24/2/25

Biochemical pathways regulating the Function of Sensory Organs

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Sensory Organs and Sensory Neurons

stimulus light.

Vision >

lecture #3

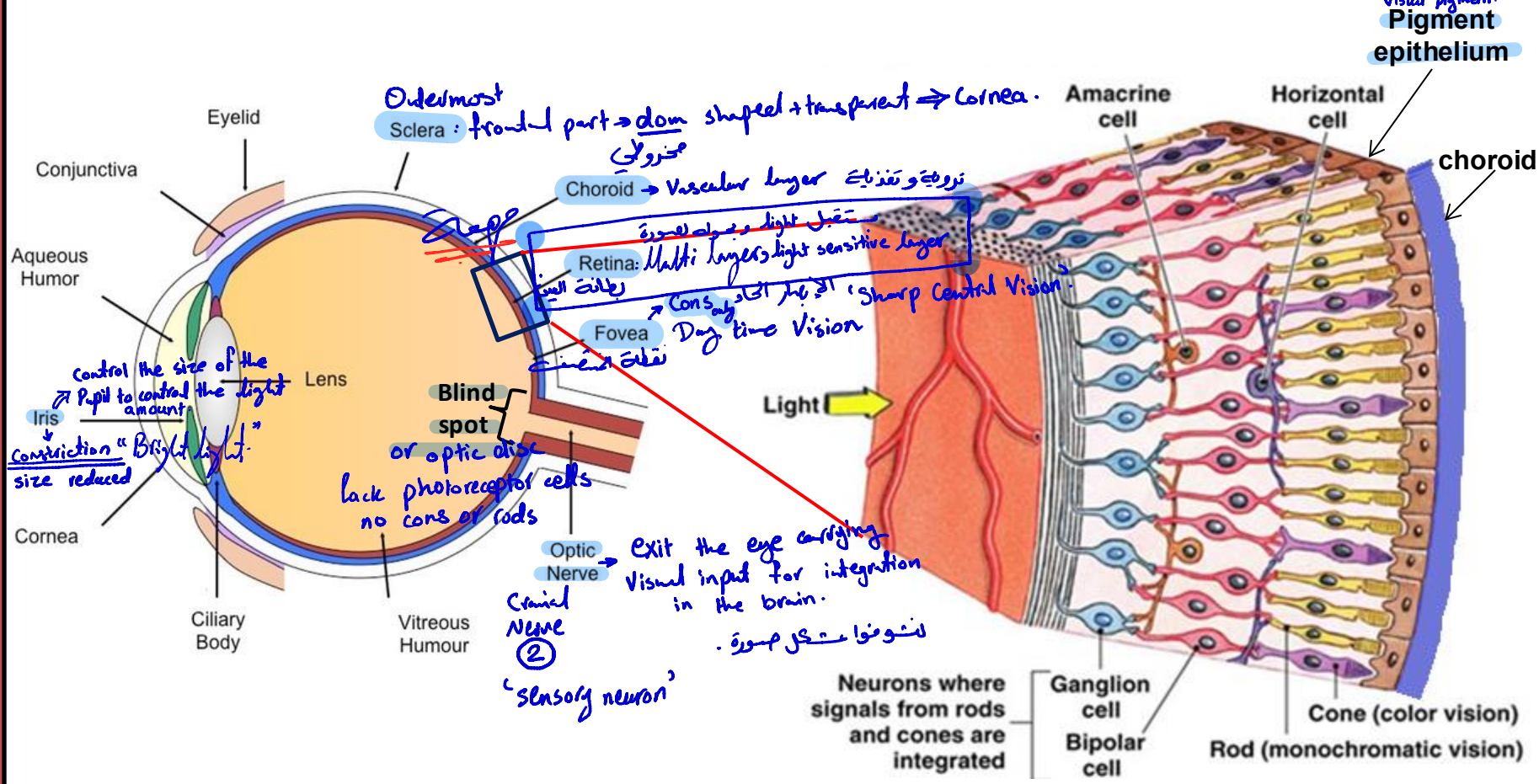
Olfaction >

Taste >

Biochemistry of Vision

The Structure of Human Eye

lens → to focus & direct the light to the retina.



