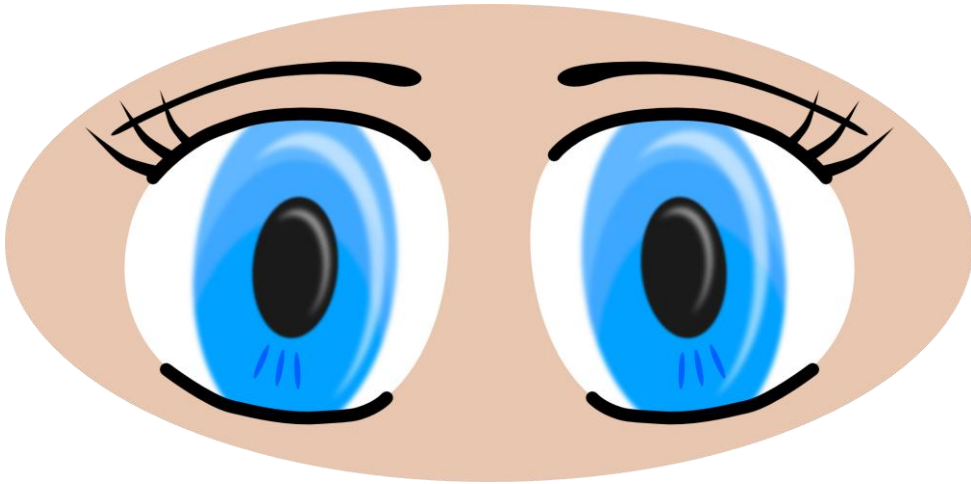
The Eye And The Retina



Learning Objectives

1. Describe the 3 concentric layers of the eye.
2. Know the names, composition and function of the principal retinal cells and layers
3. Describe how light enters the eye and is transformed into action potentials at the photoreceptor level
4. Explain the retinal basis of color perception
5. Explain how visual information is transmitted inside the eye and to the visual pathways

OBJ. # 1

The Eye

The eye consists of 3 complete layers surrounding a central space

Outer

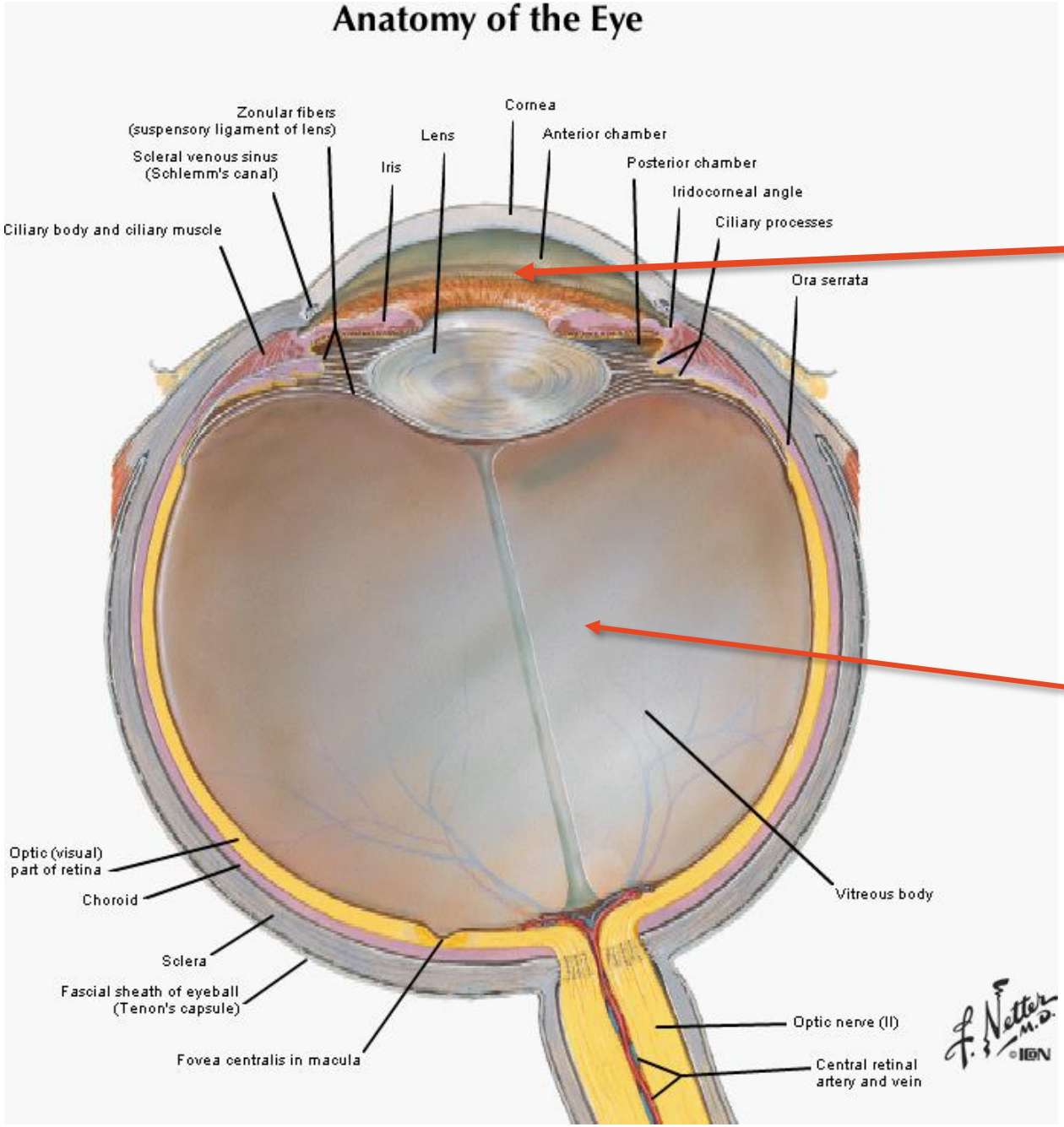
Fibrous layer – Corneoscleral layer

dense, collagenous

Vascular layer – Uvea

Neural layer – The retina

Inner



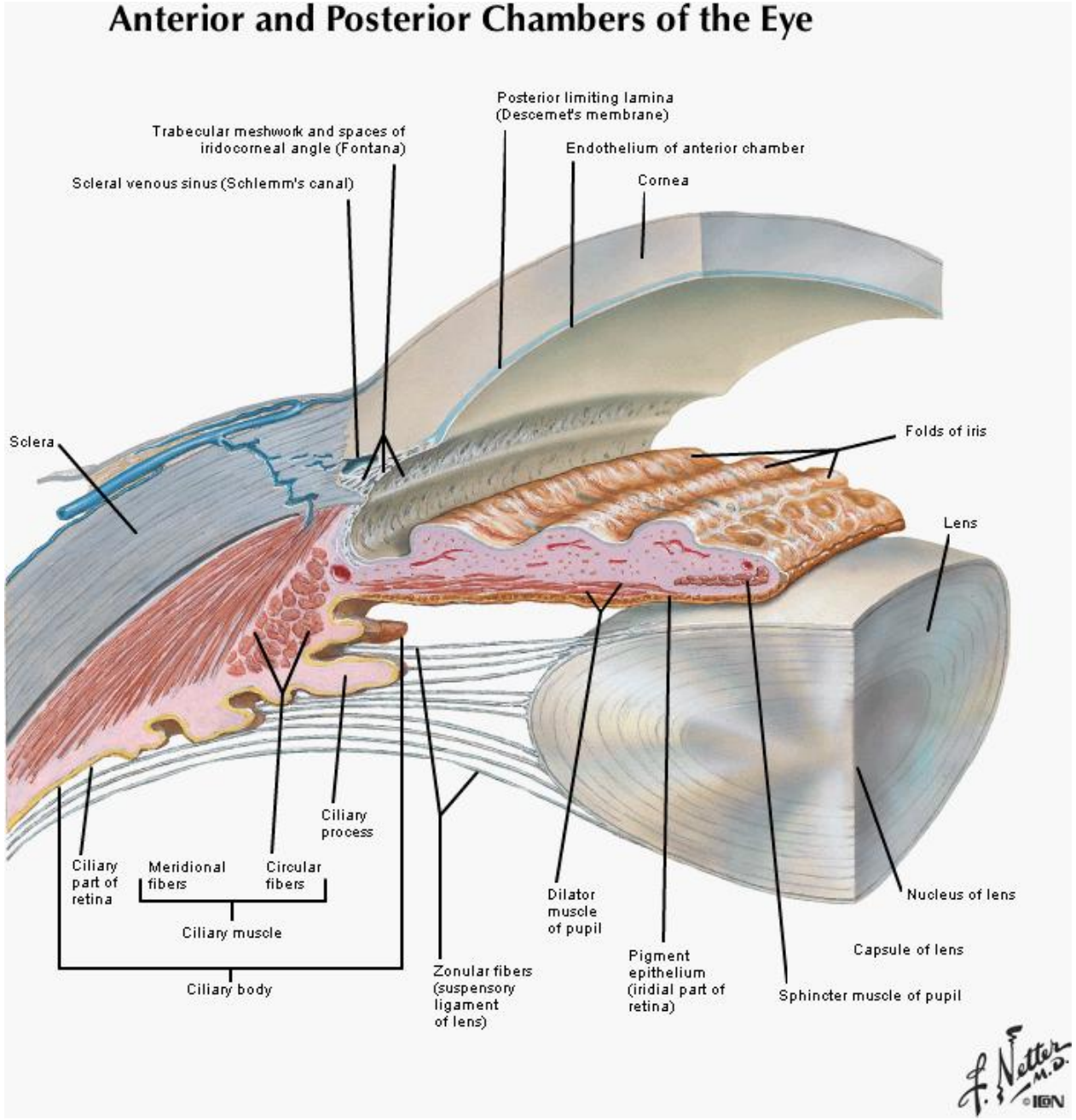
OBJ. # 1

Anterior Chamber – covered in detail by Dr. Feinberg

Vitreus Chamber:

