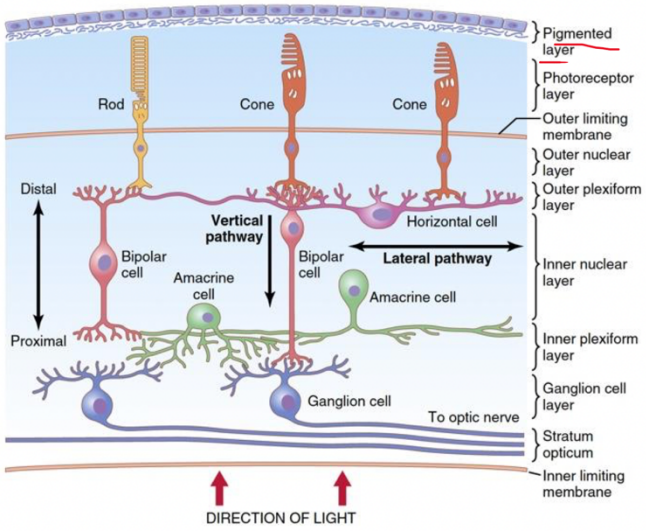
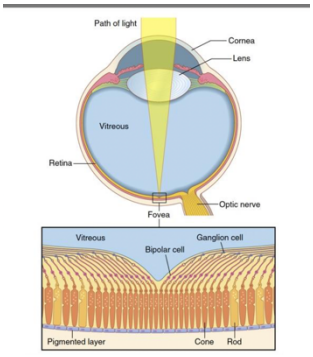
Sereen Draghmeh

Vision-II



- This is the **retina**
- Has **mainly two layers**, the **pigmented layer** and the **neural layer** and then there are **sublayers**
- The **light** will **enter** through the **inner limiting membrane all the way** to enter the **pigmented layer** at the **outer segment**
    - then the **signaling pathways processing** occurs the **opposite way** (in which from the picture we can see that the light enter from the bottom and will go to the bottom so the signaling pathways will start from the top and go down)
- This is in **all parts of the retina except for two parts**:
    1. The **optic disc** since **no photoreceptors** are present (we only have optic nerve and vessels there, no rods or cones)– **blind spot**
    2. There is a depression in the retina called the **fovea centralis**
        a. The picture here shows that the **fovea neural cells displaced** to the **periphery** in which the **light rays** will **directly go to the photoreceptors**
        b. Its **directly** in the **central of the retina**
        c. **No neural cells** on **top** of the **photoreceptor** cells in the **retina** so the **light will go directly** to **these photoreceptors**
        d. Its **important** for **visual acuity** since there is **no distraction of light** like the **other areas**

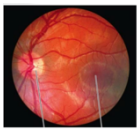


Fovea

- **Light must pass through** the **ganglion** and **bipolar layers before reaching** the **photoreceptors** in **all areas** of the **retina except** the **fovea**, **located** in the **center** of the **retina**.
- Because of this feature, and because **only cones** (which have greater acuity or discriminative ability than the rods) are **found here**, the **fovea** is the **point** of **most distinct vision**.
- The **fovea** is a **minute area** in the **center of the retina**, especially **capable** of **acute and detailed vision.**
- The central fovea is composed **almost entirely of cones**. These **cones** have a **special structure** that **aids their detection** of **detail** in the **visual image**–that is, the **foveal cones** have **especially long and slender bodies**, in **contradistinction** to the **much fatter cones** located **more peripherally in the retina**.
  - **Concentration** of the **cones** is the **highest in the central fovea** (no rods)
    - The **cones** are **found more in the central part** while the **rods** are found more in the **periphery**
  - Plus the **shape of the cones** are **more cylindrical** than the **periphery** which plays a **role** in the **acuity of the vision more photopigment packed** in this **area** so **more processing of light**
- Also, in the **foveal region**, the **blood vessels, ganglion cells, inner nuclear layer of cells**, and **plexiform layers** are all **displaced** to **one side rather than resting directly on top** of the **cones**, which **allows light to pass unimpeded to the cones**.

Macula

- The **area immediately surrounding** the **fovea is called the macula lutea**, has a **high concentration** of **cones** and **fairly high acuity.**
- **Macular acuity** is **less** than that of the **fovea because** of the **overlying ganglion** and **bipolar cells** in the **macula**.
- **Macular degeneration**.