Optic N: cluster of all ganglion cells 'axons' → Nerve fiber

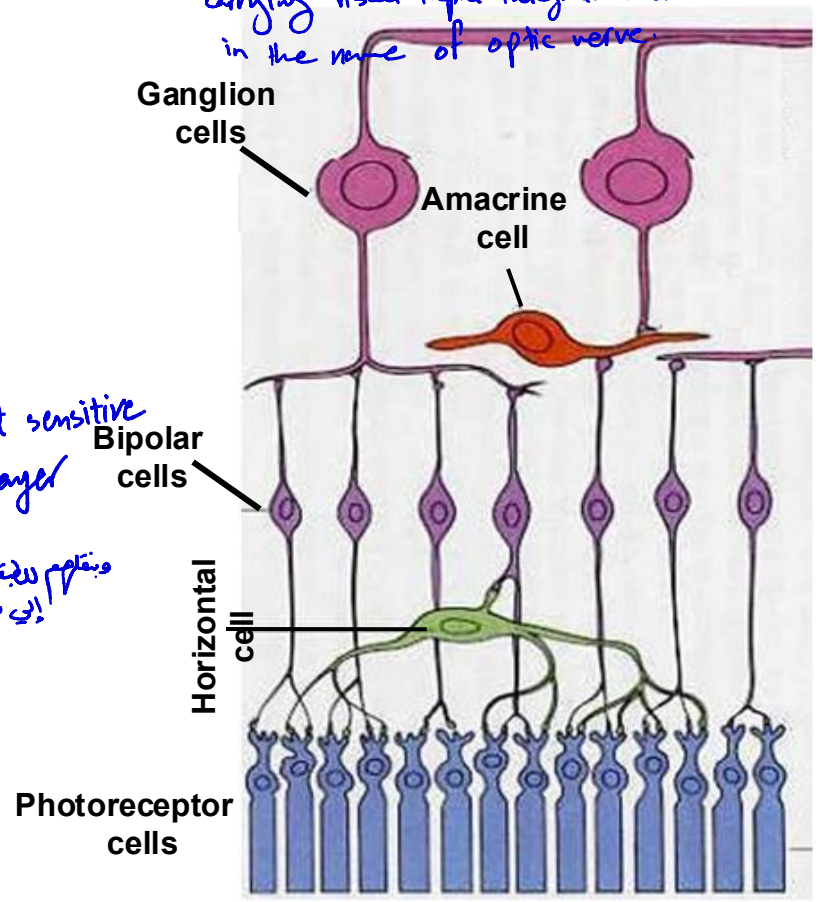
The Structure of Retina

- The retina has **3 layers of neurons** (the photoreceptor, the bipolar and the ganglion cells) and **2 layers of synapses** including the unique ribbon synapses or lateral connection via the horizontal and amacrine cells
- Horizontal cells make synapses with rods, cones and bipolar cells whereas the amacrine cells connect bipolar with ganglion cells. **Thus horizontal and amacrine cells are involved in the indirect path of visual input transmission.** / Lateral connection.

light sensitive layer

↳ direct synapse

- All the axon of the ganglion cells cluster togather to form nerve fibers.
  ↳ collection of these will go to optic disc carrying visual input integration of the brain in the nerve of optic nerve.

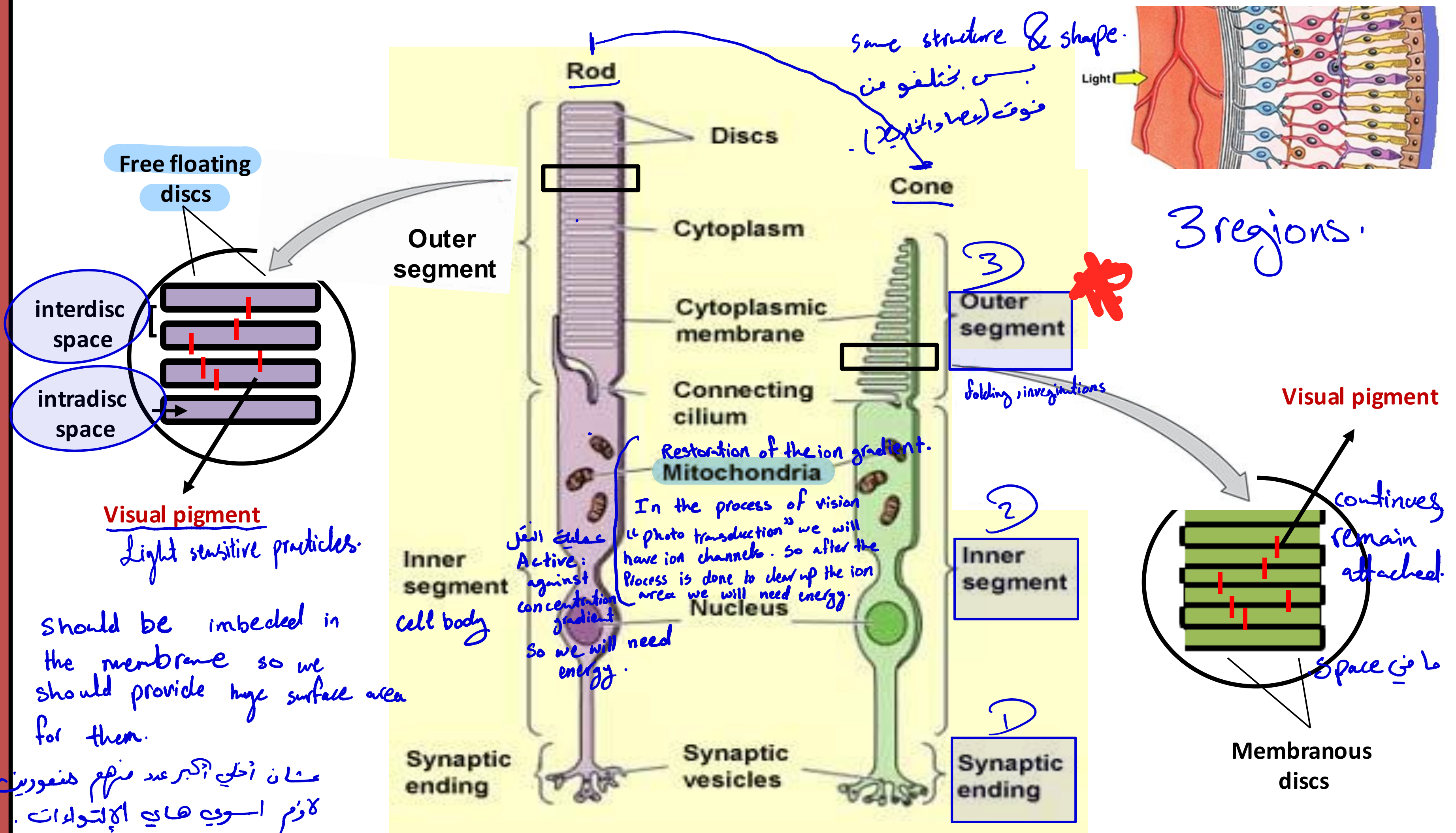


Neuronal cells sensitive to the light.