- Everything behind the lens
- Filled with **vitreous humor**, a gelatinous structure

retinal layer forms optic nerve



suspensory ligaments - separate anterior and posterior

OBJ. # 1

Closer view of the anterior structures of the eye:

- Focuses light onto the retina
- Iris adjusts the amount of light coming into the eye
- Lens changes shape to focus the light onto the retina

OBJ. # 2

Macula and Fovea Centralis:

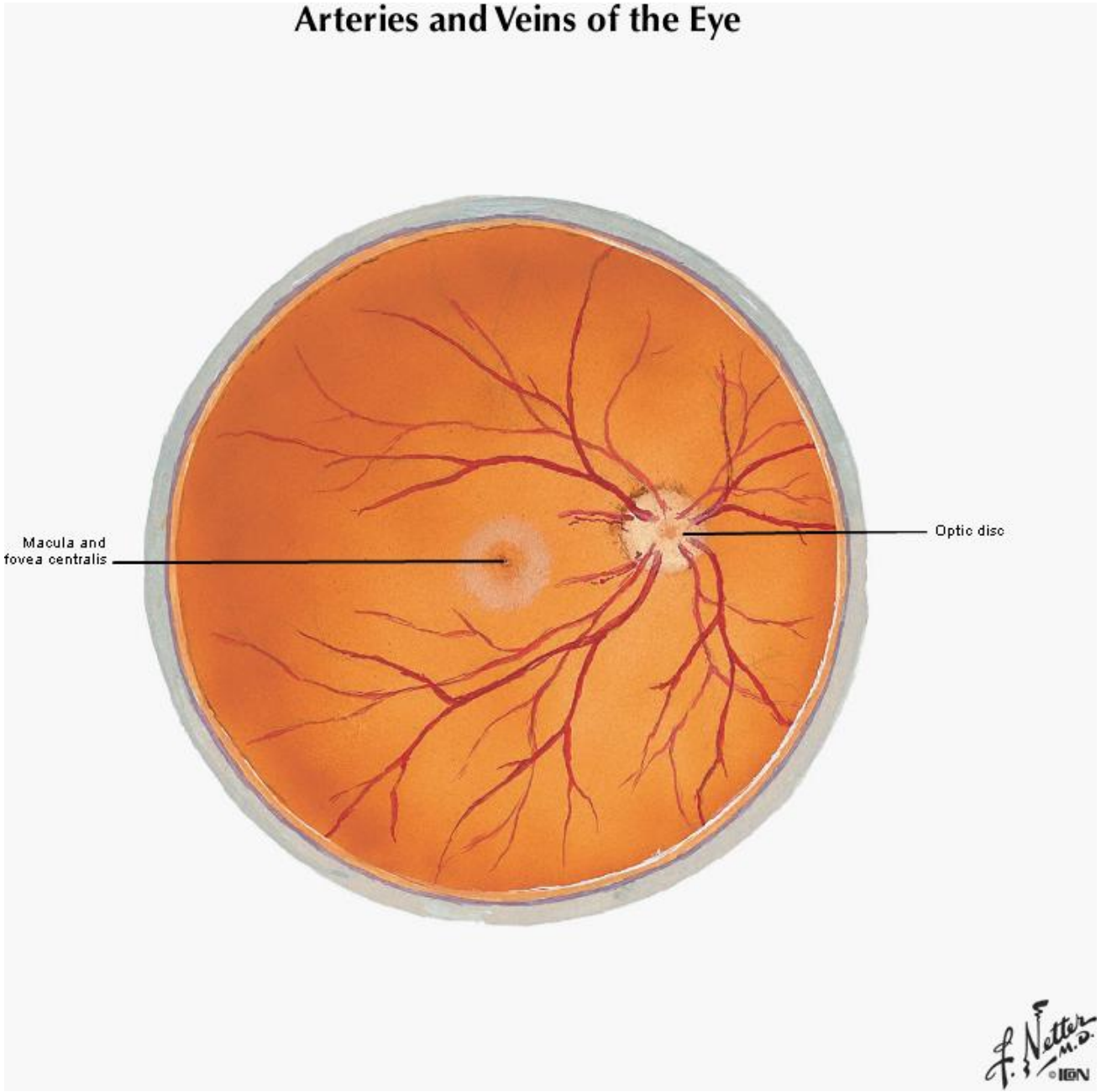
- Central vision – point of maximal visual acuity.
- Area of highest density of photo receptors

Optic Disc or Papilla:

- Structure through which the axons of the retinal ganglion cells and vasculature of the retina enter the eye blind spot
- **Continuous with the CNS**

Clinical Pearl:

- **Increased intracranial pressure** in the CNS is transmitted to the eye via the optic nerve and is observed as a swelling of the optic disc called **papilledema**



OBJ. # 2

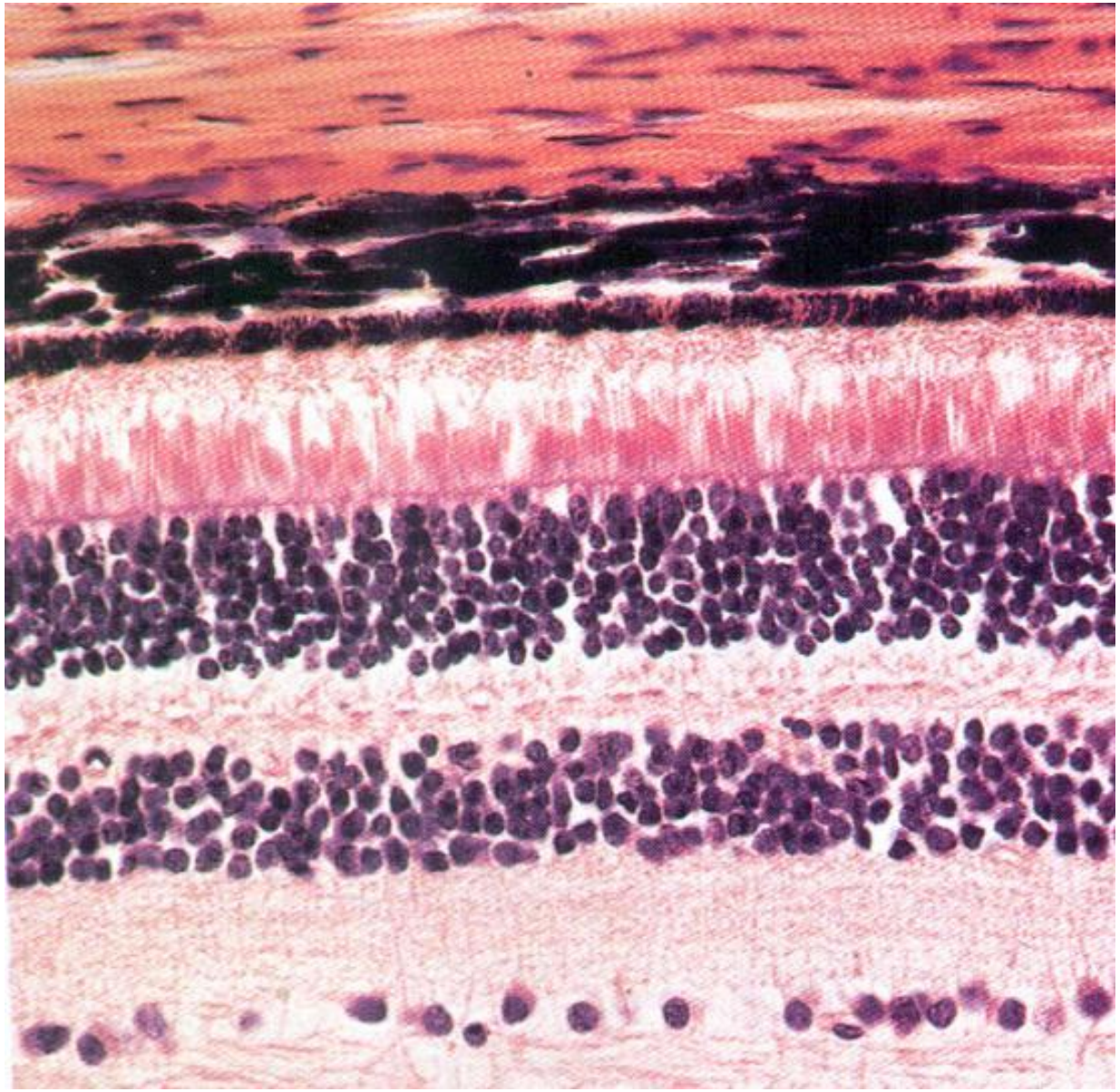
Retina

5 different neuronal cell types:

