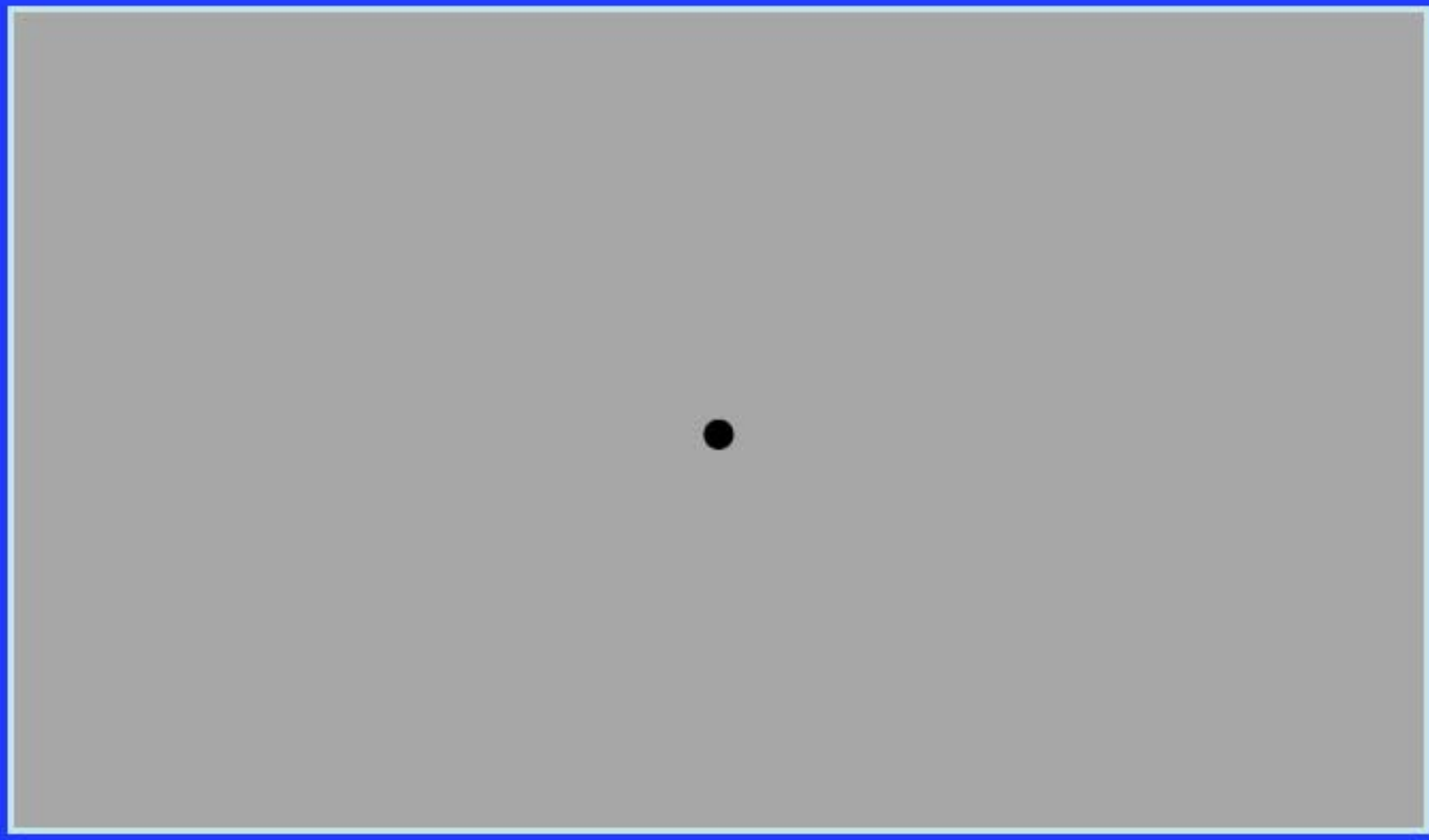


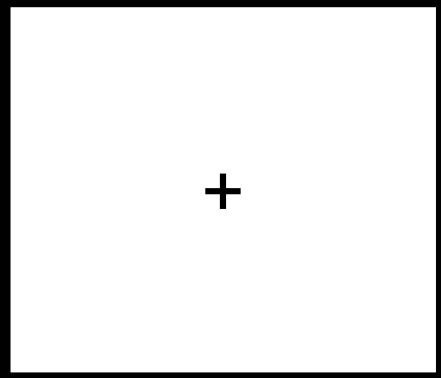


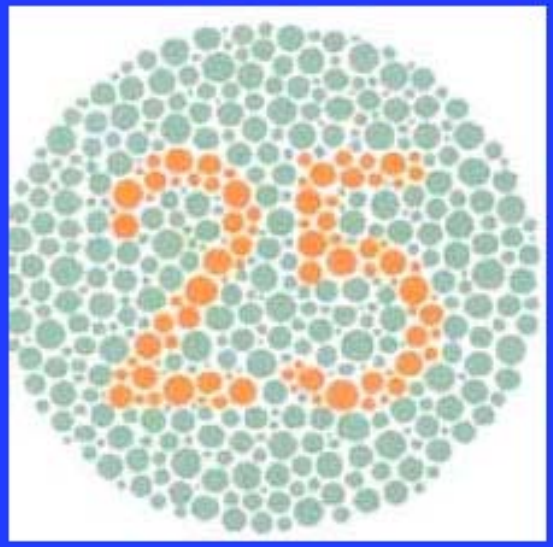