Photoreceptor cells

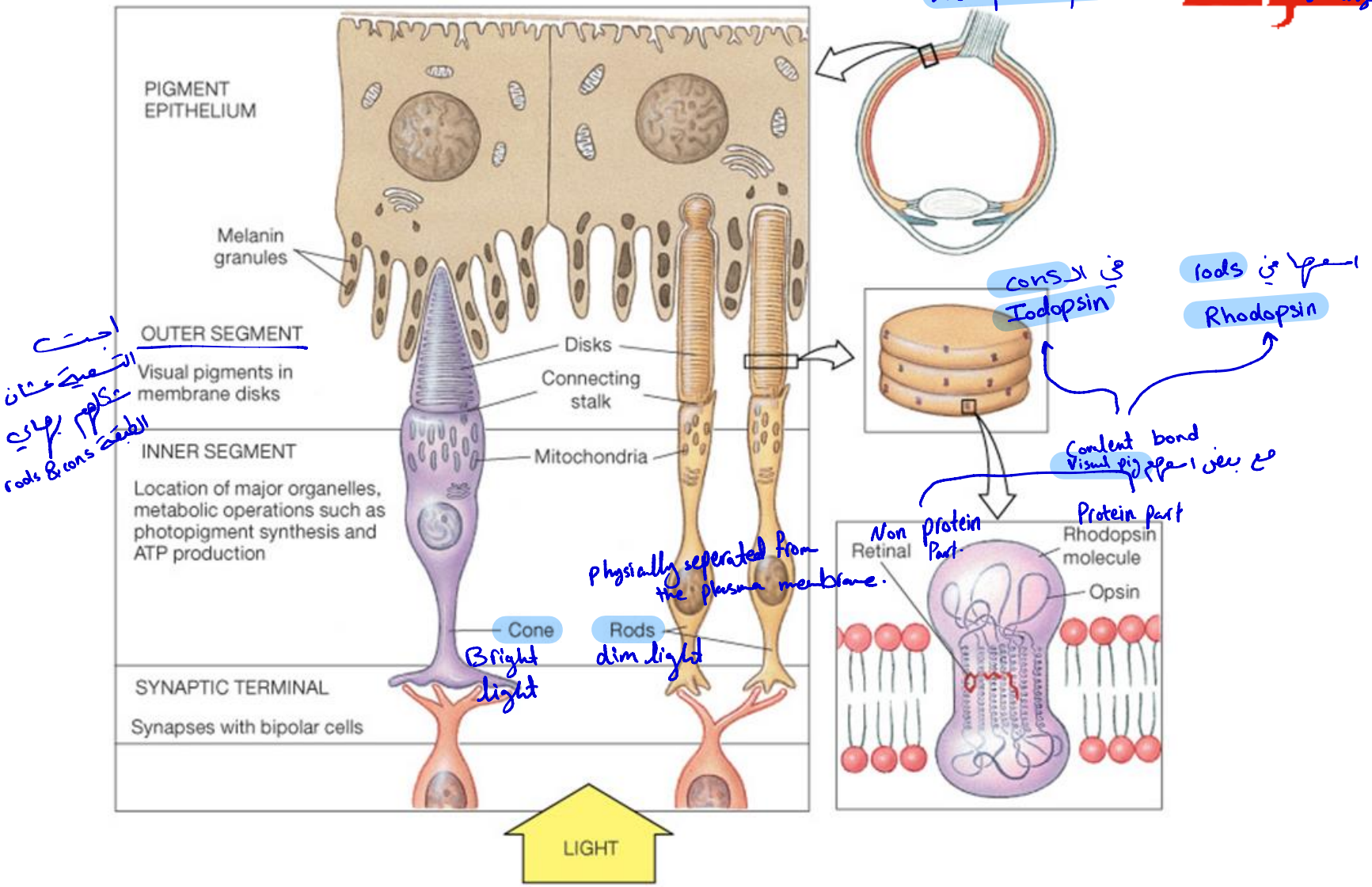
Visual pigment

Retina contains two types of photoreceptors:



Same structure & shape.
بس تختلف من فوق (مع اختلاف).
3 regions.
Folding, invaginations
Restoration of the ion gradient.
In the process of vision "photo transduction" we will have ion channels. So after the process is done to clear up the ion area we will need energy.
Active: against concentration gradient so we will need energy.
Cell body
Light sensitive particles.
Should be imbeded in the membrane so we should provide huge surface area for them.
عشان أخلي أكبر عدد منهم منفوسين لازم أسوي هاي الإلتواءات.
continues remain attached.
Space ما في