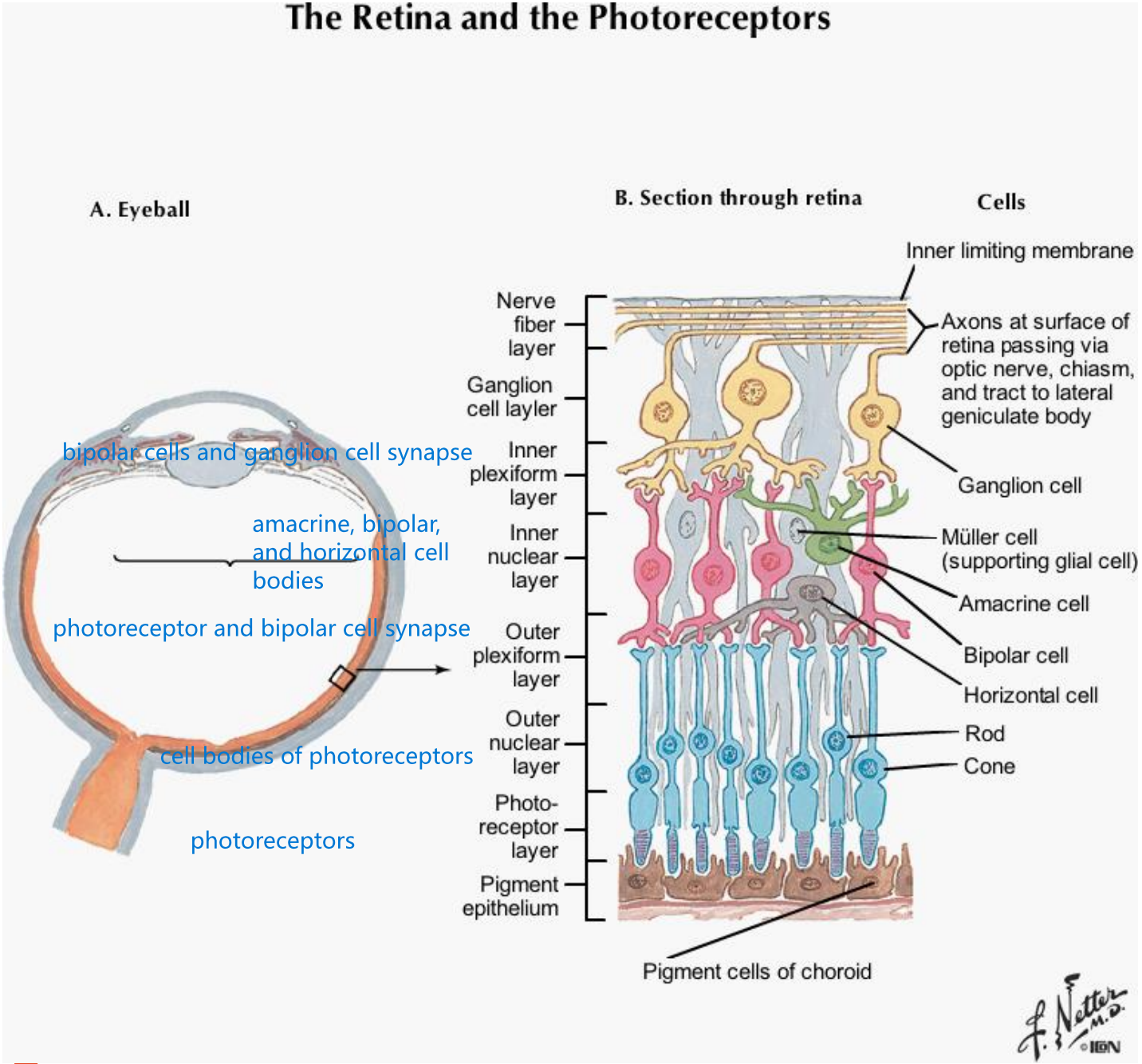
- Photoreceptors
- Bipolar cells
- Horizontal cells
- Amacrine cells
- Ganglion cells

↓

OPTIC NERVE



OBJ. # 2

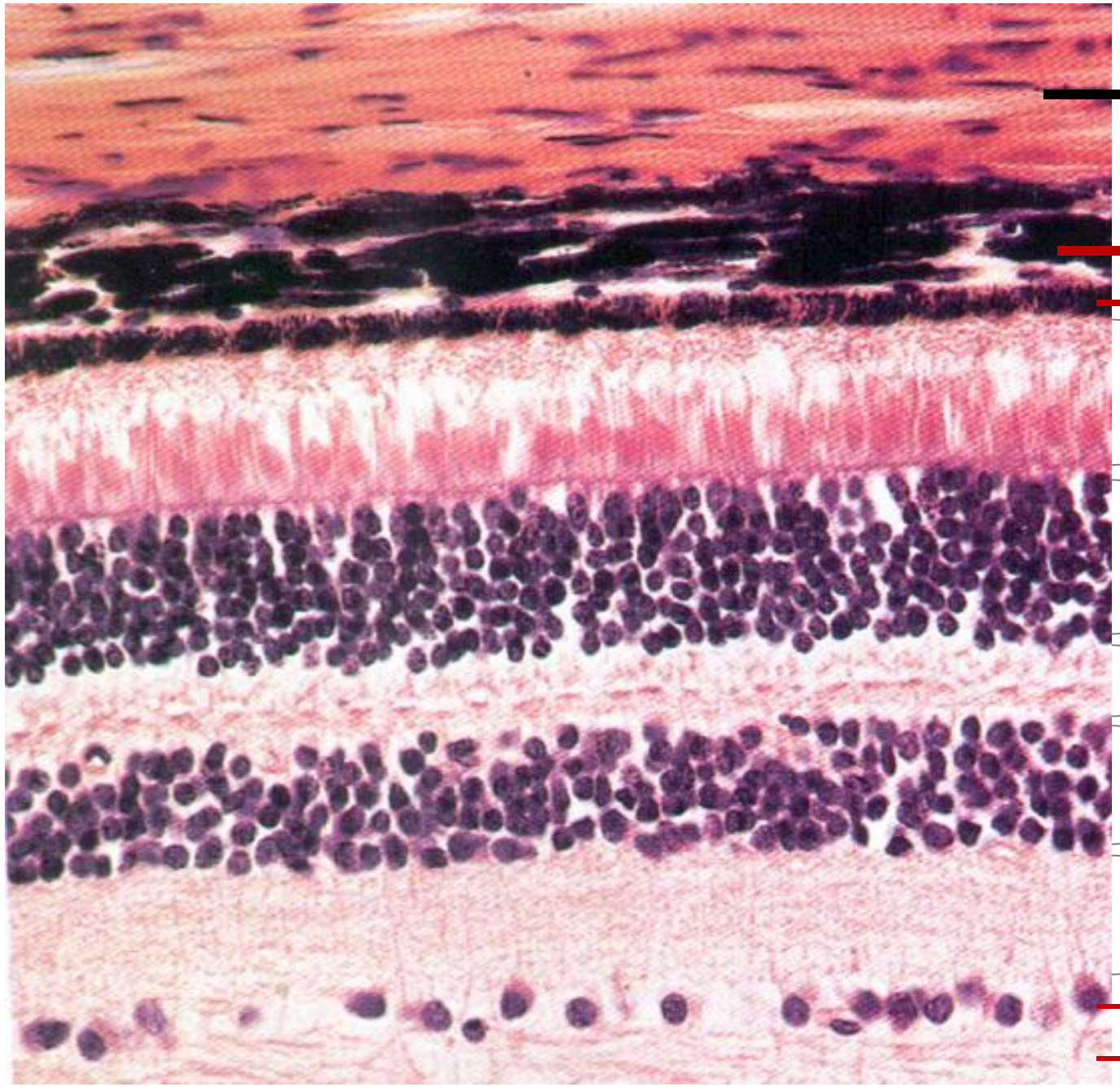


May seem a little backwards:

- The photo receptor cells are buried in the most posterior part of the retinal layer in the pigment cells of the choroid. pigment epithelium
- **Light physically travels through the cells of the retinal layers but does not interact with any of them until it reaches the photoreceptor layer**.

light scatters so if photoreceptors not buried in a dark layer can lose some

OBJ. # 2



- Sclera
- Uvea
- Retinal Pigment epithelium
- Photoreceptor layer
- Outer nuclear layer

density drops as you get to ganglion cell layer

- Outer Plexiform layer
- Inner Nuclear layer
- Inner Plexiform layer
- Ganglion cell layer
- Optic nerve layer