  - One of the **most common causes of blindness** in the **elderly** in the **western countries**
  - Patients **cant see** the **center**, they have a **donut type of vision** only the periphery is seen
  - The **structure** in the **picture** on the **left** is the **optic disc** and the **one on the right** is the **macula lutea** in which in the **centre** of it is the **fovea**

Pigment

- Remember the **outer most layer of** the **retina** is the **pigmented layer** and from its name we can conclude it has a pigment
- The **black pigment melanin** in the **pigment layer prevents light reflection throughout** the **eye ball**, which is **extremely important for clear vision**.
  - The **pigment** is to **prevent** the **reflection** of the **light**
- **Albinism**
  - **Normally** when **they see the light** they have **photophobia** and are annoyed by bright light **due** to the **absence** of the **pigment** so **reflection keeps occurring**
  - They **also have other ophthalmologic symptoms** and signs

Vitamin A

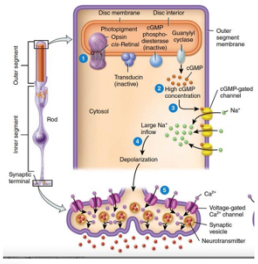
- The **pigment layer** also **stores large quantities of vitamin A**. That is **exchanged back and forth through** the **cell membranes of the outer segments** of the **rods** and **cones**, which are **embedded** in the **pigment**.
- vitamin A is an **important precursor** of the **photosensitive chemicals** of the **rods** and **cones**.
  - Vitamin A is one of the **components in the retina**
  - **Very rare to have significant vitamin A deficiency** since its **stored** in the **liver** so **very unlikely** to have **significant vitamin A def**
- **Night blindness**
  - **Due to vitamin A def**

Photoreceptors

- The **major functional segments** of **either a rod or cone are**:
  - (1) the **outer segment**
    - **Towards** the **sclera**
    - **Where phototransduction takes place**
  - (2) the **inner segment**
    - **Towards** the **vitreous humor**
  - (3) the **nucleus**
  - (4) the **synaptic body**.
    - Which means there are **neurotransmitters that will be released** to **communicate with the next cell**
- The **light-sensitive photochemical** is **found** in the **outer segment**. In the case of the **rods**, this **photochemical** is **rhodopsin**; in the **cones**, it is **one of three "color" photochemicals**, **usually called simply color pigments**, that **function almost exactly** the **same** as **rhodopsin except** for **differences in spectral sensitivity**.
- In the **outer segments** of the **rods and cones**, note the **large numbers of discs**. **Each disc** is **actually** an **infolded shelf of cell membrane**. There are as many as 1000 discs in each rod or cone.

- The **inner segment** of the **rod** or **cone contains** the **usual cytoplasm**, with **cytoplasmic organelles**. **Especially important** are the **mitochondria**, which **play** the **important role** of **providing energy** for **function** of the **photoreceptors**.
- The **synaptic body** is the **portion** of the **rod** or **cone** that **connects with subsequent neuronal cells**, the **horizontal and bipolar cells**, which **represent the next stages** in the **vision chain**.
- **Both rhodopsin** and the **color pigments** are **conjugated proteins**. They are **incorporated into the membranes** of the **discs** in the **form of transmembrane proteins**.
- The **concentrations of these photosensitive pigments** in the **discs** are **so great** that the **pigments themselves constitute about 40%** of the **entire mass** of the **outer segment**

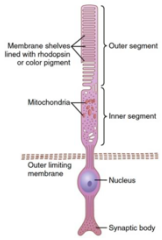
Photo-transduction



- In the **rods** the **outer segment** are like **discs packed** all **together** and these **packed discs** are like **membranes** that **contain the photosensitive chemical/pigment** which are **transmembrane proteins**
- The **rods contains many discs** which **means there is a high concentration** of **photopigments** which is **important to increase sensitivity to light**
- This **photosensitive chemicals are made up of 2 parts**: **retinal** (**cis retinal**- resting stage) and **opsin** (different in rods and cones, in **rods scotopsin** and in the **cones** its called **photopsin**, there are different types)
- In the **outer segment** of the **cell** is a **high concentration** of **cGMP** which is **important** since we have **cGMP ligand gated sodium channels** which **attach** to **cGMP**
  - **During resting stage -dark**
    - When the **cGMP attaches** to the **cGMP ligand gated sodium gated channel** it will **cause** the **channel** to **open causing influx** of **sodium** which **causes depolarization**
    - This **depolarization** will **reach** the **synaptic terminal** which has **voltage gated calcium channels** that will **activate** them **causing influx of Ca2+**
    - The **influx of Ca2+** will **stimulate** this **cascade of events** to **cause exocytosis releasing** the **neurotransmitter glutamate** which is an **excitatory neurotransmitter** but we are in the resting stage
- **During excitatory stage - light**
  - When **the light comes** it will **activate rhodopsin** (**retinal + scotopisin**)