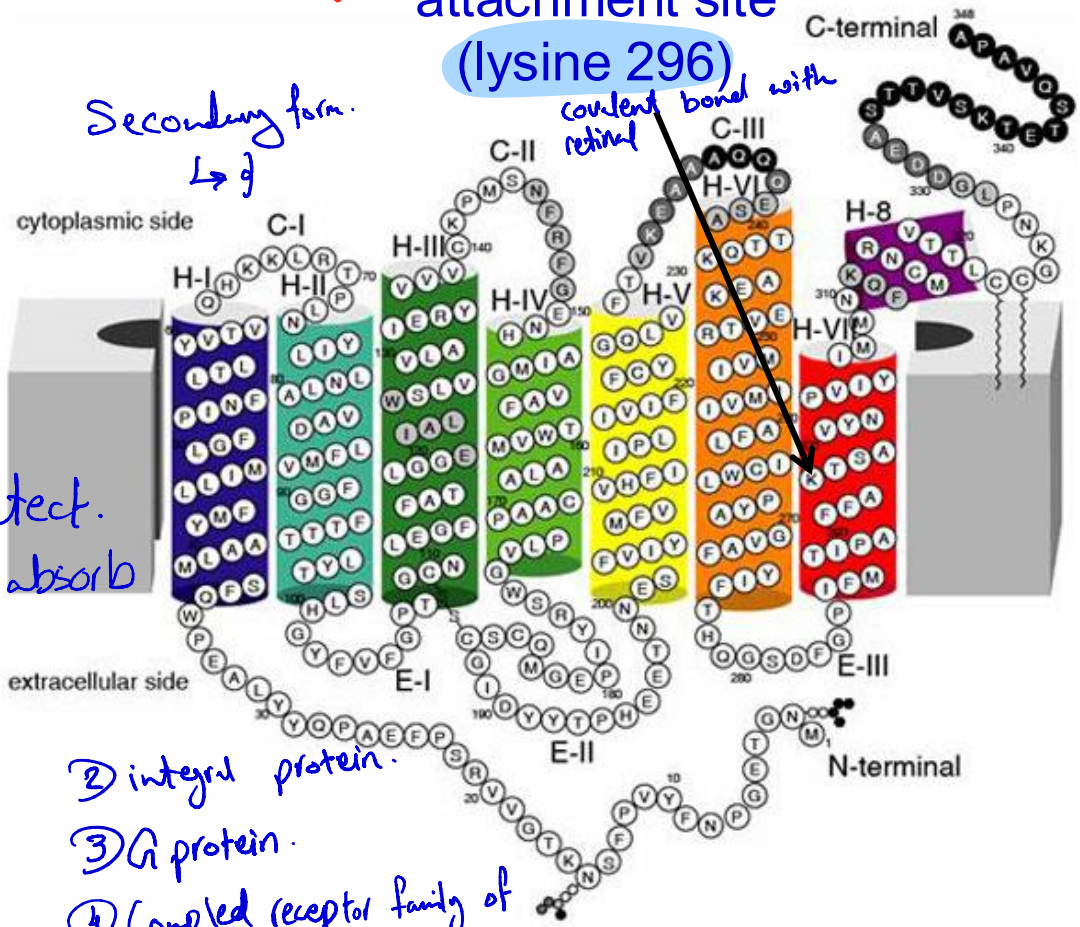
Visual Pigment



Outer segment of the pigmentation is the visual pigment peering portion of the photoreceptor cells

Structure of Rhodopsin

- Rhodopsin is the only visual pigment in rods
- It consists of the transmembrane protein (GPCR) called **opsin** and light sensitive moiety called **retinal** (the aldehyde form of Vitamin A)



Receptor form of the light.

Secondary form. ↳ β

covalent bond with retinal

Can detect & absorb

non protein part.

② integral protein.

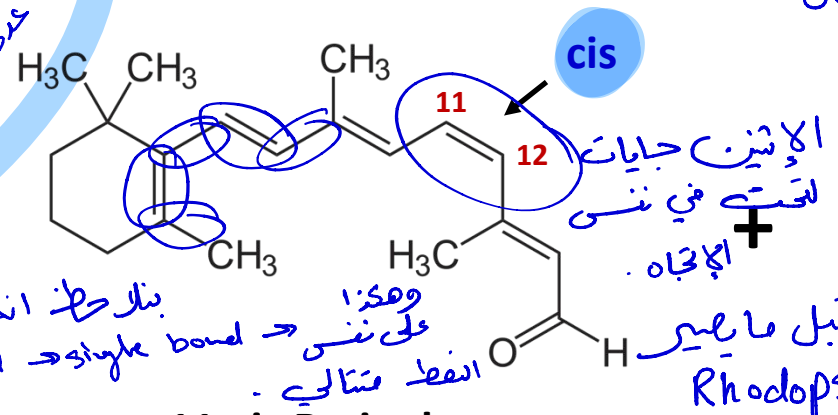
③ G protein.

④ Coupled receptor family of proteins.

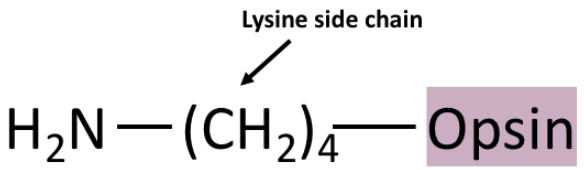
Rhodopsin ⇒ ligand preboned 'Retinal' ⇒ till it will be stimulated with the light.

Retinal Binding to Opsin

Stereoisomerase in the alkine



11-cis Retinal



Opsin

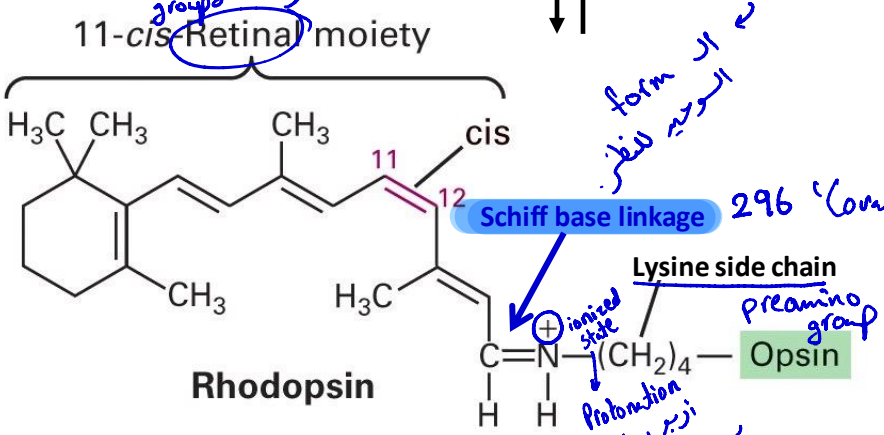
Rhodopsin.

double bond → single bond

Conjugate system will have colour.

Vitamin A

Retinal / Retinoic acid.



Rhodopsin

296 'Covalent & Reversible'

+ H_2O

stimulation

Cis → Trans.

→ Active Rhodopsin.

Trans → cis

Rods
نوع واحد بس عشان
حساس بالعتمة مابفيز
الألوان.