How light is transformed into visual information

OBJ. # 3

Electromagnetic radiation: Photons of light

Travel through

Refractory structures focus light onto retina

- Cornea
- Lens

OBJ. # 3

Light

↓ Reaches the photoreceptors

Photoreceptor

↓ Is in charge of

Transformation of electromagnetic energy into → ELECTRICAL SIGNALS

↓ This process is called

Phototransduction

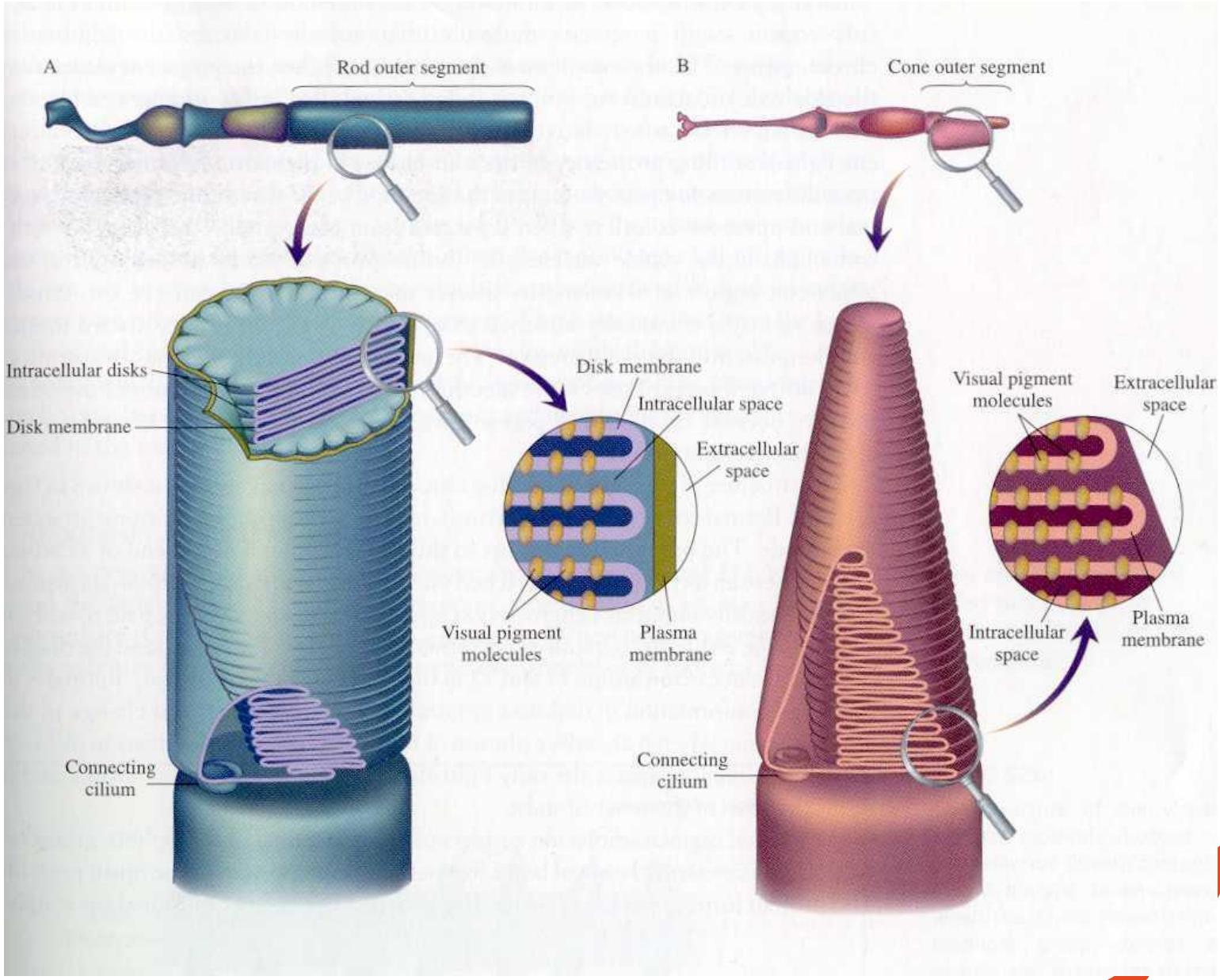
OBJ. # 3

stacks of transmembrane proteins - rhodopsin

2 Types:

- Rods
- Cones

Photoreceptors



Photoreceptors – Functional differences

OBJ. # 3

Rods

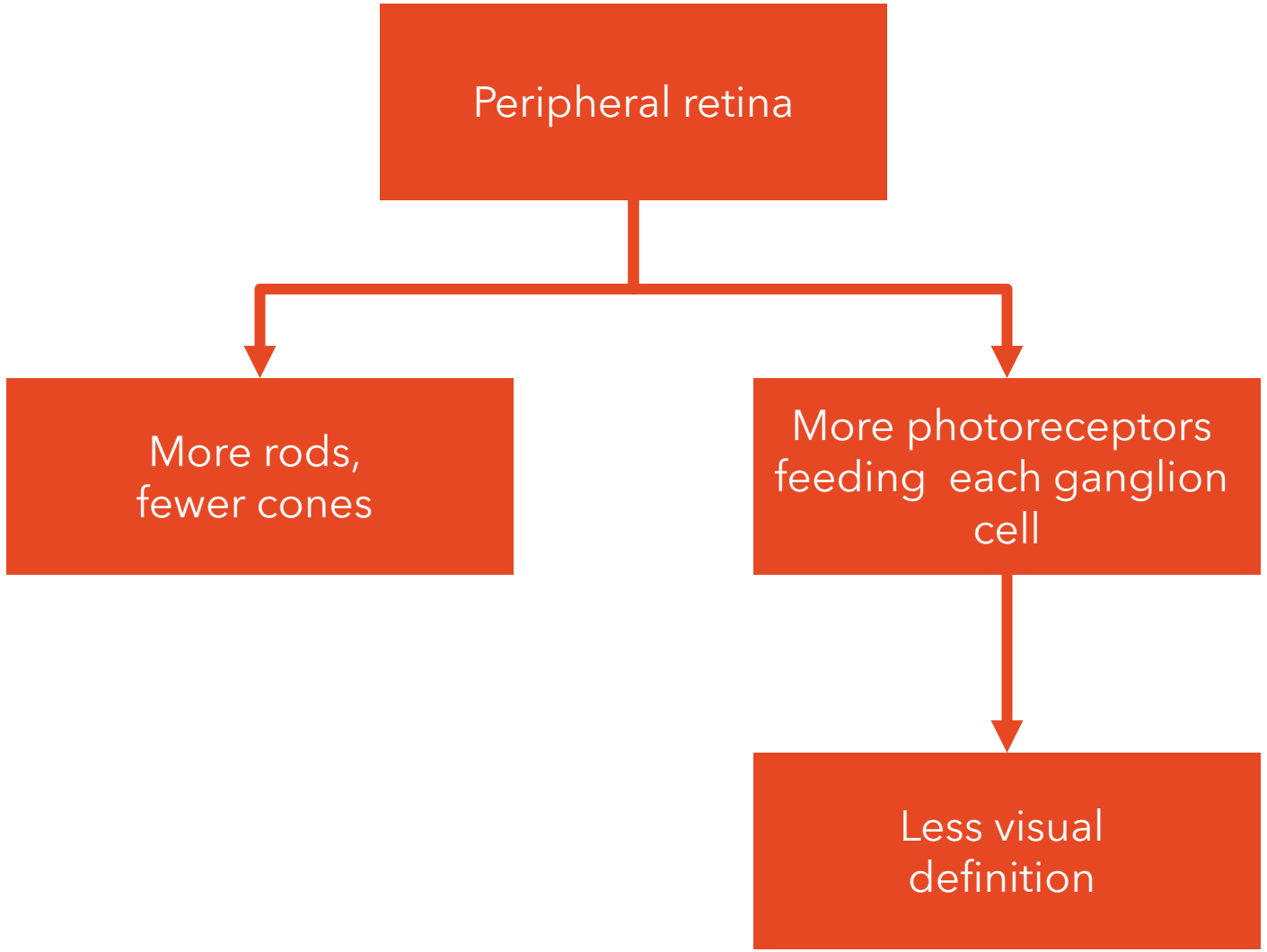
- Longer outer segment
- 30 times more sensitive to light
- Adapted for night time light conditions - Scotopic conditions

Cones

- Adapted for visual acuity
- Adapted for color vision
- Day time light conditions – PHOTOPIC CONDITIONS

