

Fondamenti di bioingegneria

***Laurea in
Ingegneria Informatica, Biomedica e delle
Telecomunicazioni***

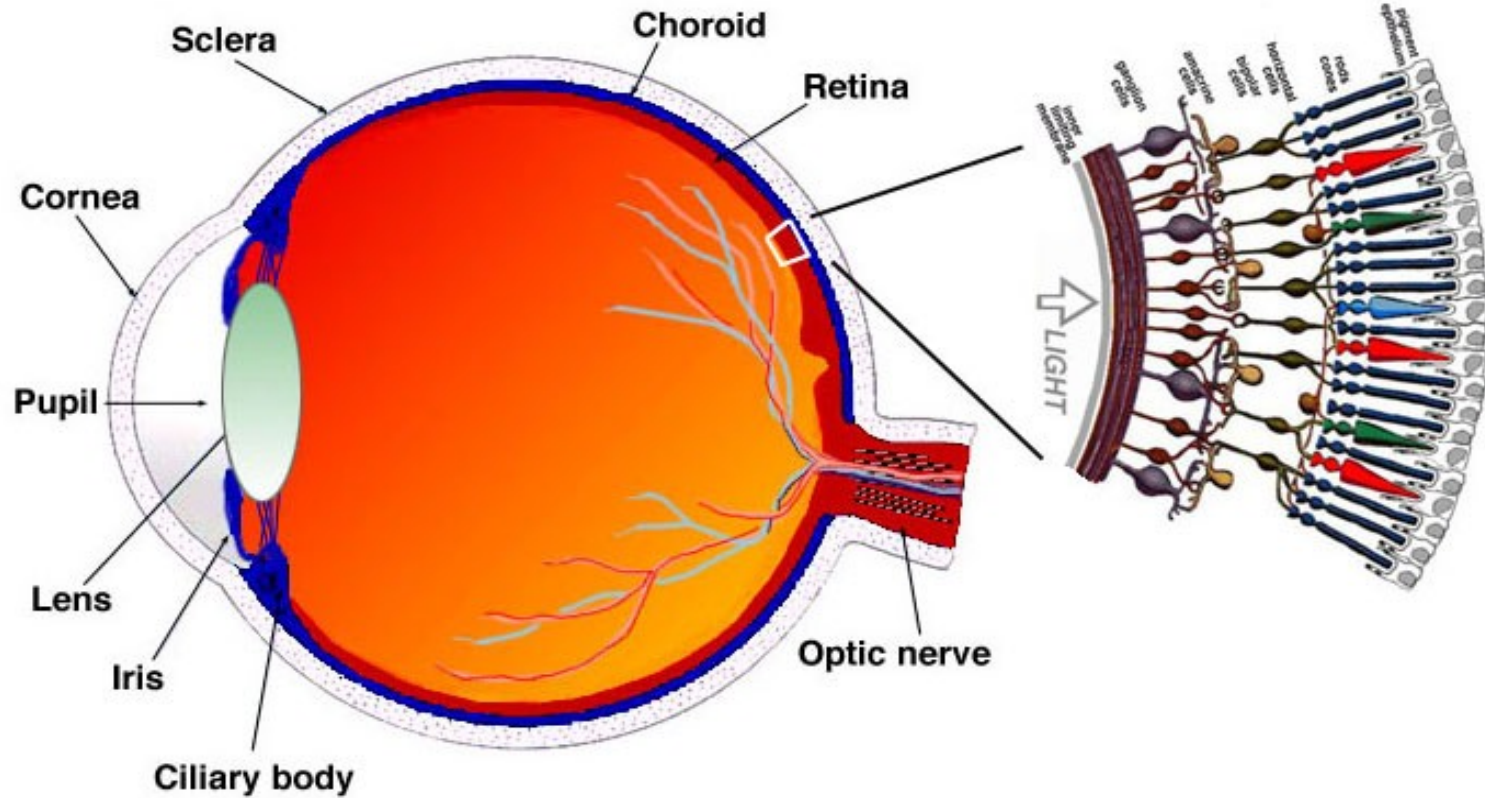
Fabio Baselice