green ON/red OFF

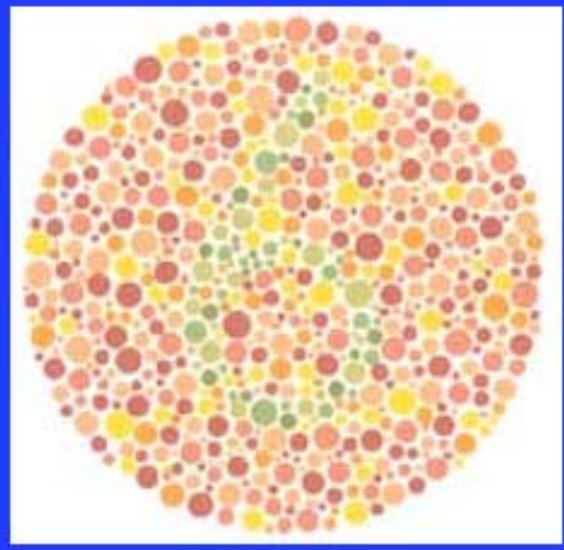
green OFF/red ON



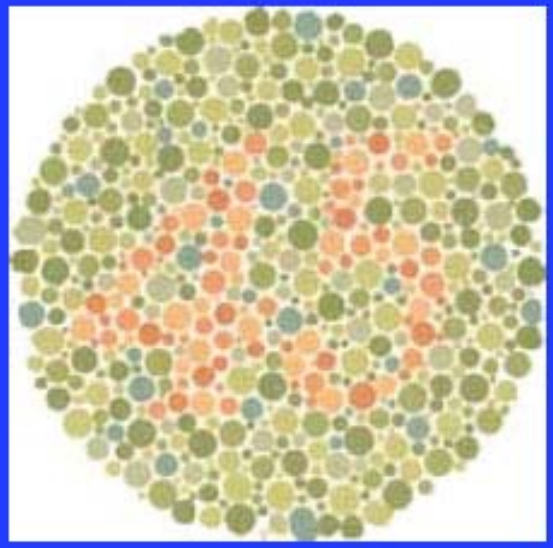