OBJ. # 3

Photoreceptor Distribution



OBJ. # 3

Photoreceptor Distribution

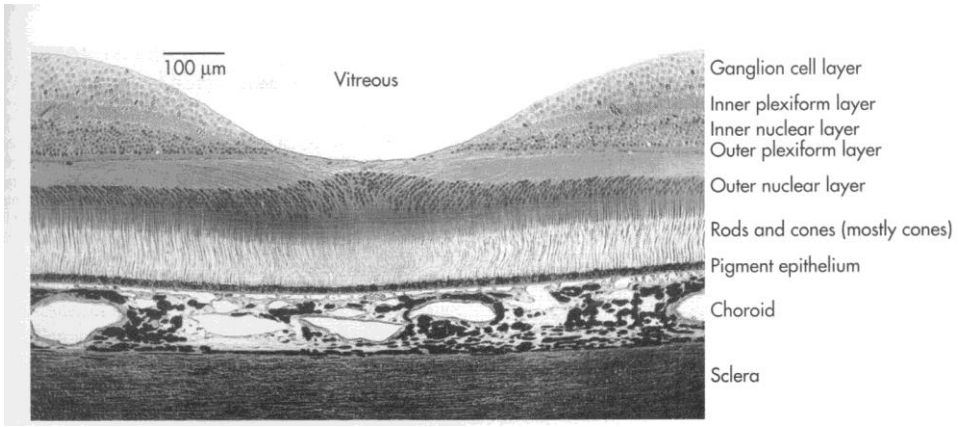
Central retina
- Macula
- Fovea

Less photoreceptors per ganglion cell

More cones, fewer rods

Increase visual Acuity

but not as sensitive to light

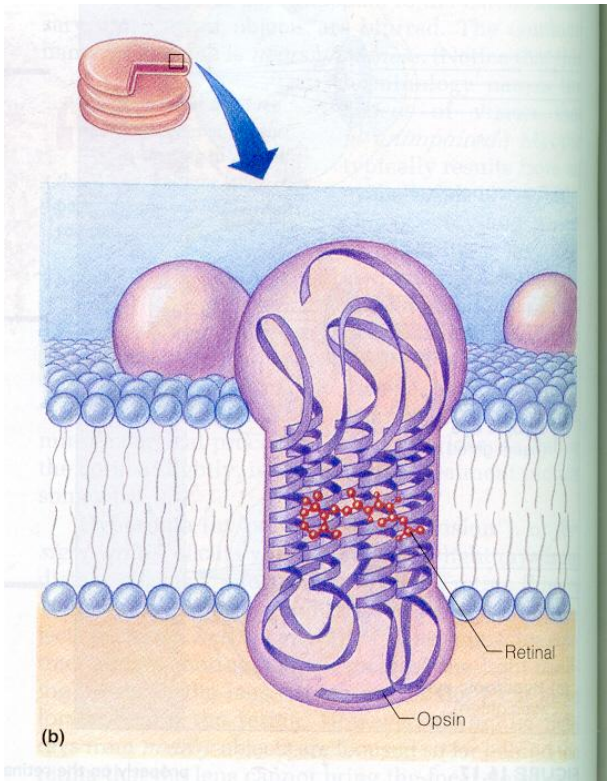


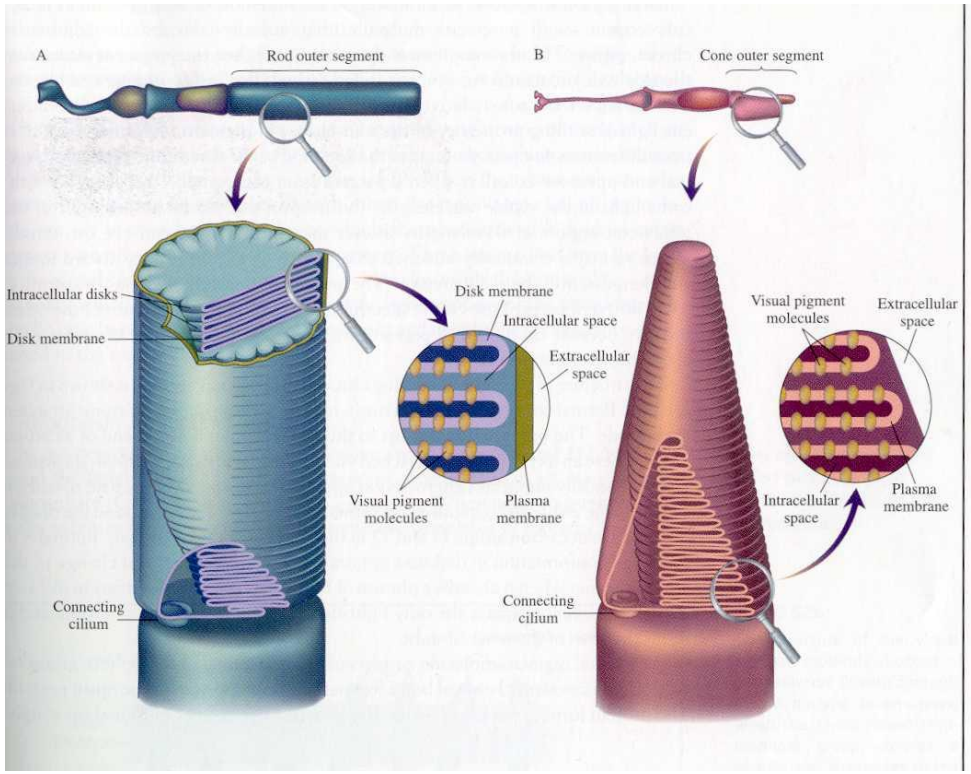
Phototransduction

OBJ. # 3

Occurs in the outer photoreceptor segment

The photopigment involved is called Rhodopsin: It is composed of a protein molecule: the Opsin and a Chromophore molecule: the Retinal



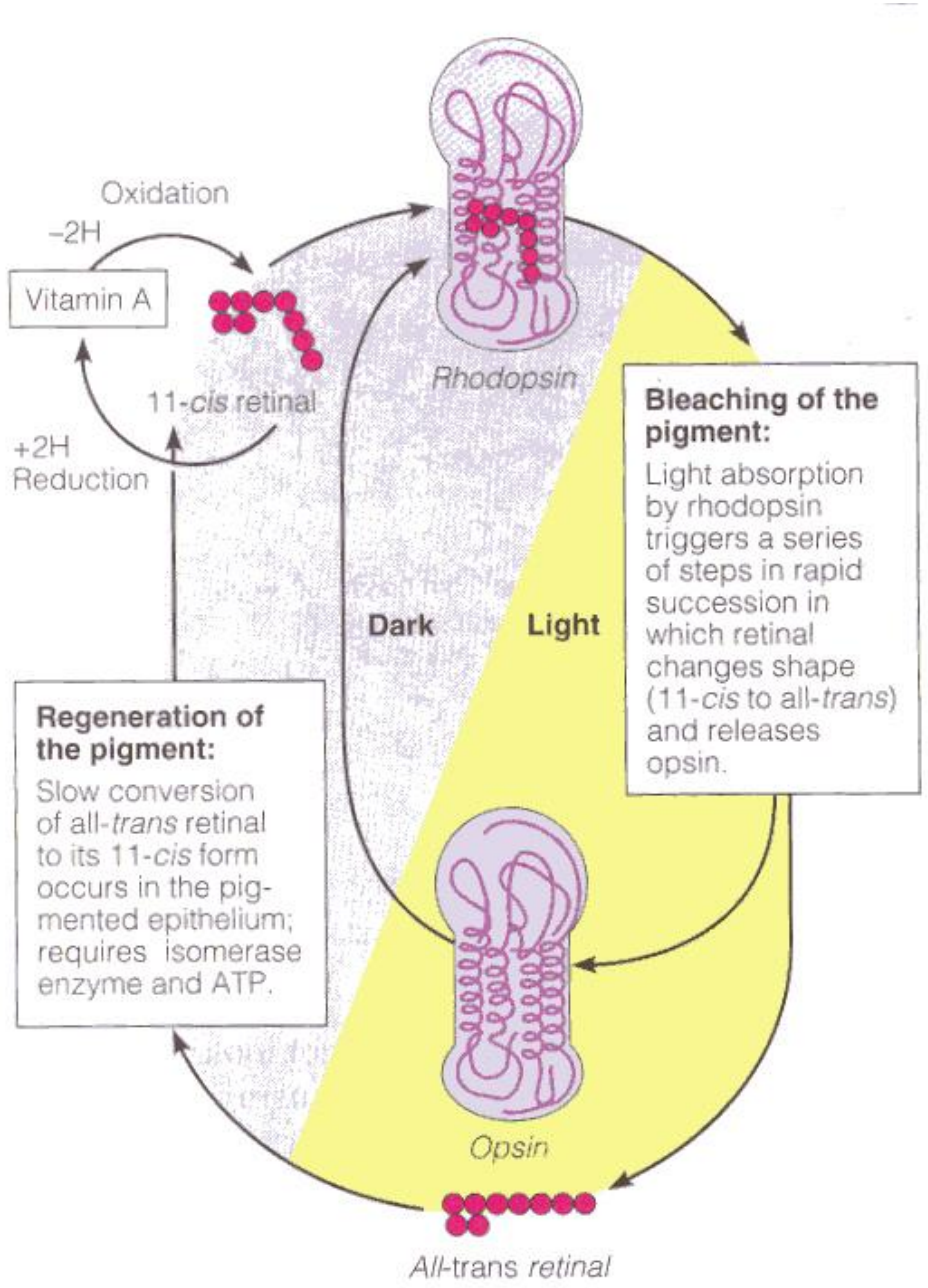


The Retinal pigment Molecule could be in 2 isoforms:

- 11 –Cis
- All Trans

Here is the cycle of light vs. darkness and how Retinal suffers a conformational change