- when the **light comes** the **retinal will change** from **cis to trans** which will **cause** it to **detach** from the **opsin** and **activate transudcin** which will **activate** the **phosphodiesterase**
- so **decreasing cGMP** so no **cGMP binding** to the **cGMP ligand gated sodium channels** so **no opening** of **the Na+ cahnnnel**
- So **hyperpolarization occurs receptor potential** so **no Ca2+ influx** so no **neurotransmitter release**

- This **phototransduction** in **rods** is **very brief** and we **know that there is regeneration** of **retinal** to **reconvert to 11-cis retinal** so that it **can go back to normal**
  - This **process** of **regeneration** will take **some time**

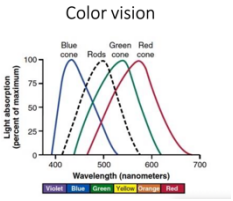


- The **outer segme**nt of the **rod that projects into the pigment layer** of the **retina** has **light-sensitive pigment** called **rhodopsin**.
- This **substance** is a **combination of the protein scotopsin** and the **carotenoid pigment retinal**.
- **Furthermore**, the **retinal** is a **particular type called 11-cis retinal**. This **cis form** of **retinal** is **important because** only this **form** can **bind with scotopsin** to **synthesize rhodopsin**.
- **all-trans retinal no longer fits** with the **orientation of the reactive sites** on the **protein scotopsin**, the **all-trans retinal begins** to **pull away** from the **scotopsin**.
- **Several changes lead** to the **formation of metarhodopsin II**, also **called activated rhodopsin**, that **excites electrical changes in the rods**.
- When **light energy** is **absorbed by rhodopsin**, the **rhodopsin begins** to **decompose within** a **very small fraction of a second**.

Re-formation

- The **first stage in re-formation** of **rhodopsin** is to **reconvert the all- trans retinal into 11-cis retinal.**
- This **process requires metabolic energy** and is **catalyzed by the enzyme retinal isomerase**.
- **Once** the **11-cis retinal is formed**, it **automatically recombines with the scotopsin** to **re-form rhodopsin**, which then **remains stable until its decomposition** is **again triggered** by **absorption of light energy.**

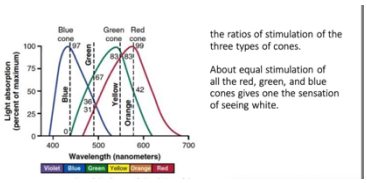
Cones



- We have **3 types of cones** (**Red, Blue and Green**) that **respond** to **different colours** / **wavelength**
  - The **blue cone pigment** is **called S pigment** (S for short wave)
  - The **green cone pigment** is called **M pigment** (M for Medium wave)
  - The **red cone pigment** is called **L pigment** (L for Long wave)
- So these **different types** of **cones** have **different types of photopigments** and **photopsins** to **detect different ranges of wavelengths**
- They can **detect** a **wide range**
- **Photochemicals** in the **cones** have **almost exactly** the **same chemical composition** as that of **rhodopsin in the rods**.
- The **only difference** is that the **protein portions**, or the **opsins–called photopsins** in the **cones**–are **slightly** different from the **scotopsin of the rods**.
- The **retinal portion** of **all** the **visual pigments** is **exactly the same** in the **cones** and **rods**.