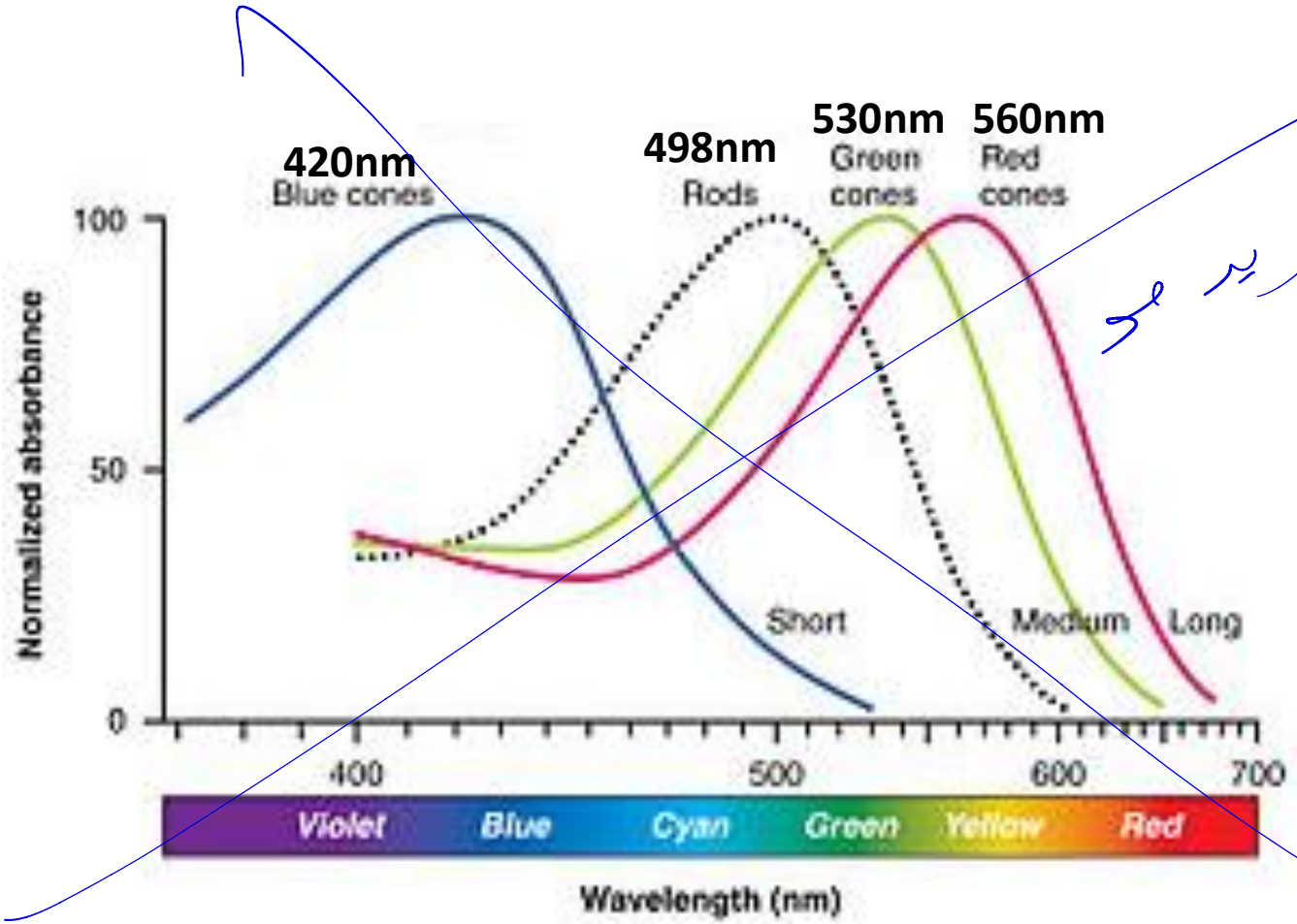
Iodopsin

- Iodopsin is the visual pigment in cones consisting of cone opsin protein (photopsin) and the same light sensitive moiety: retinal
- 3 different types of iodopsins and consequently 3 different types of cone cells (which give us color vision):

Absorb the light wave at different wave length. sensitive long wave length light.

1. L cones (photopsin I + retinal) ⟶ red light, ~~560nm~~
2. M cones (photopsin II + retinal) ⟶ green light, ~~530nm~~
3. S cones (photopsin III + retinal) ⟶ blue light, ~~420nm~~

3 Different Cones



Phototransduction

- Phototransduction is the process by which the light detected by photoreceptor cells in the retina is converted into electrical (or cellular) signals.

كيف بتصير العملية ؟

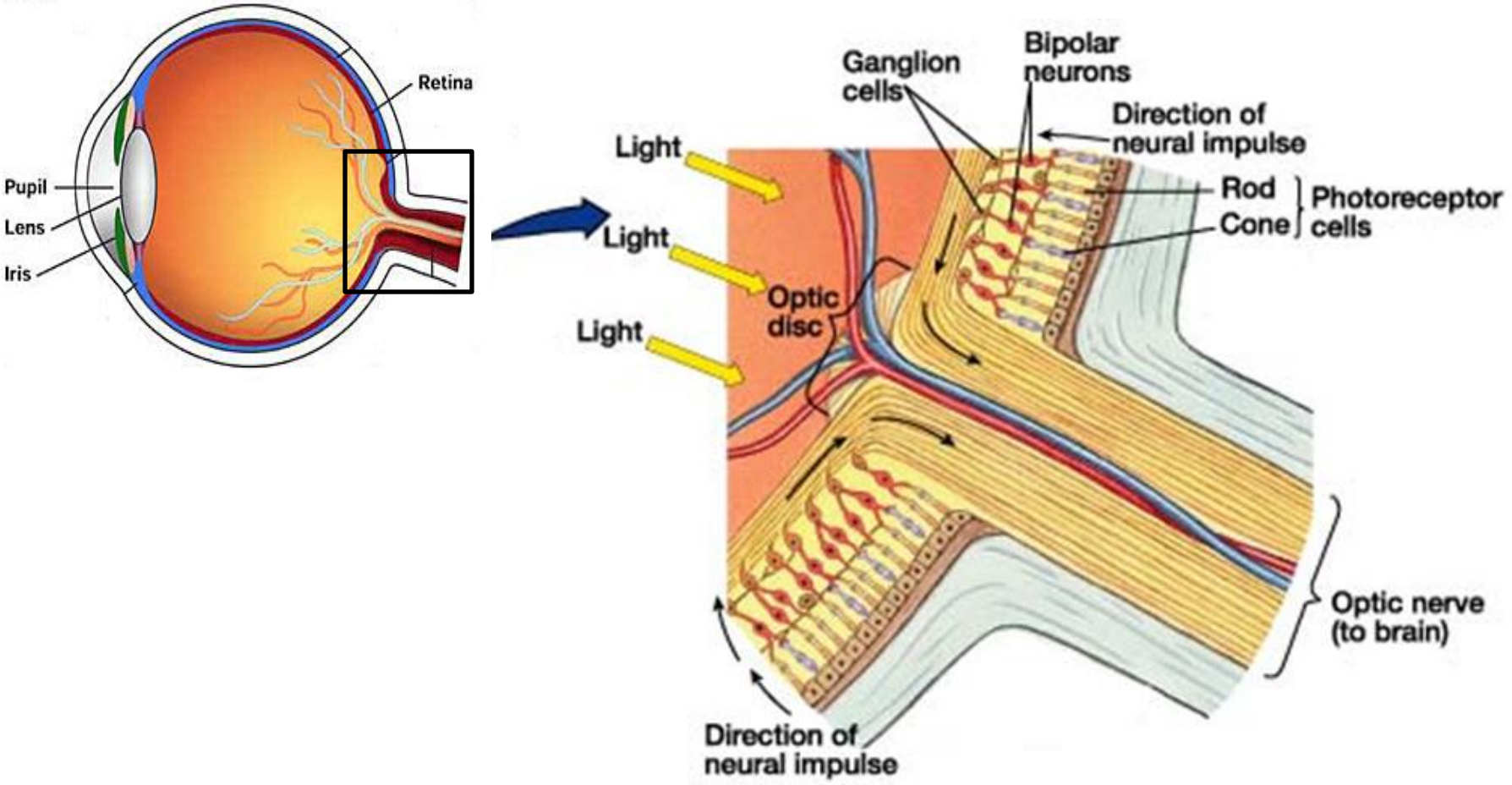
الضوء بسقط على العين على lens بتحوله على Retina ، بتخترق طبقات ال Retina كلها وبعدين بوصل لل outer segment و