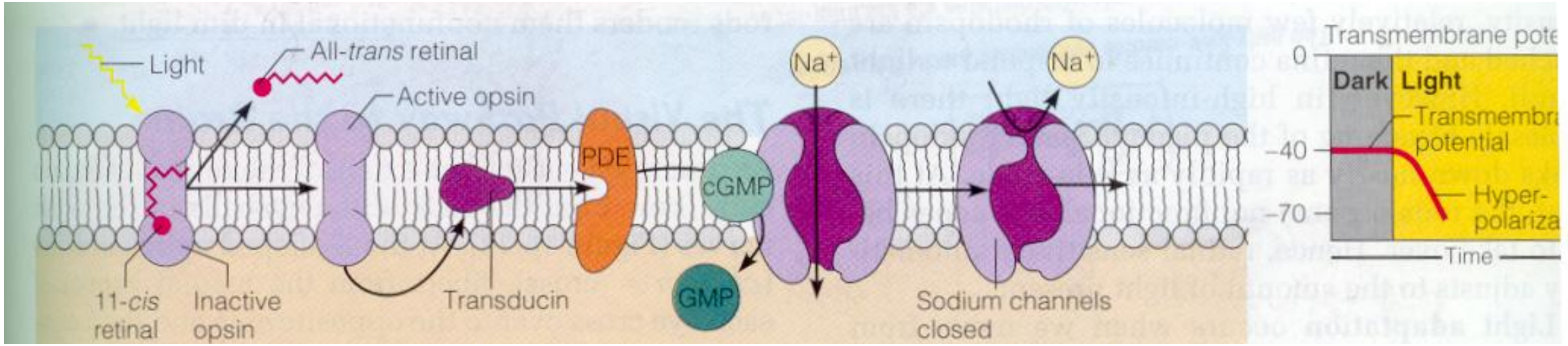
11-cis: sensitive to light



OBJ. # 3

Phototransduction

OBJ. # 3



Light

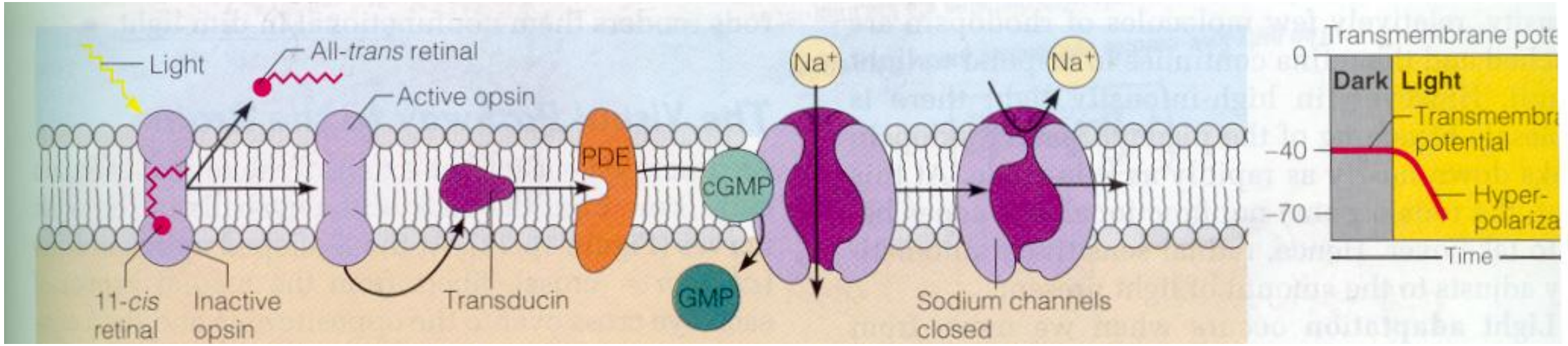
GPCR - means to amplify quickly

cell less positive and hyperpolarizes photoreceptor

Retinal detaches from opsin → Opsin becomes activated → Activates G-protein Transducin