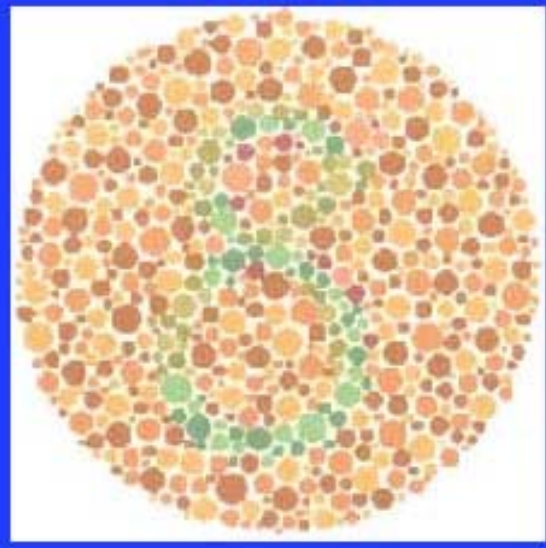


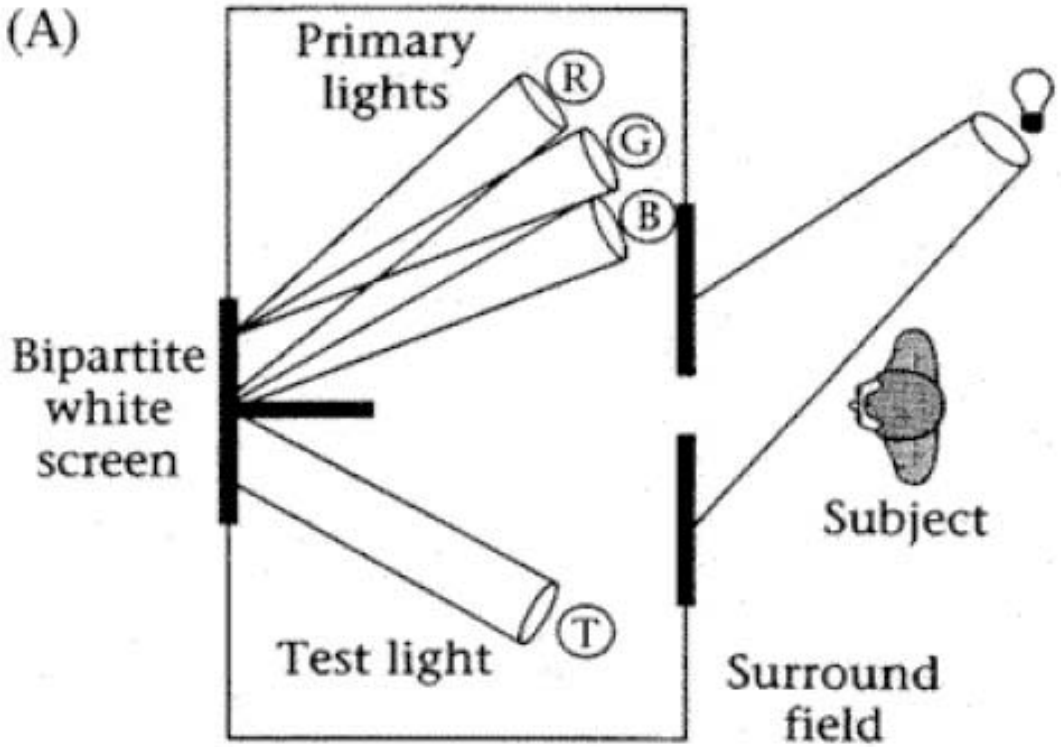