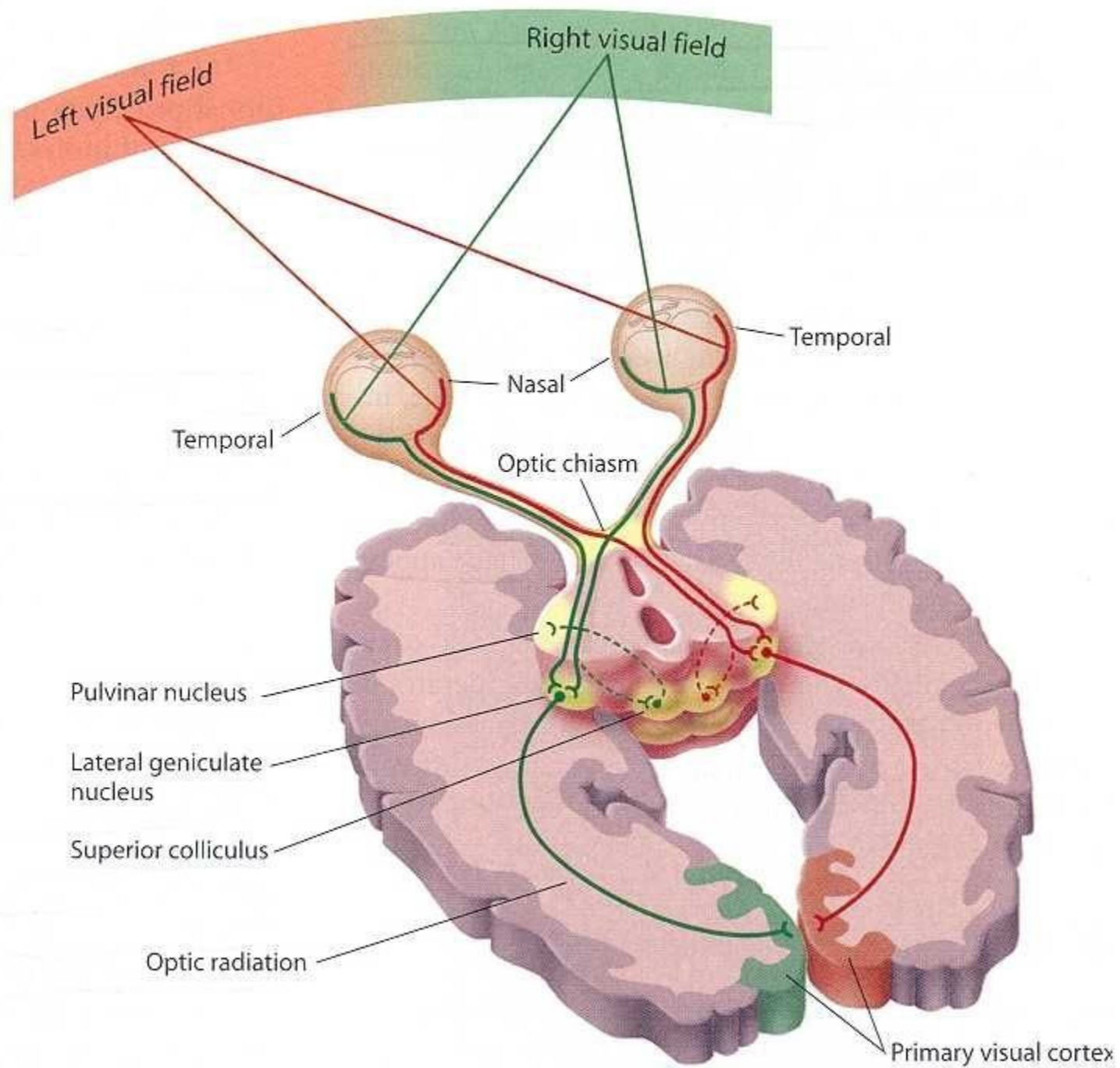


Argomenti

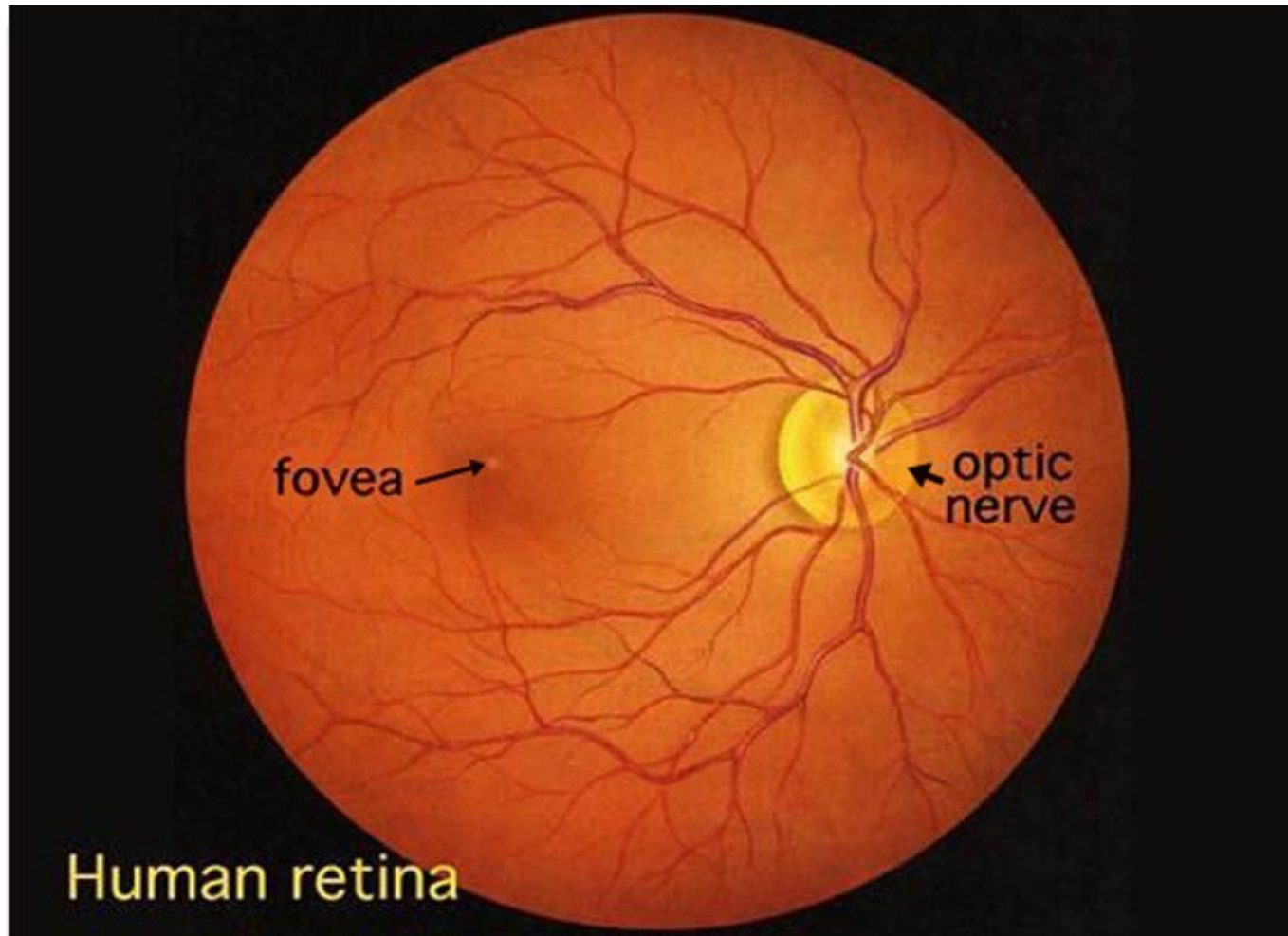
- Anatomia della visione
- Elettroretinogramma (ERG)
- Elettrooculogramma (EOG)