يمتصه ال Visual segment وبتغير cys ل Trans بعدين ال light بتحول ل electrical segment لأنه تتكون معرضة أيونات تدخل و

تطلع . light response ← electrical signal ← cellular signal. ← بصير active G-protein ← بعدين بصير 2nd messenger.

وهاي التغيرات بتنعكس ع شكل visual input وبتصير عملية vision.

Phototransduction



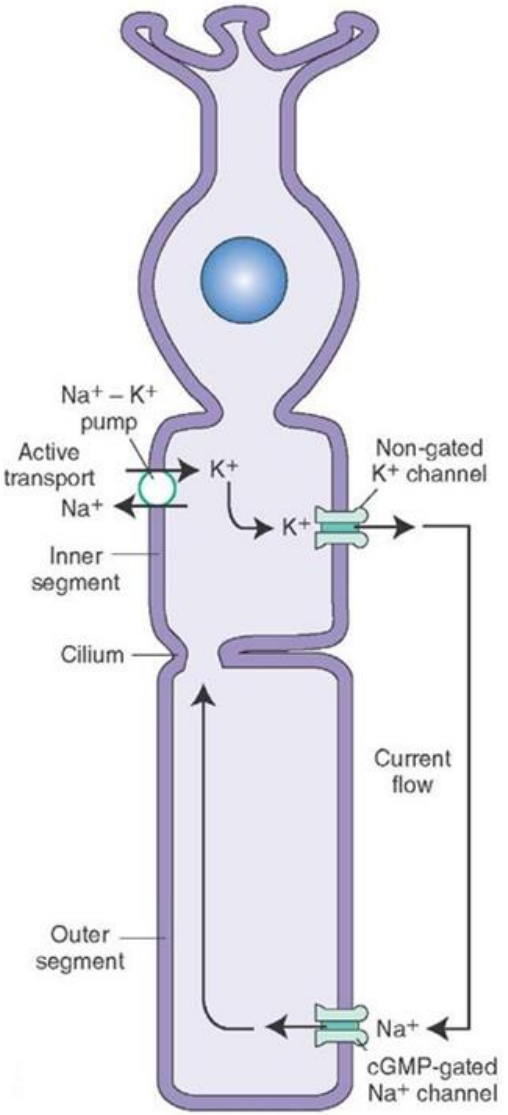
Phototransduction

- Phototransduction is the process by which the light detected by photoreceptor cells in the retina is converted into electrical (or cellular) signals.
- These are transmitted as nerve impulses back through layers of retina to optic nerve fibers
- The optic nerve carries the information to the brain to be processed there
- What is the molecular mechanism involved in visual cycle and how does the absorbed light create a response ?