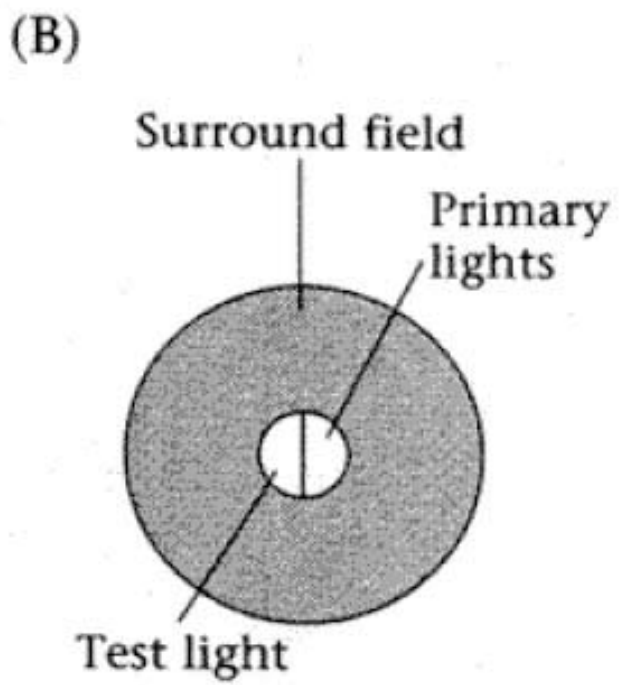


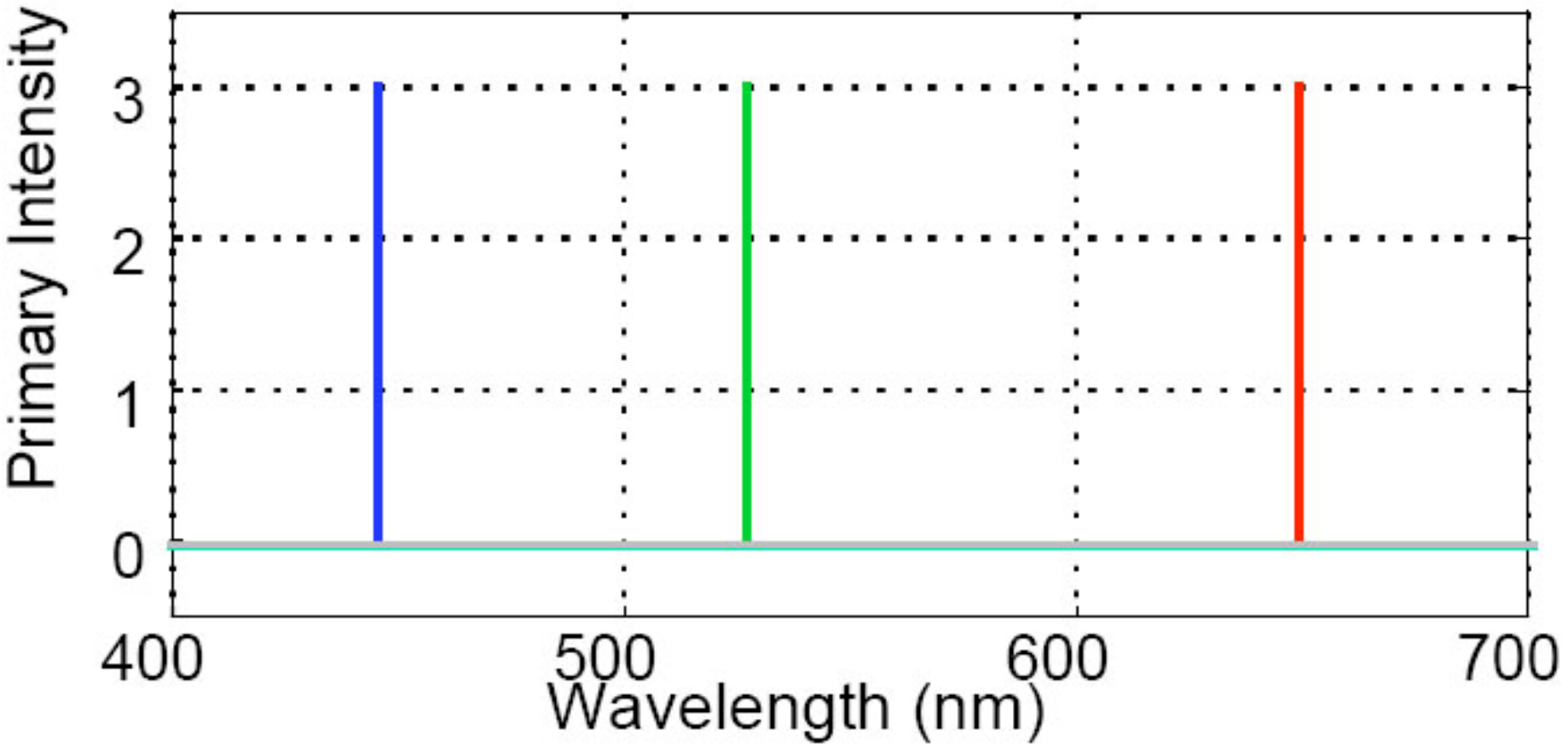
Ishihara pseudoisochromatic plates from Japan