L'occhio

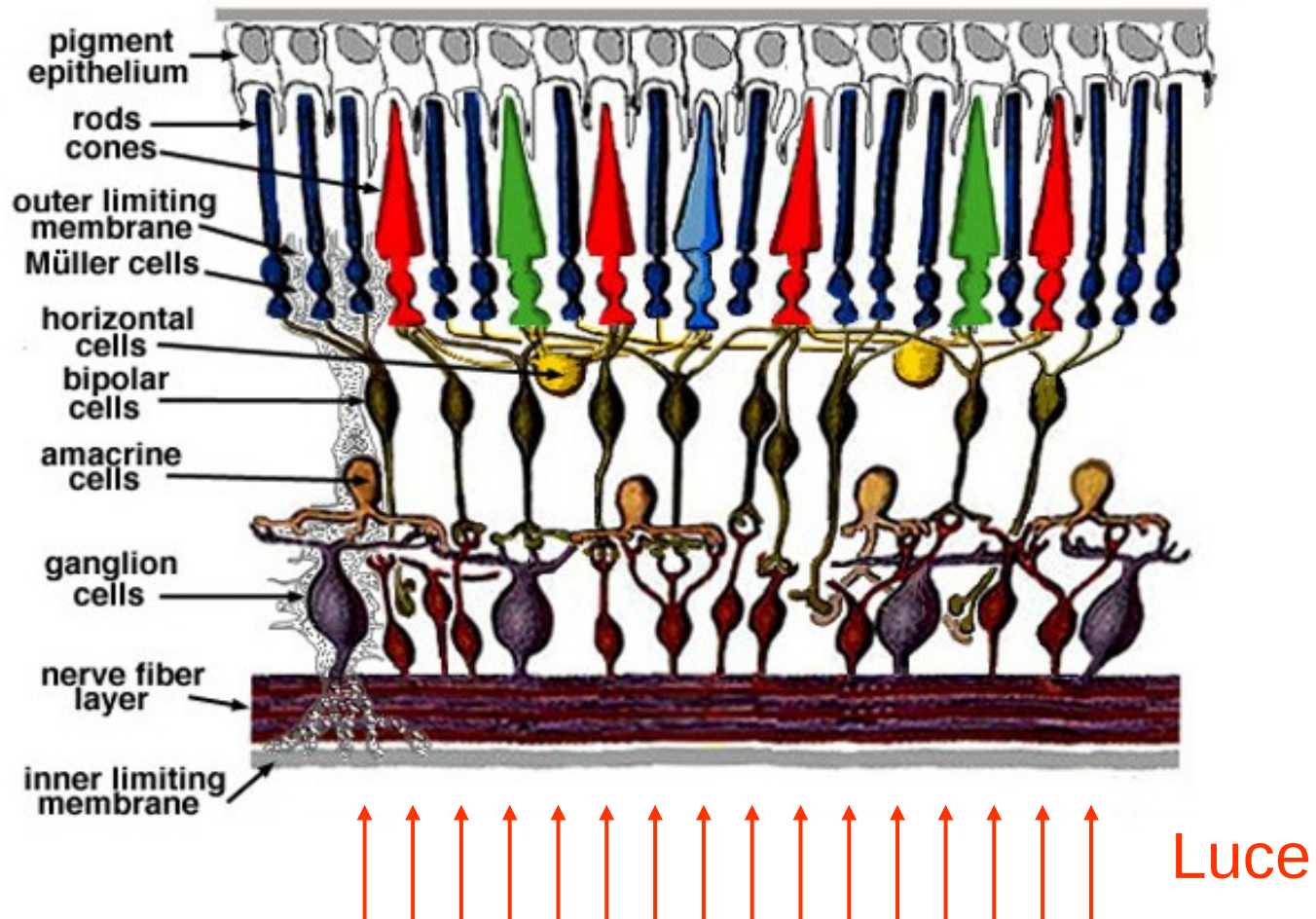




La retina



La retina



Fotorecettori

Densità di Coni e Bastoncelli

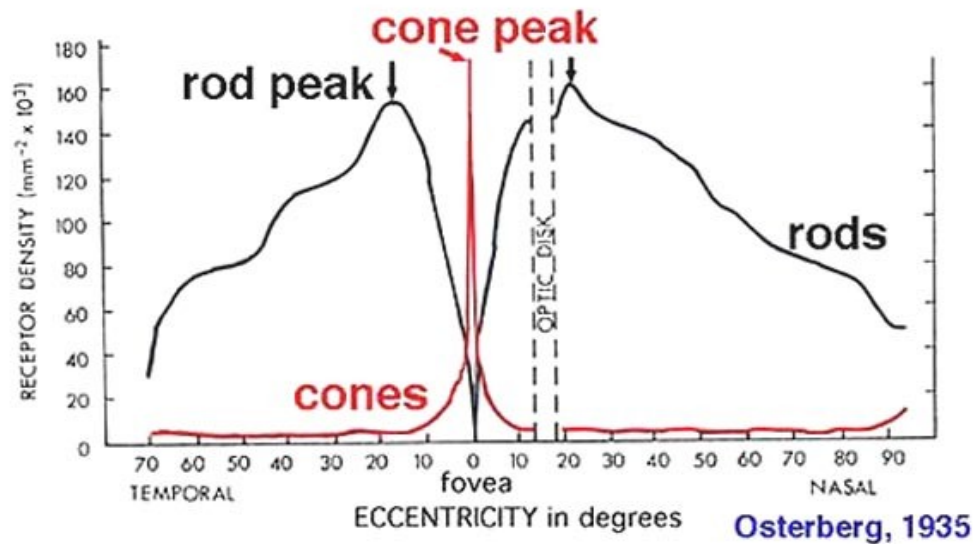


Fig. 20. Graph to show rod and cone densities along the horizontal meridian.