Phototransduction

OBJ. # 3

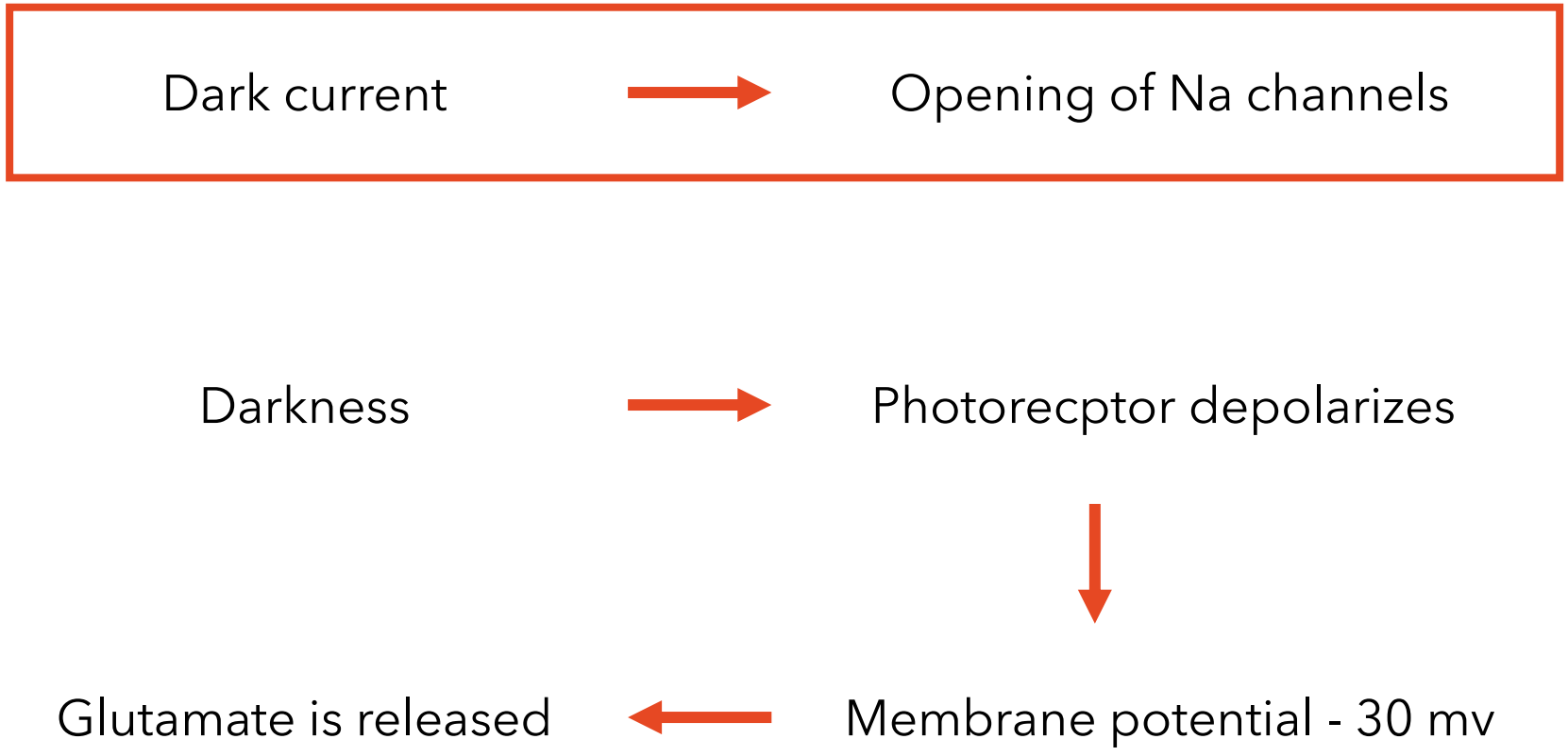


Activates enzymatic cascade, PDE → Hydrolysis of cGMP, second messenger

Amplification of the signal

Phototransduction

OBJ. # 3



Phototransduction

OBJ. # 3

Light → Photoreceptor hyperpolarizes

↓

Membrane potential - 70 mv

↓

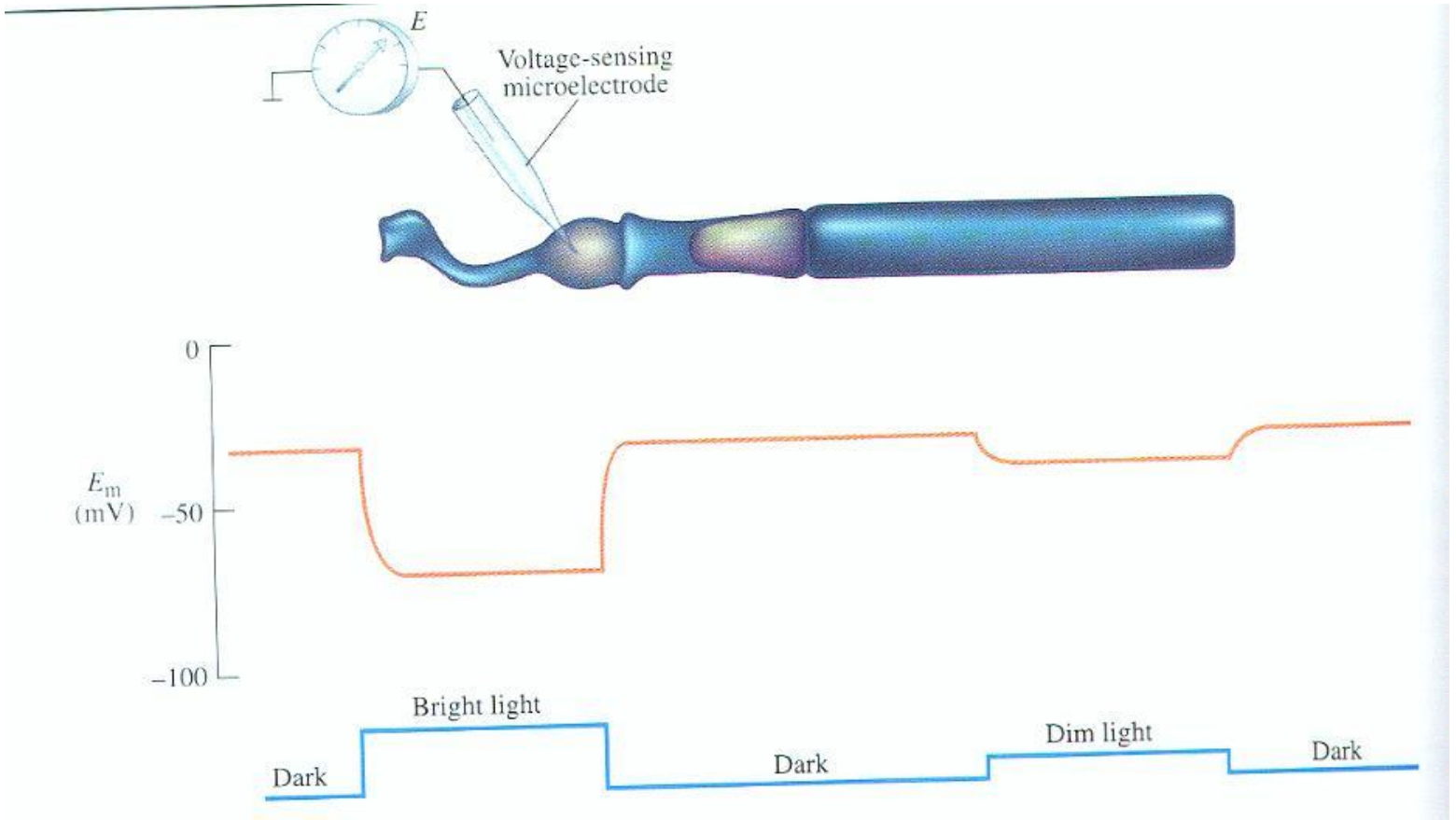
None or less glutamate
is released

Modulation of the signal

OBJ. # 3

different sensitivities

Recording of a photoreceptor firing under different light intensities



less sensitive to light
takes more energy to perceive color

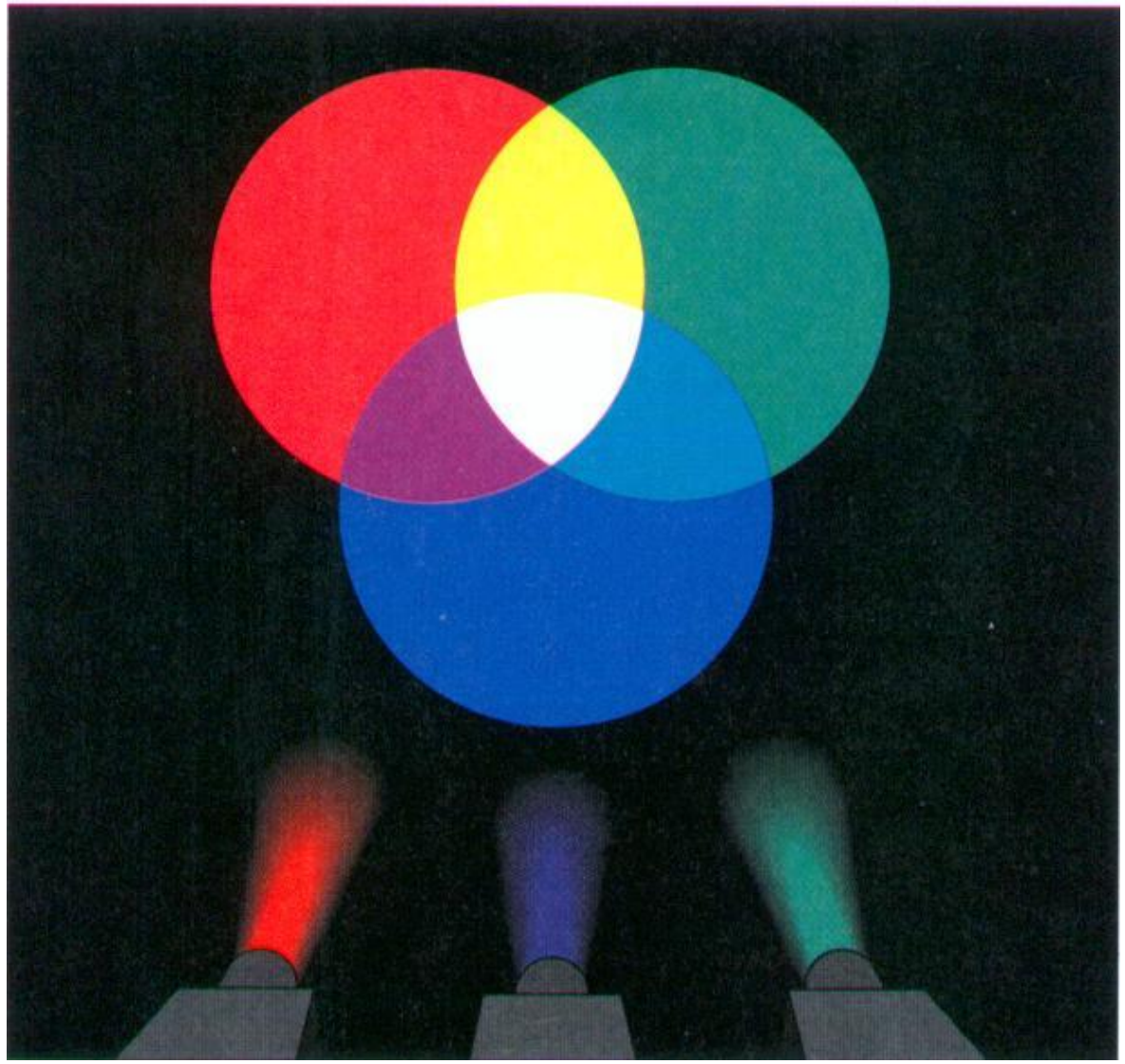
OBJ. # 4

Visual Primary Colors

Cones → Day vision
Cones → Color vision

3 different opsin molecules

- Blue → 430 nm
- Green → 530 nm
- Red → 560 nm



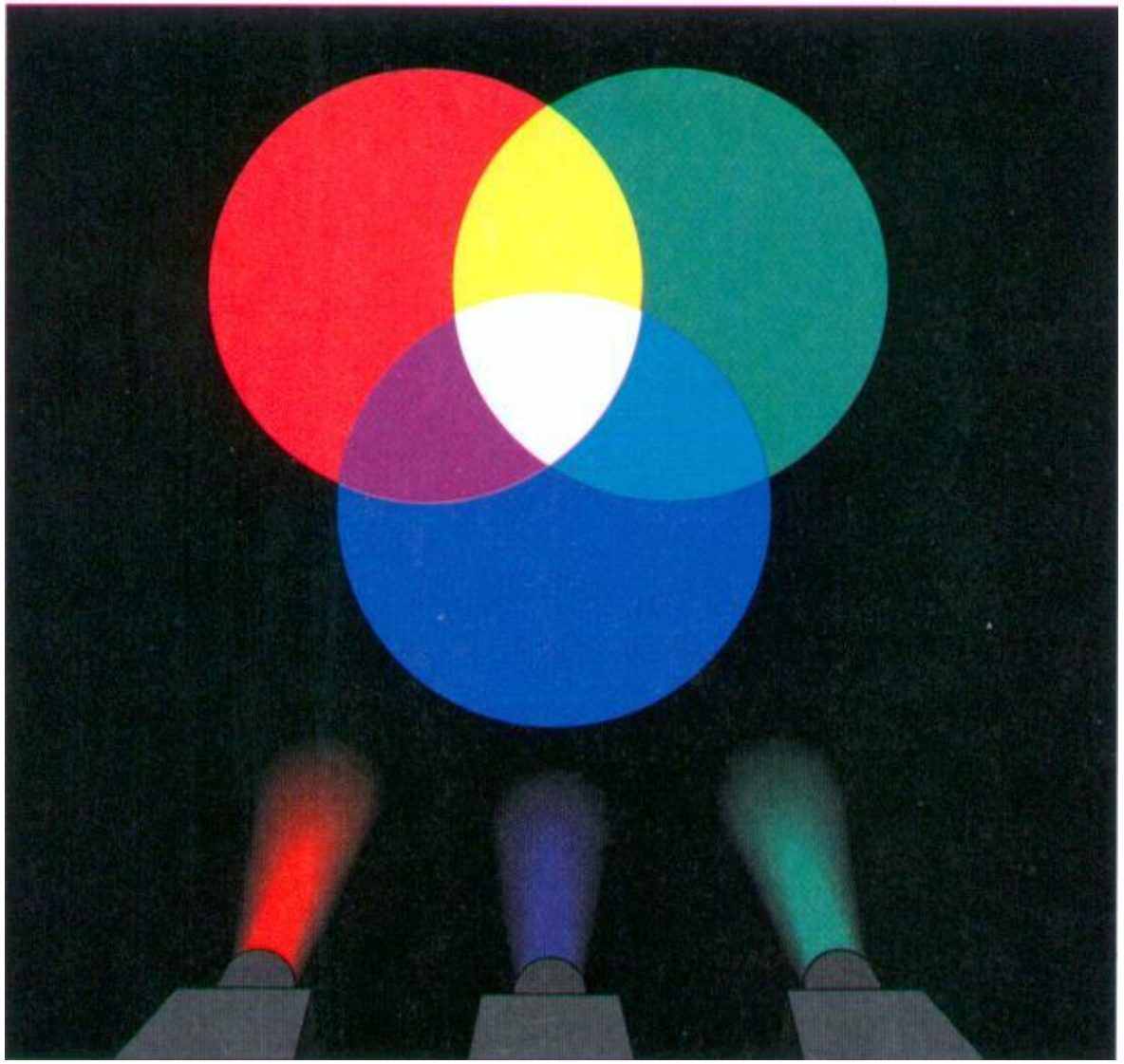
OBJ. # 4

Color Vision

Each point in the retina → Cluster of 3 receptor types

Perception of color → Comparison of the relative activation of each receptor

3 receptors activated at the same time → White color



Response to illumination

OBJ. # 5

Photoreceptors → Changes in membrane potential

↓

Horizontal cells ← Lateral inhibition (modulation) can increase sensitivity of edges - increase the contrast