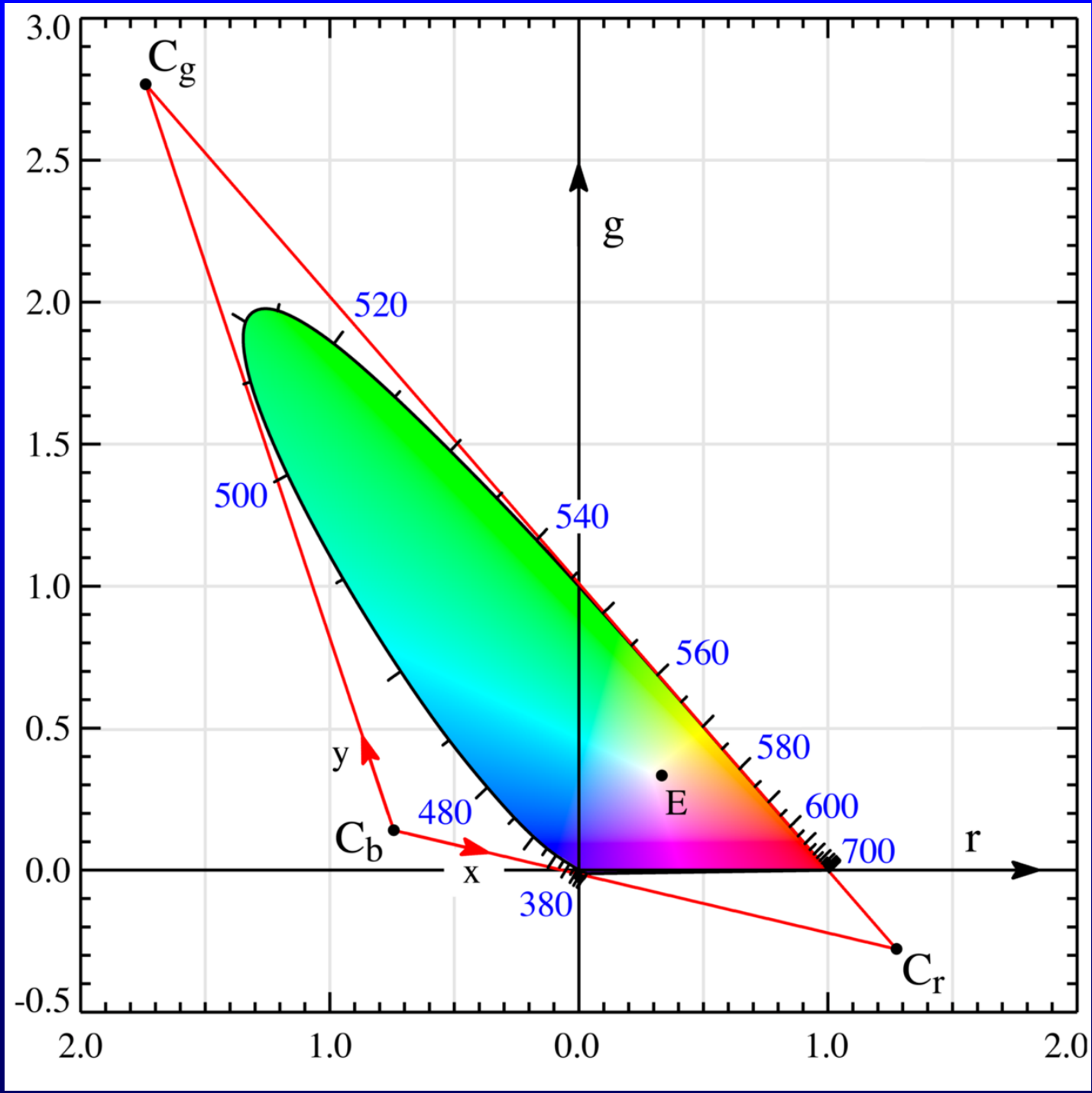


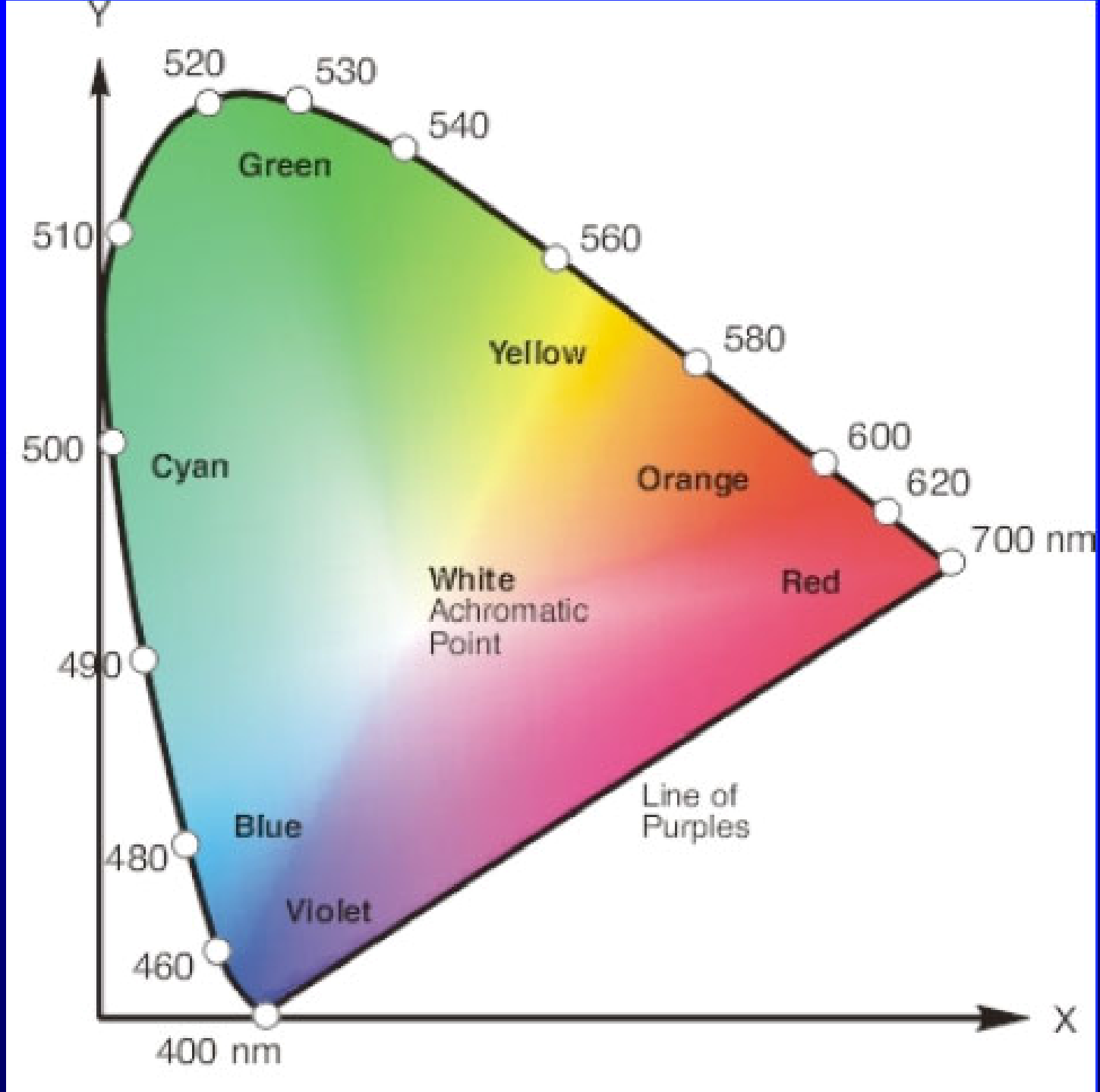



(A)
Primary lights
R
G
B
Bipartite white screen
Test light
T
Subject
Surround field


(B)
Surround field
Primary lights
Test light


Primary Intensity
3
2
1
0
400
500
600
700
Wavelength (nm)


3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.0
1.0
0.0
1.0
2.0
g
r
y
x
C_g
C_b
C_r
E
520
500
540
560
580
600
700
480
380


Y
520
530
540
Green
510
560
Yellow
580
500
Cyan
600
Orange
620
700 nm
White
Achromatic
Point
Red
490
Line of
Purples
Blue
480
Violet
460
400 nm
X