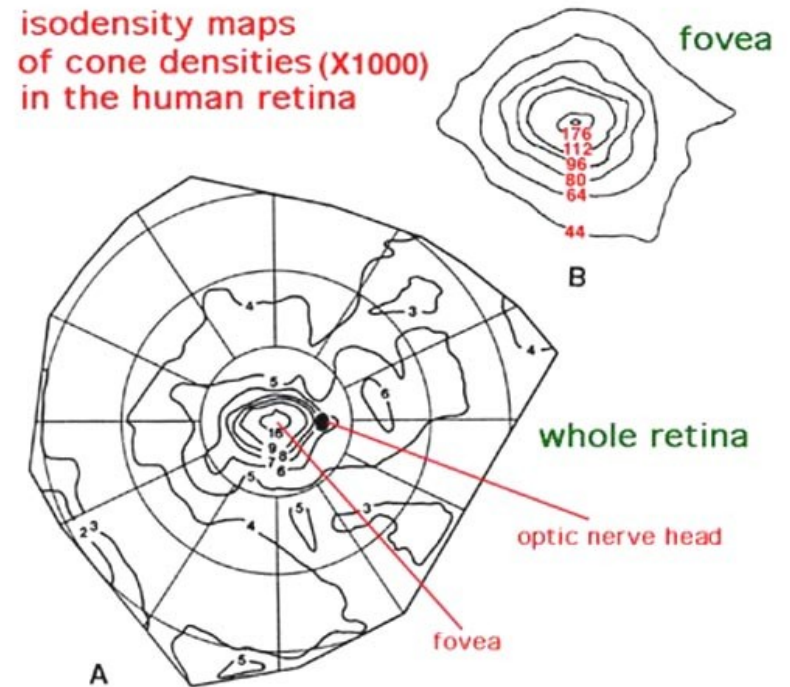
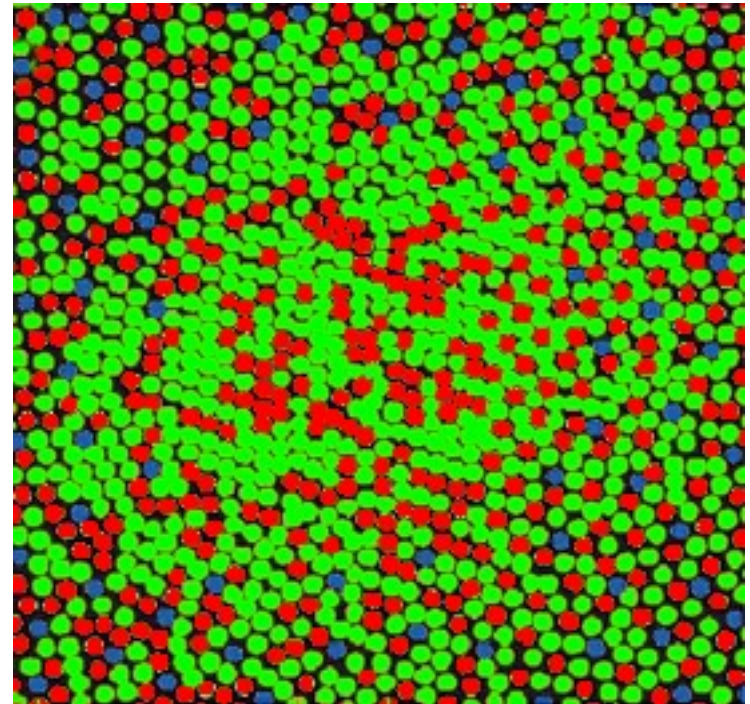
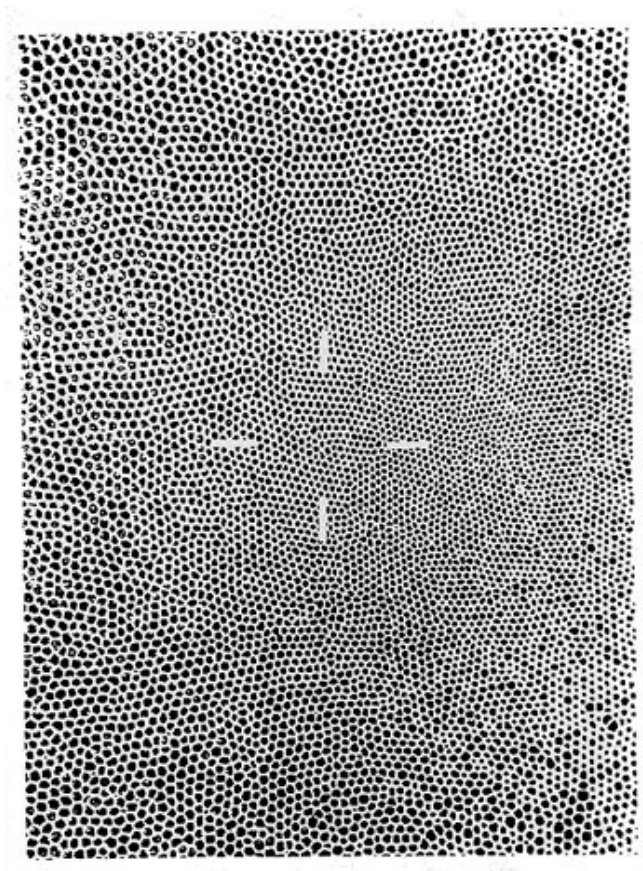
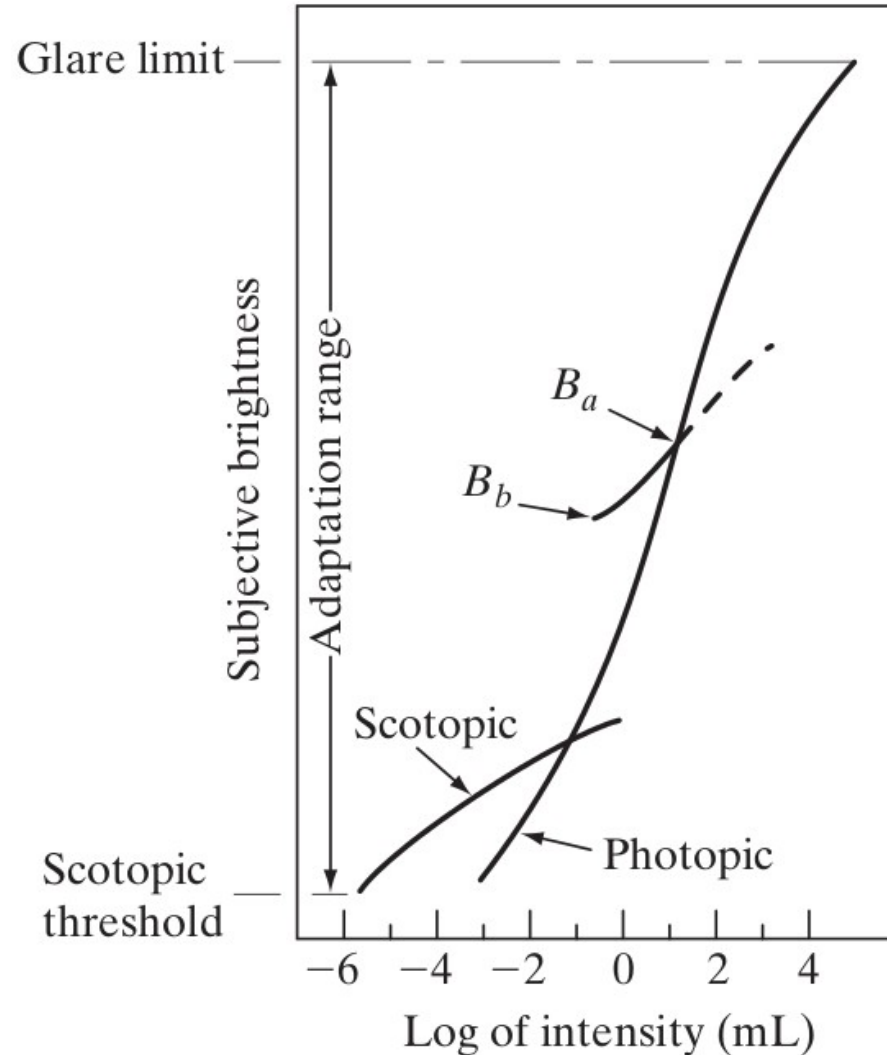


Fig. 21. Cone densities in human retina as revealed in whole mount. The foveal area is enlarged in B. (from Curcio et al., 1987).