↓

Bipolar cell

↓

Amacrine cells ← Lateral inhibition (modulation)

↓

Ganglion cell ← The only cell to fire action potentials

↓

Final retinal output

Retinal Processing

OBJ. # 5

Retinal Output

Some ganglion cells	→	Inform the brain about light intensity
Some ganglion cells	→	Inform the brain about moving objects within their receptive fields
Some ganglion cells	→	Inform the brain about object shape and color vision

Types Of Ganglion Cells

OBJ. # 5

Parasol cells:

- Seem to detect stimulus movement
- Large cell bodies, large dendritic field
- Project to the Magnocellular layer of the LGN

P cells, (midget cells):

- Information about shape and fine details
- Sensitive to differences in wavelength – color
- Small cell bodies, smaller dendritic field
- Project the the parvocellular layer of the LGN

OBJ. # 5

Retinal Output

Brain receives information about different processes

Parallel processing

2 eyes

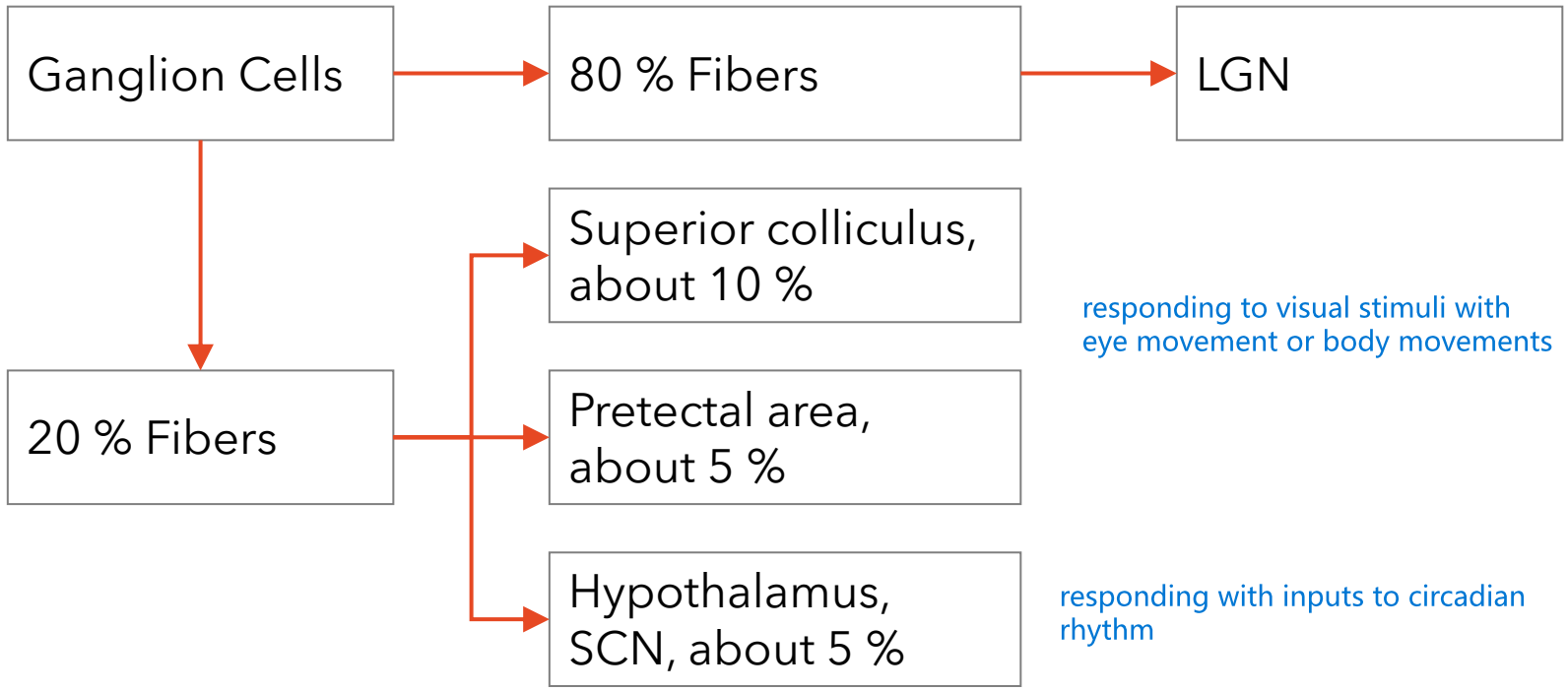
Each point in space is viewed by

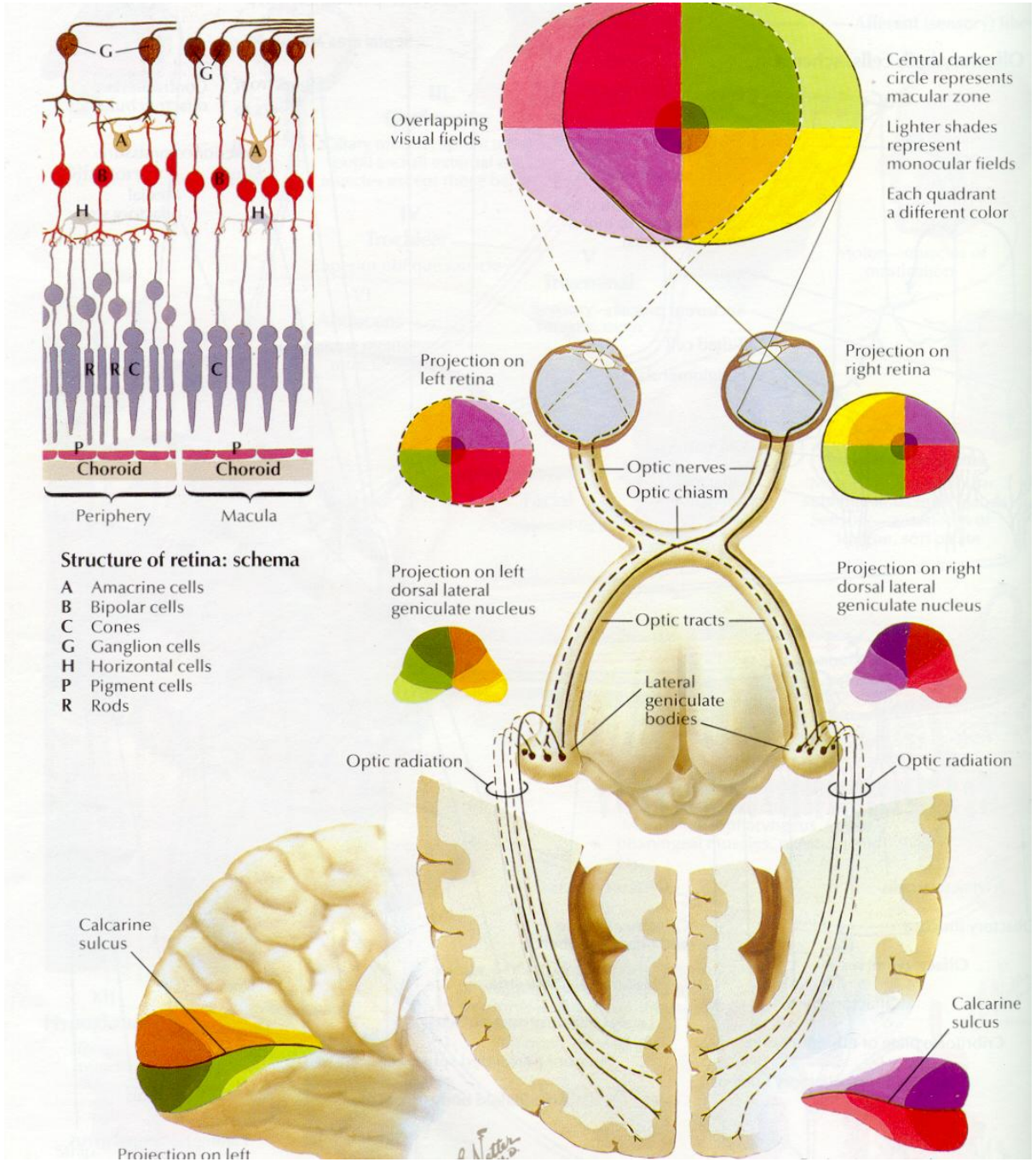
- Magnocellular ganglion cells
- Parvocellular ganglion cells
- Intermediate ganglion cells

6 cells for each point in space

Retinal Output

OBJ. # 5




G
G
A
A
B
B
H
H
R R C
C
P
P
Choroid
Choroid
Periphery
Macula
Structure of retina: schema
A Amacrine cells
B Bipolar cells
C Cones
G Ganglion cells
H Horizontal cells
P Pigment cells
R Rods
Overlapping visual fields
Central darker circle represents macular zone
Lighter shades represent monocular fields
Each quadrant a different color
Projection on left retina
Projection on right retina
Optic nerves
Optic chiasm
Projection on left dorsal lateral geniculate nucleus
Projection on right dorsal lateral geniculate nucleus
Optic tracts
Lateral geniculate bodies
Optic radiation
Optic radiation
Calcarine sulcus
Calcarine sulcus
Projection on left

OBJ. # 5