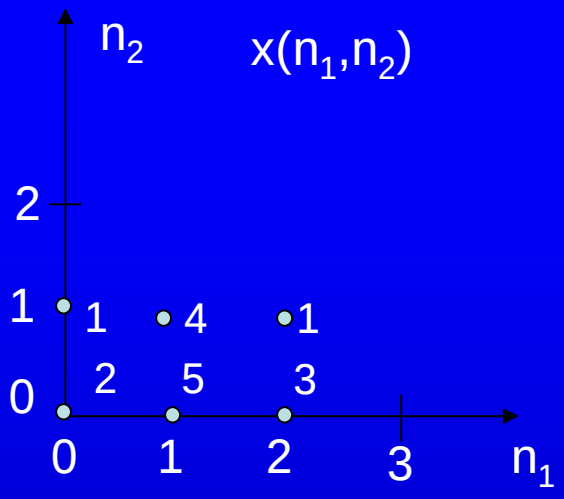
Señales 2-D

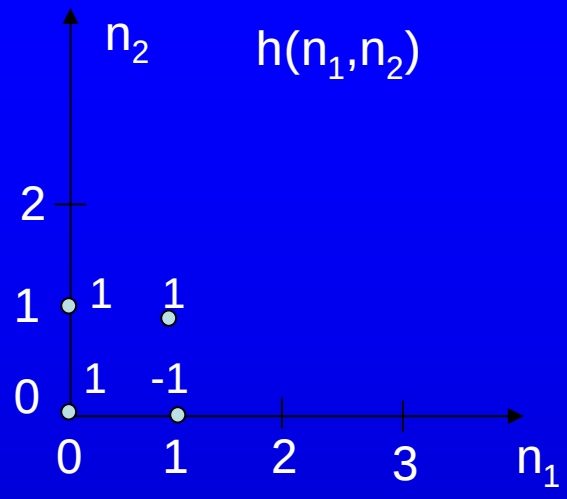
- Secuencia 2-D

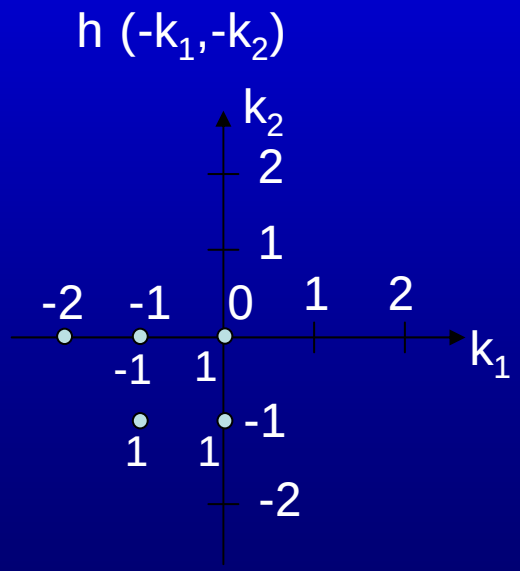
$$\delta(n_1, n_2)$$
$$u(n_1, n_2)$$

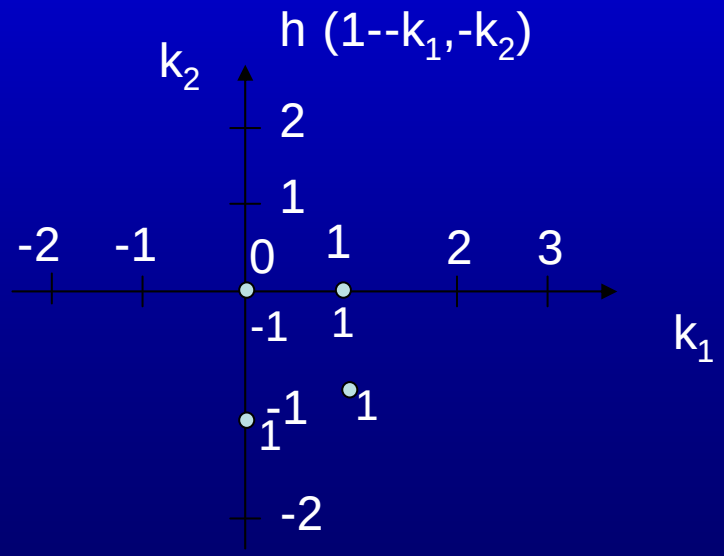
- Convolución 2-D

$$y(n_1, n_2) = x(n_1, n_2) * h(n_1, n_2) = \sum_{k_1} \sum_{k_2} x(k_1, k_2) h(n_1 - k_1, n_2 - k_2)$$