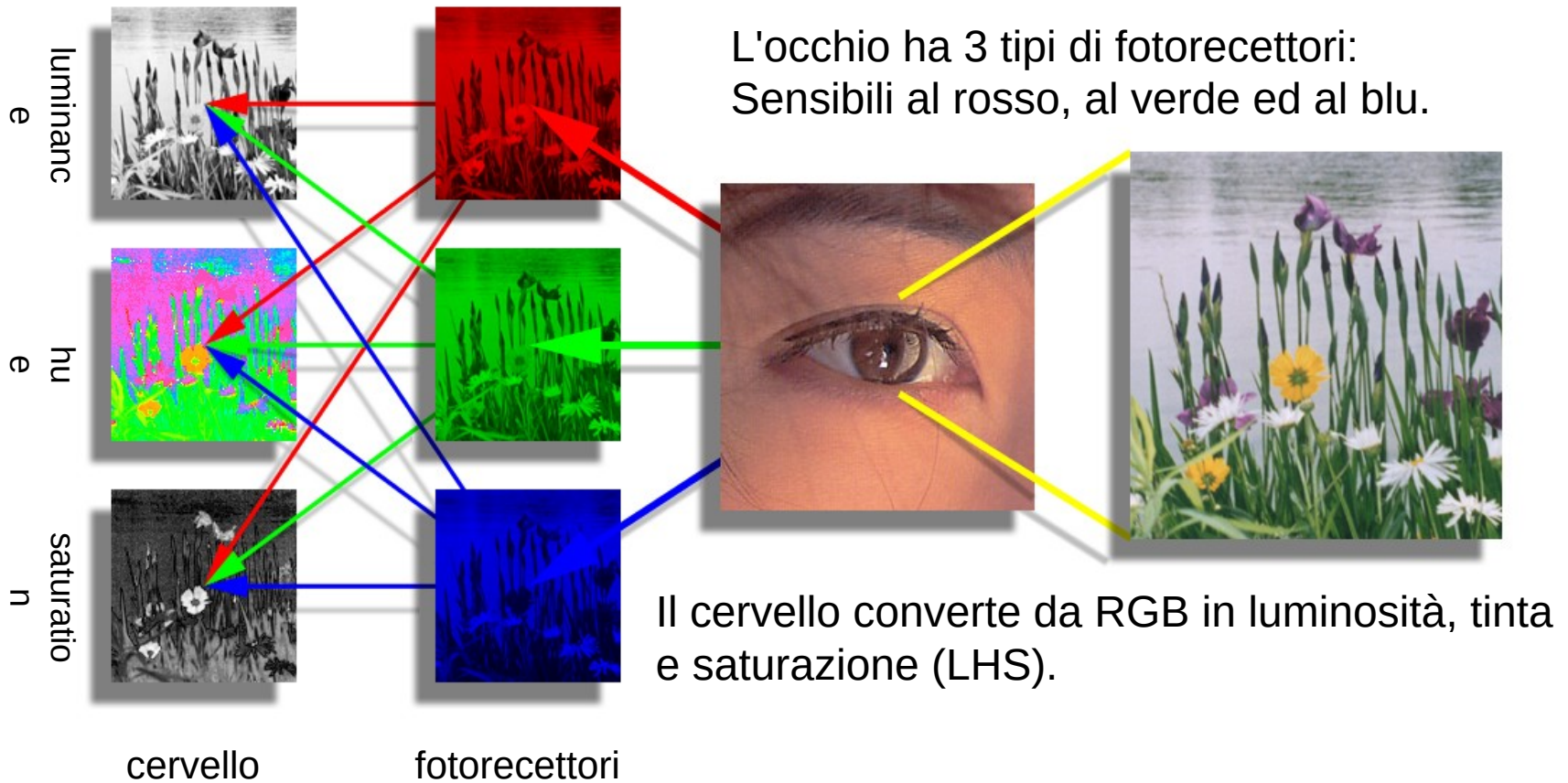
La retina – mosaico di recettori



Luminosità percepita

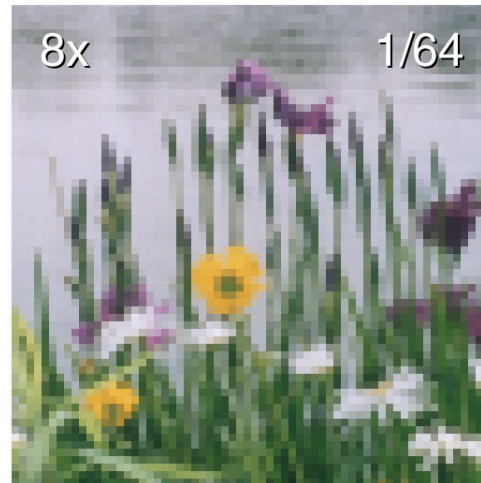
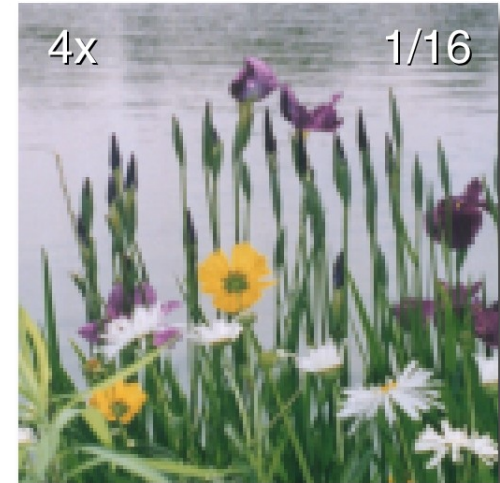


Il cervello: da RGB ad LHS



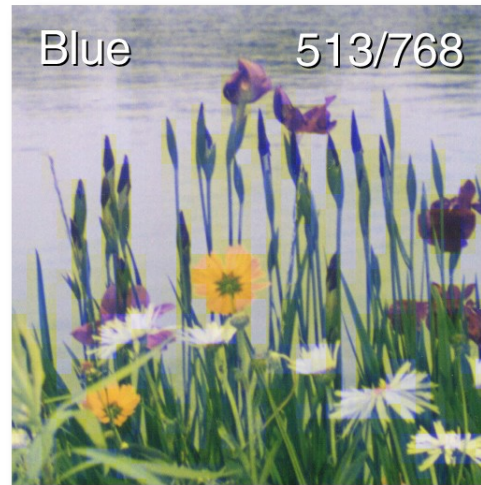
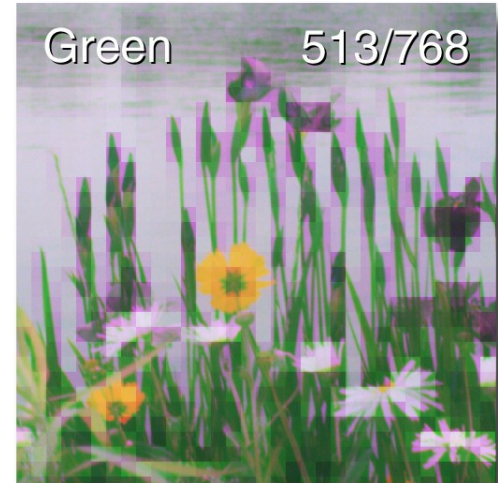
L – downsample factor
R – information content