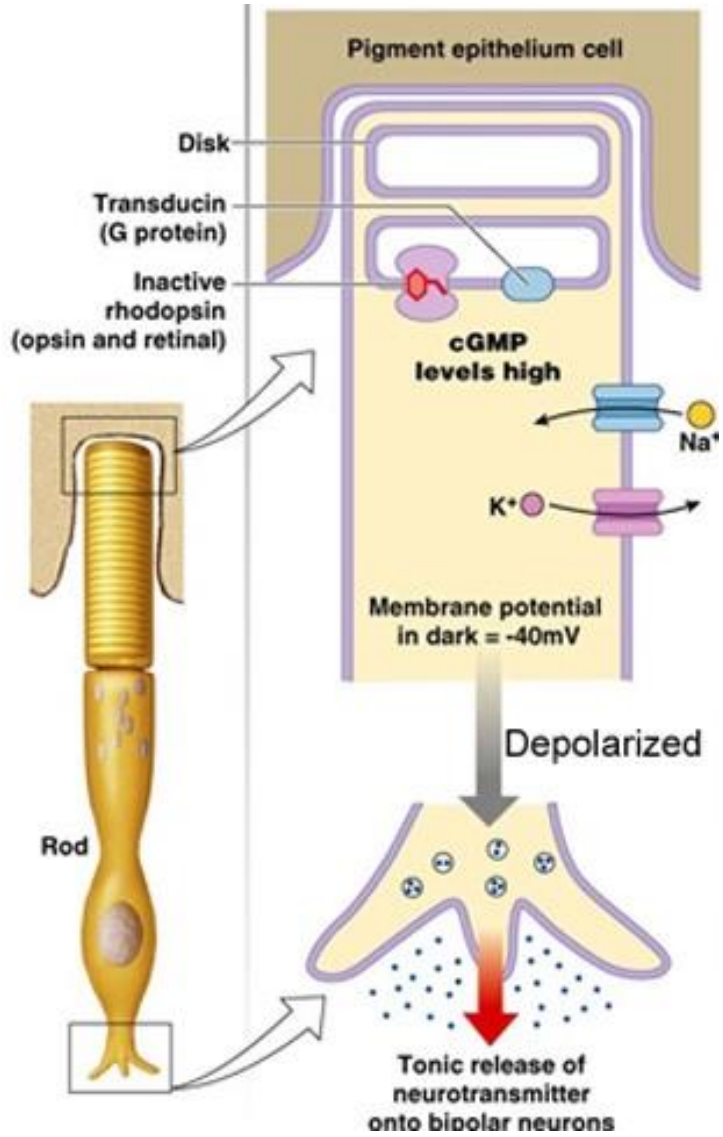
Phototransduction Cascade

- In the absence of light, the photoreceptor cell is in the depolarized state with membrane potential of -40 mV. This depends on:

1. **Non-gated K^+ channel:** outflux of **K^+** (ongoing outward K^+ current)
2. **cGMP-gated Na^+ channel:** influx of **Na^+** (inward Na^+ current known as **dark current**)
3. **Na^+- K^+ pump:** it is an active transport requires ATP (to transfer 3 **Na^+** out and 2 **K^+** in)

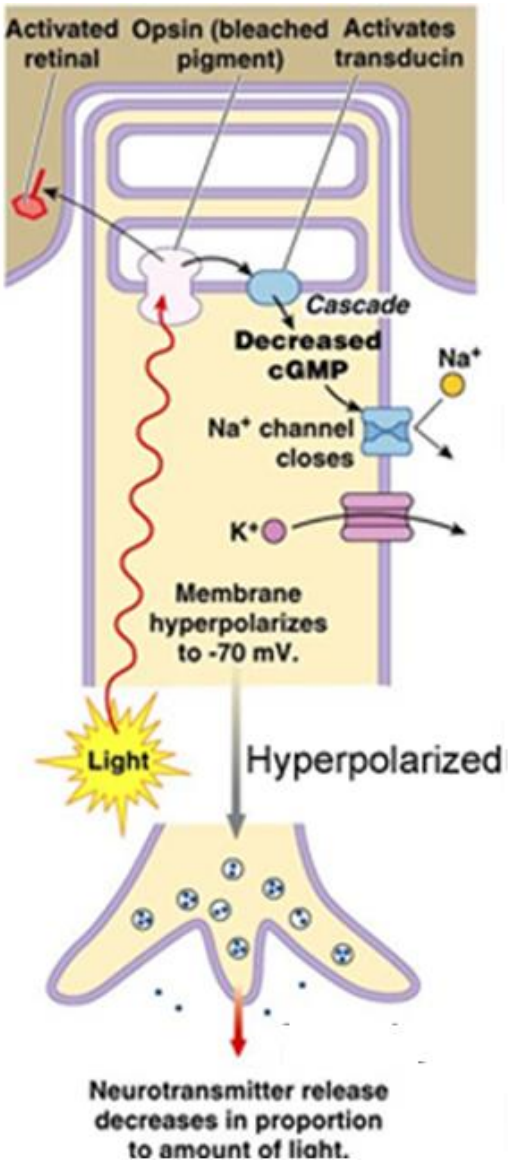


Phototransduction Cascade



- In darkness, **rhodopsin is inactive** and cGMP level is high thus Na^+ channels are open.
- The neurotransmitter molecules are released from synaptic terminal of photoreceptor cell.

Phototransduction Cascade



In presence of light, a series of changes occur within **rhodopsin** which activate a downstream signaling cascade resulting in the **closure of Na^+ channels**. Indeed, rhodopsin dissociates, the activated opsin decreases **cGMP** which in turn closes Na^+ channels and **hyperpolarizes** the cell. Consequently, less neurotransmitter molecules are released.

Photoisomerization of retinal

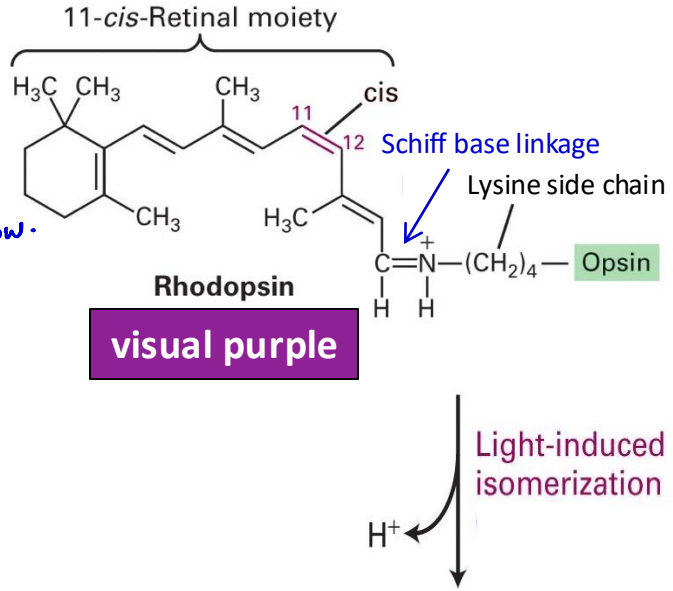
photobleaching ?

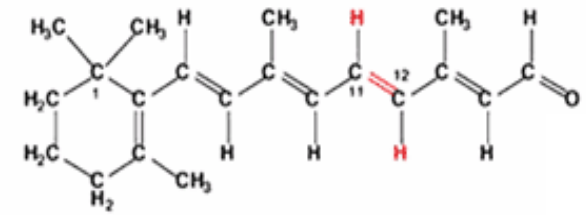
[cyst] inactive rhodopsine

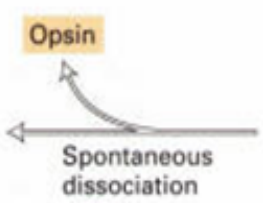
[All trans] meta rhodopsine 2.