n2
x(n1,n2)
2
1
0
1
4
1
2
5
3
0
1
2
3
n1

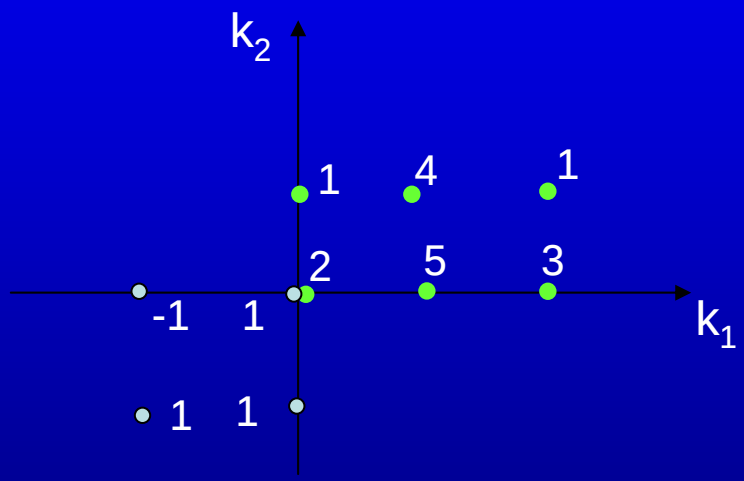

n2
h(n1,n2)
2
1
0
1
1
1
-1
0
1
2
3
n1


h (-k1,-k2)
k2
2
1
-2
-1
0
1
2
k1
-1
1
1
-1
1
-2

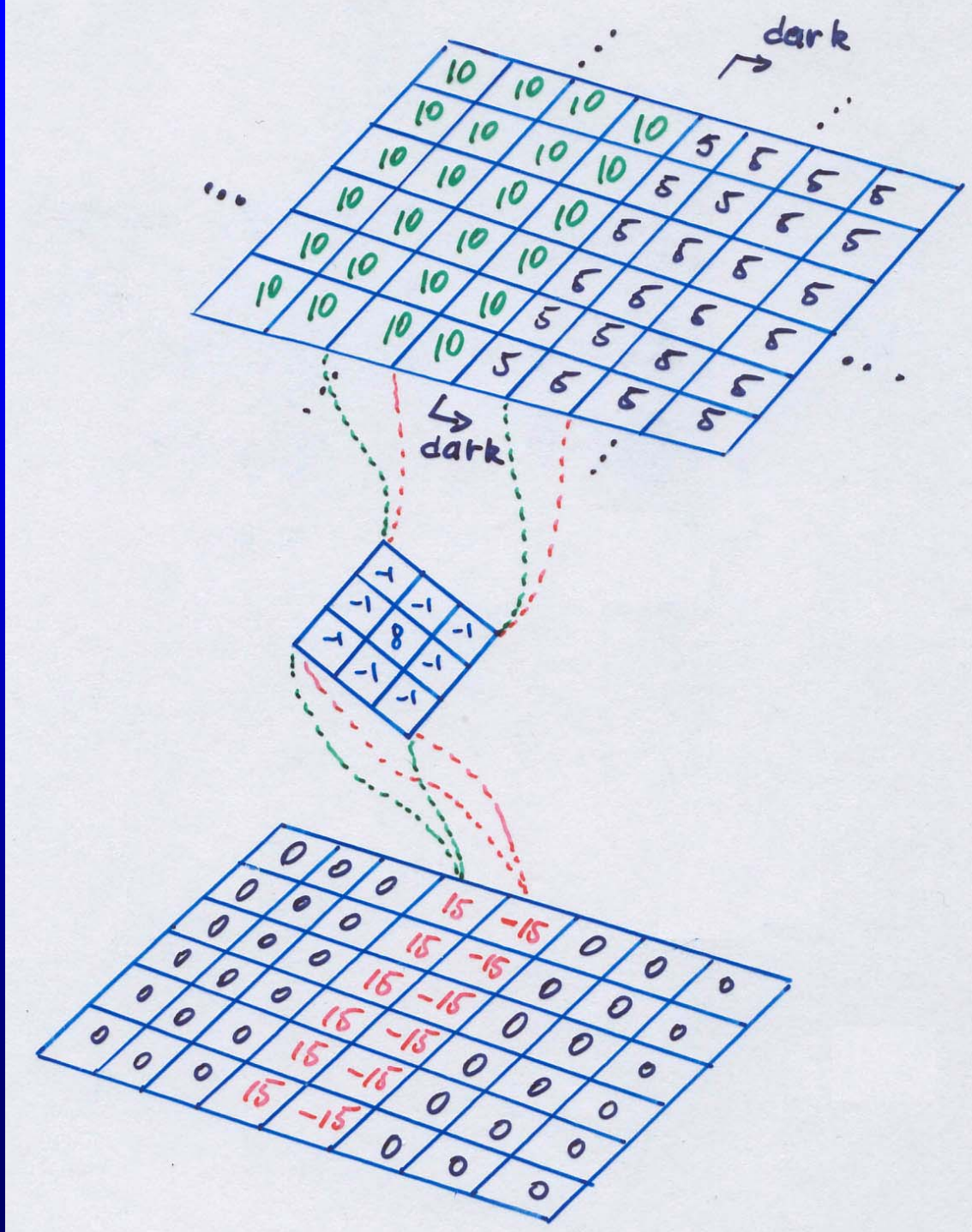

h (1--k1,-k2)
k2
2
1
-2
-1
0
1
2
3
k1
-1
1
1
-1
1
-2

$$n_1 = n_2 = 0$$

$$y(0,0) = \sum_{k_1} \sum_{k_2} (-k_1, -k_2)\, x(k_1, k_2)$$



Y (0,0) = 1·2 = 2


dark
dark