Pixelization of Color Images: All Bands Equal



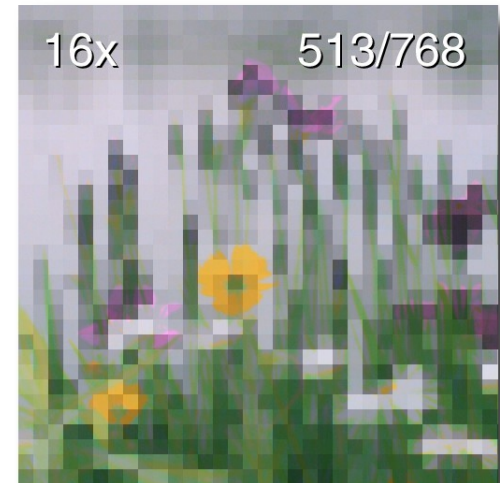
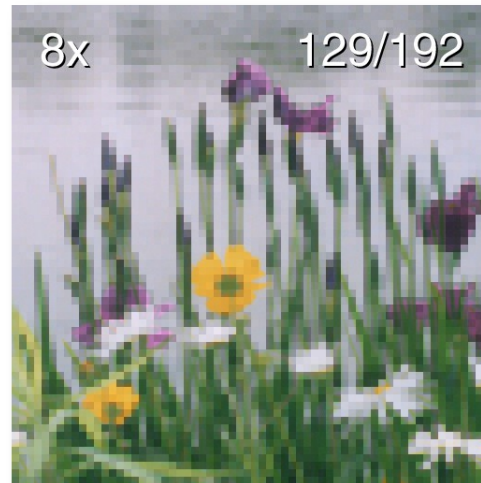
L – downsampled band
R – information content

16× Pixelization of Color Images: R, G, & B Bands



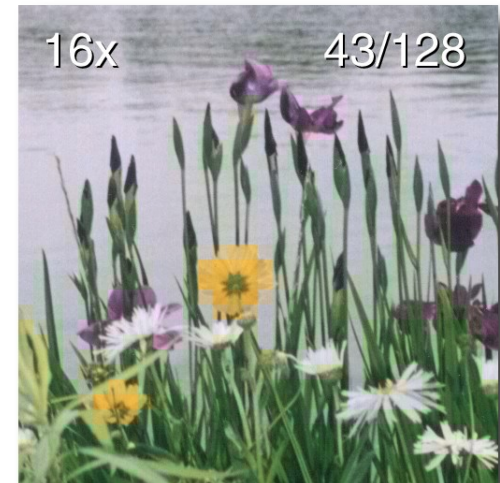
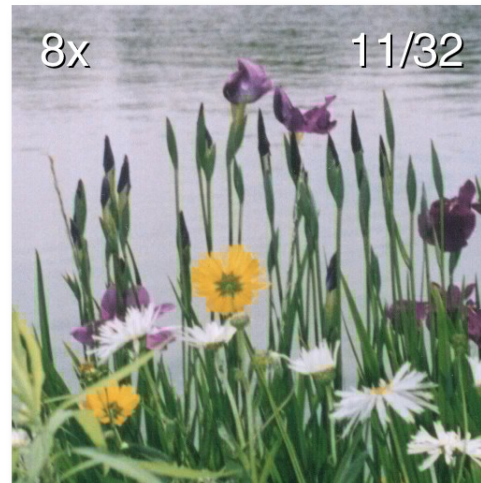
L – downsample factor
R – information content

16x Pixelization of Color Images: Luminance Only

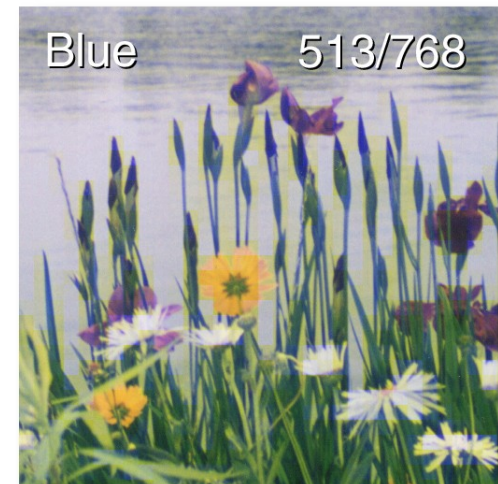
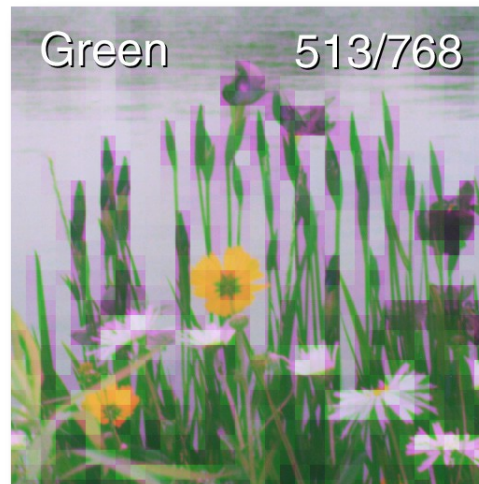
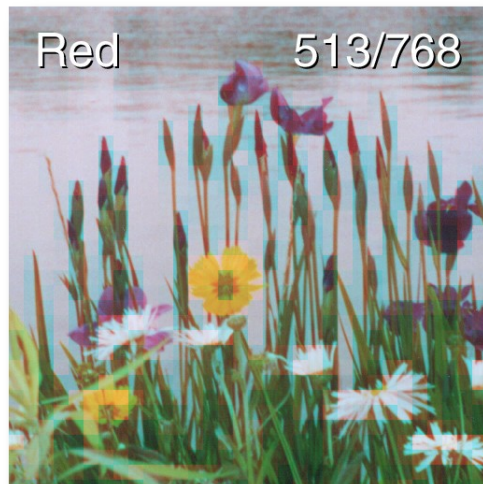
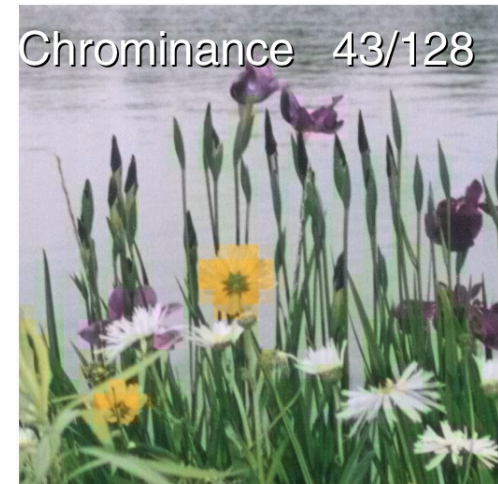
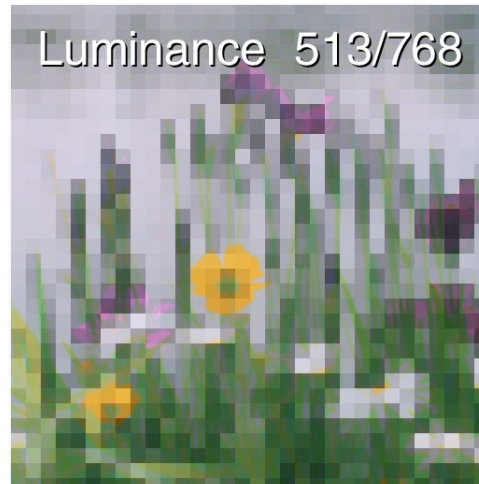