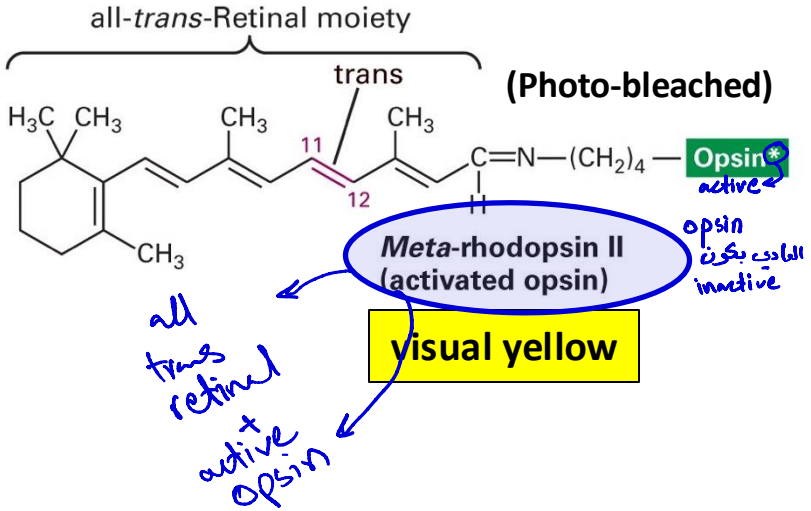
Visual purple → Visual yellow.

. colour فقد

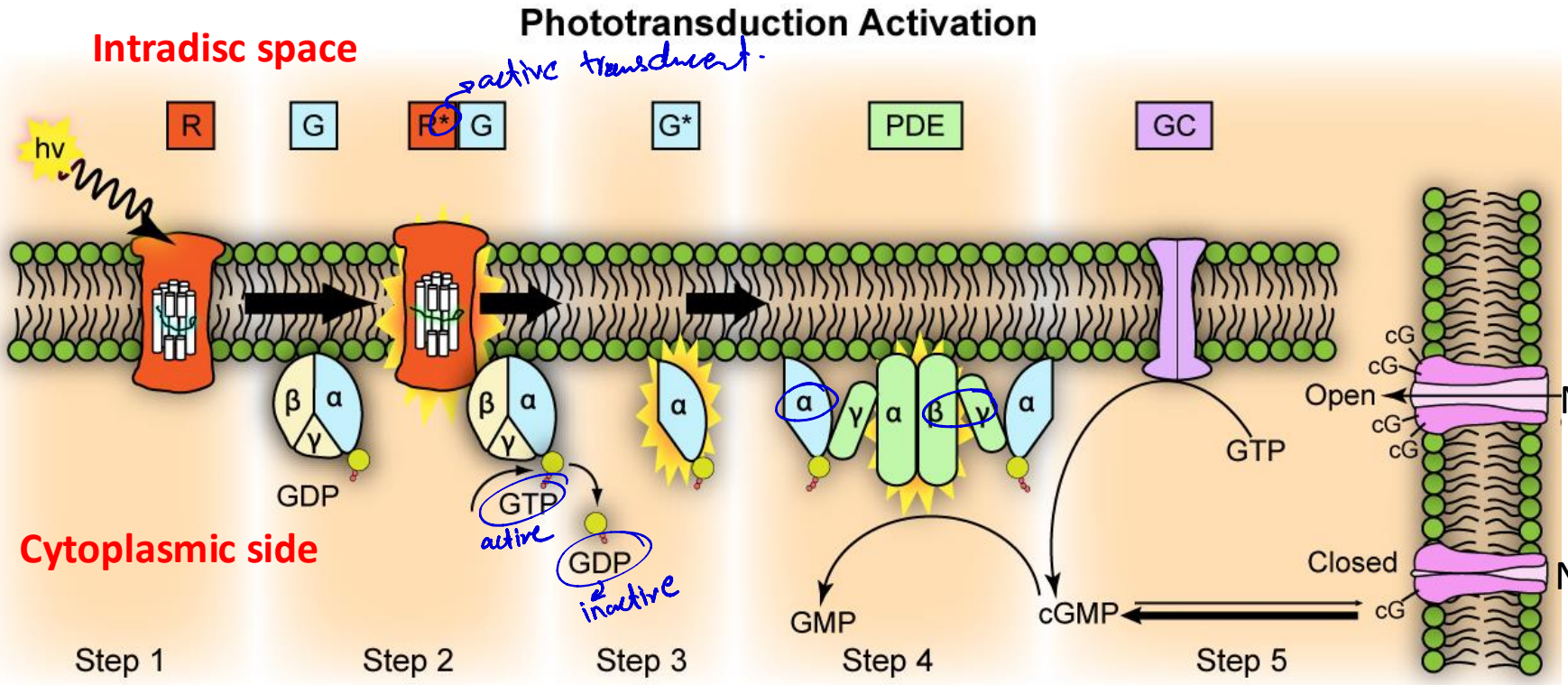








G-protein signaling pathway



G-protein signaling pathway

- The activated rhodopsin (**R***) binds to and activates the heterotrimeric G-protein "transducin" by exchanging its GDP with GTP
- The α-subunit of transducin bound to GTP (the activated transducin, **G***) dissociates from its β and γ subunits
- **G*** binds to the inhibitory γ subunits of phosphodiesterase enzyme (PDE) activating its two catalytic subunits: α and β. The activated PDE converts cGMP to GMP so reduces the cGMP level and consequently the closure of **Na^+ channels**. Thus, the membrane is hyperpolarized and the rate of neurotransmitters release is reduced
- Normally, Guanylyl cyclase (GC) enzyme synthesizes cGMP from GTP. **So cGMP is the second messenger in phototransduction cascade**

#part 1.