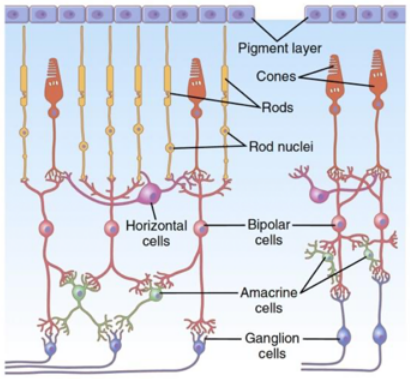
Color vision

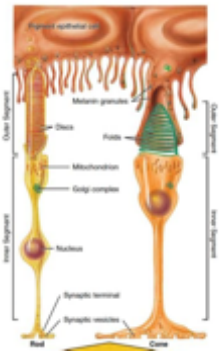
- **Each photopigment maximally absorbs** a **particular wavelength** but **also absorbs** a **range** of **wavelengths shorter** and **longer** than this **peak absorption**.
- The **farther** a **wavelength** is **from** the **peak wavelength absorbed**, the **less strongly** the **photopigment responds**.
- The **absorption curves** for the **three cone types overlap** so that **two** or **three cones** may **respond** to a **given wavelength but to a different extent**.
- **Each cone type** is **most effectively activated** by a **particular wavelength** of **light** in the **range** of **color indicated by its name**.
- **cones** also **respond** in **varying degrees to other wavelengths**.
- **According** to the **trichromatic theory** of **color vision**, the **perception of the many colors** of the **world depends** on the **three cone types' various ratios** of **stimulation** in **response** to **different wavelengths**.
  - For example to describe the different colours we use percentages
    - yellow colour we can explain it by saying its 83,83,0
      - It activates 83 percent form the green cones and 83 percent from the red cone and zero percent of the blue cone activate and this gives sensation of the yellow colour
    - Orange 42 green, 99 red and 0 blue
    - Blue is 97 blue, 0 green and 0 red
    - When we equally stimulate all three cones we get a white colour
  - In colour blindness they see colours they see the different shades but no to the normal degree it also depends on the type of colour blindness



Cones Vs Rods

- **Shape**:
  - **Cones** : **cone like**
  - **Rods**: **rod l**ike
    - Keep in mind though that **there is not much of a difference** in **shape** in the **fovea** since the **cones start looking more cylindrical**
- **Location**:
  - **More cones** in the **center** of the **retina**
  - **Rods**: **more** in the **periphery**
- **Number**:
  - **Rods** are **more common** than the **cones**
- **Sensitivity**:
  - **Rods** are **more sensitive to light**
- **Visual acuity**:
  - **Cones** is more
- **Colour vision**:
  - **Cones** are **used**
- **Pattern** of **synapses**
  - **Rods**: there are **convergence on one bipolar cell**
    - **dim light photons**, **although capable** of **generating receptor potentials** in **rods**, **lack the intensity to trigger action potentials** in **ganglion cells on their own**.
    - **Despite inducing hyperpolarization** in the **rod membrane**, the **signal** is **not strong enough** to **surpass the threshold**. **Therefore**, **multiple rods converge onto a single bipolar cell**, **allowing** for the **summation of receptor potentials** to **reach a level that can propagate action potentials** to **ganglion** cells. This **process contributes** to the **less precise image perceived in darkness**, as the **brain struggles to pinpoint** which **photoreceptor detected** the **stimulus**.
    - **Rods**, **due** to their **numerous presence** and **convergence onto bipolar cells**, are **noted for** their **sensitivity** and **responsiveness** to **low levels** of **light**, even though **individual photons are insufficient** to **trigger ganglion cell action potentials**





Rods vs cones:

shape
location
number
sensitivity to light
visual acuity
color vision

  - **Cones**:
    - **Photons** of **bright light** are **absorbed** by **cones** with **enough intensity** to **independently generate action potentials**. This is **why each cone typically synapses** with **just one bipolar cell**, **enhancing** the **sharpness** of the **image perceived** by the **brain through** the **cone pathway**.
      - **1:1 ratio**

Dark and light adaptation

- In the **dark**, the **photopigments broken down during light exposure** are **gradually regenerated**.
- As a **result**, the **sensitivity** of your **eyes gradually increases** so that **you begin to see in the darkened surroundings**.
- **Conversely**, when you **move** from **the dark to the light**, at **first your eyes** are very **sensitive** to the **dazzling light**.
- As **some** of the **photopigments** are **rapidly broken** down by the **intense light**, the sensitivity of the **eyes decreases** and **normal contrasts can again be detected**, a **process known** as **light adaptation**.

Photoreceptor	Sensitivity to Light	Acuity	Dark Adaptation	Color Vision
Rods	Low threshold Sensitive to low-intensity light Night vision	Low acuity Not present on fovea	Adapt late	No
Cones	High threshold Sensitive to high-intensity light Day vision	High acuity Present on fovea	Adapt early	Yes

Night blindness

- Our **eyes' sensitivity can change as much** as **1 million times** as **they adjust** to **various levels** of **illumination through dark** and **light adaptation**.
- **Because retinal** is a **derivative of vitamin A**, **adequate amounts** of this **nutrient must** be **available** for **synthesis of photopigments**.
- **Night blindness occurs** as a **result** of **dietary deficiencies of vitamin A.**

Adaptation

- These **adaptive measures** are also **enhanced** by **pupillary reflexes** that **adjust** the **amount** of **available light permitted** to **enter** the eye.
- The **other mechanism** is **neural adaptation**, **involving** the **neurons** in the **successive stages** of the **visual chain** in the **retina and** in the **brain**.