L – downsample factor
R – information content

16x Pixelization of Color Images: Chrominance (H+S) Only

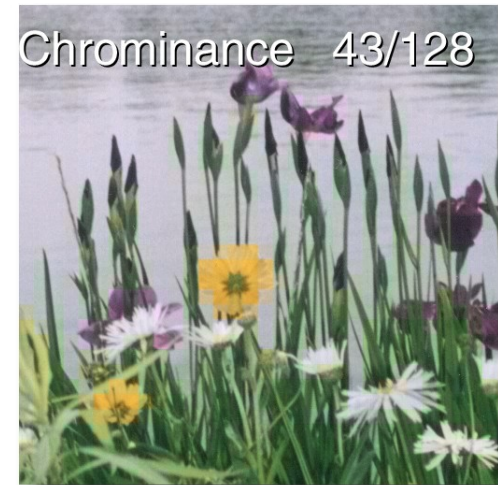
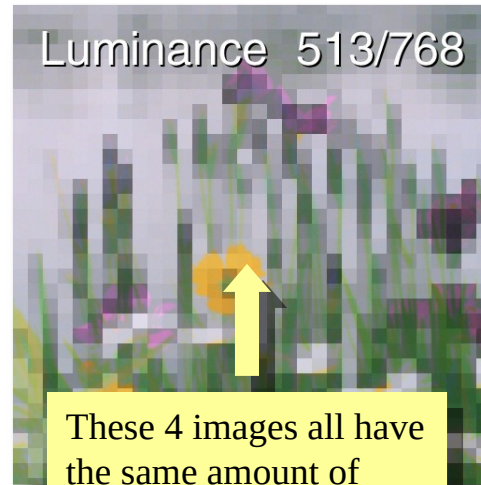


L – downsampled band
R – information content

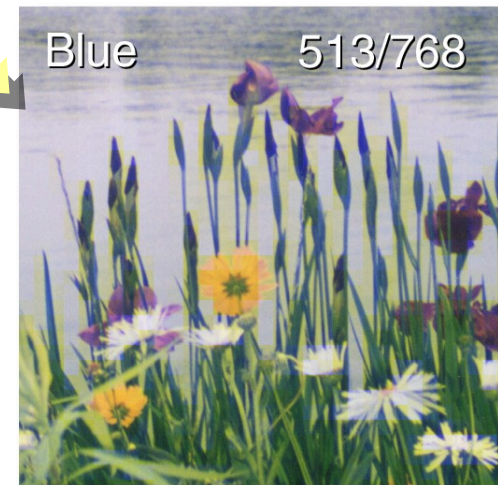
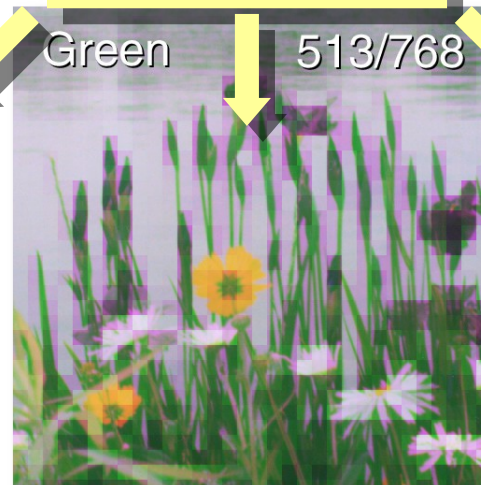
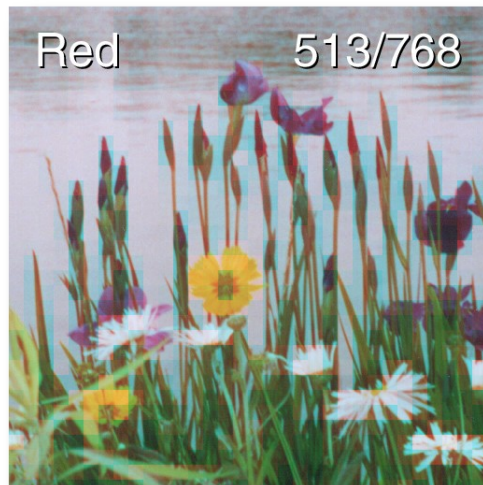


L – downsampled band
R – information content

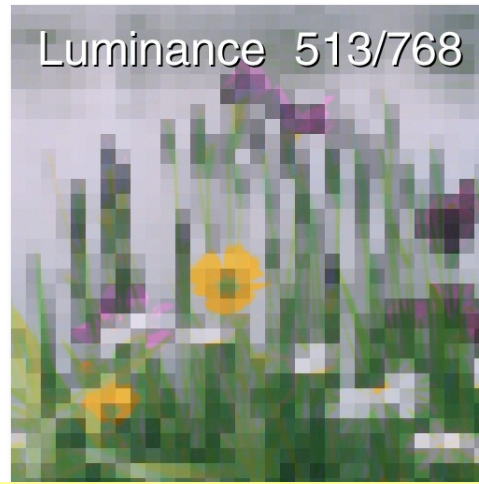
16× Pixelization



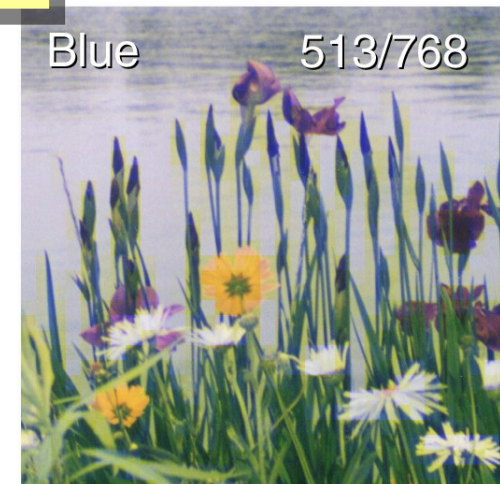
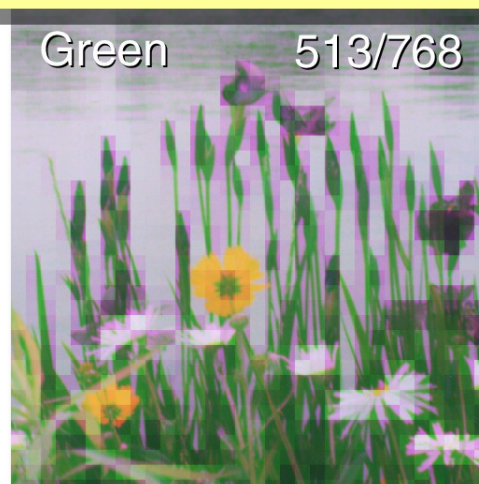
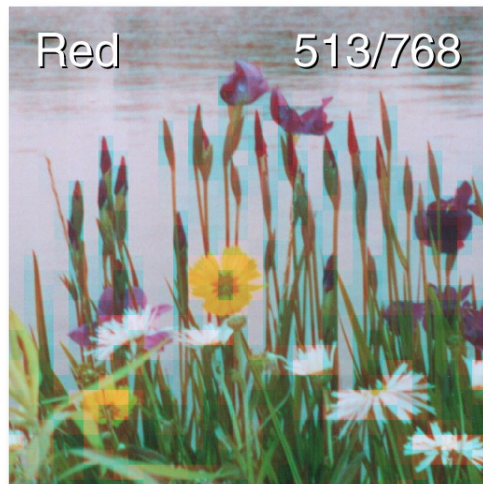
These 4 images all have
the same amount of
digital information...



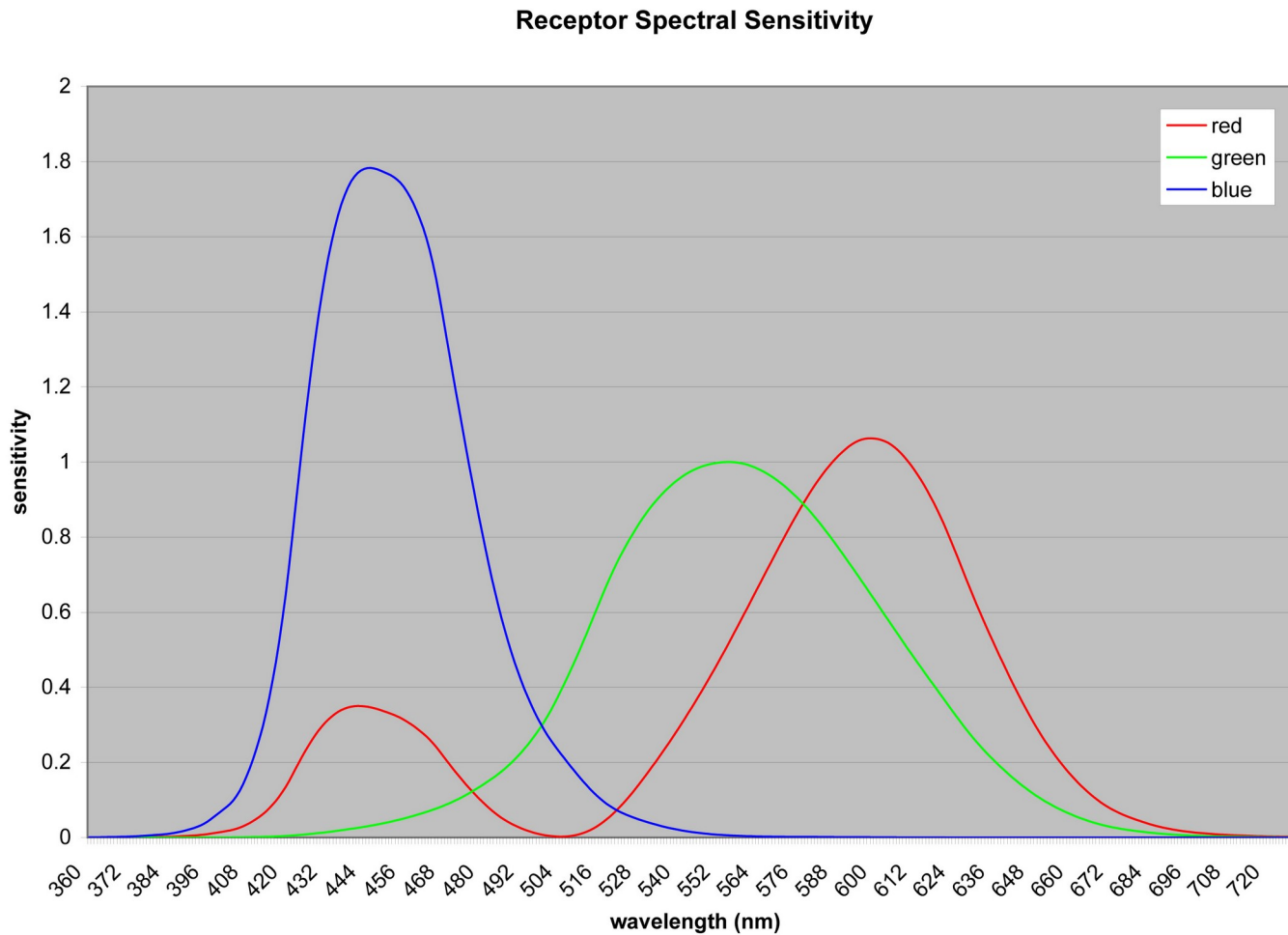
L – downsampled band
R – information content



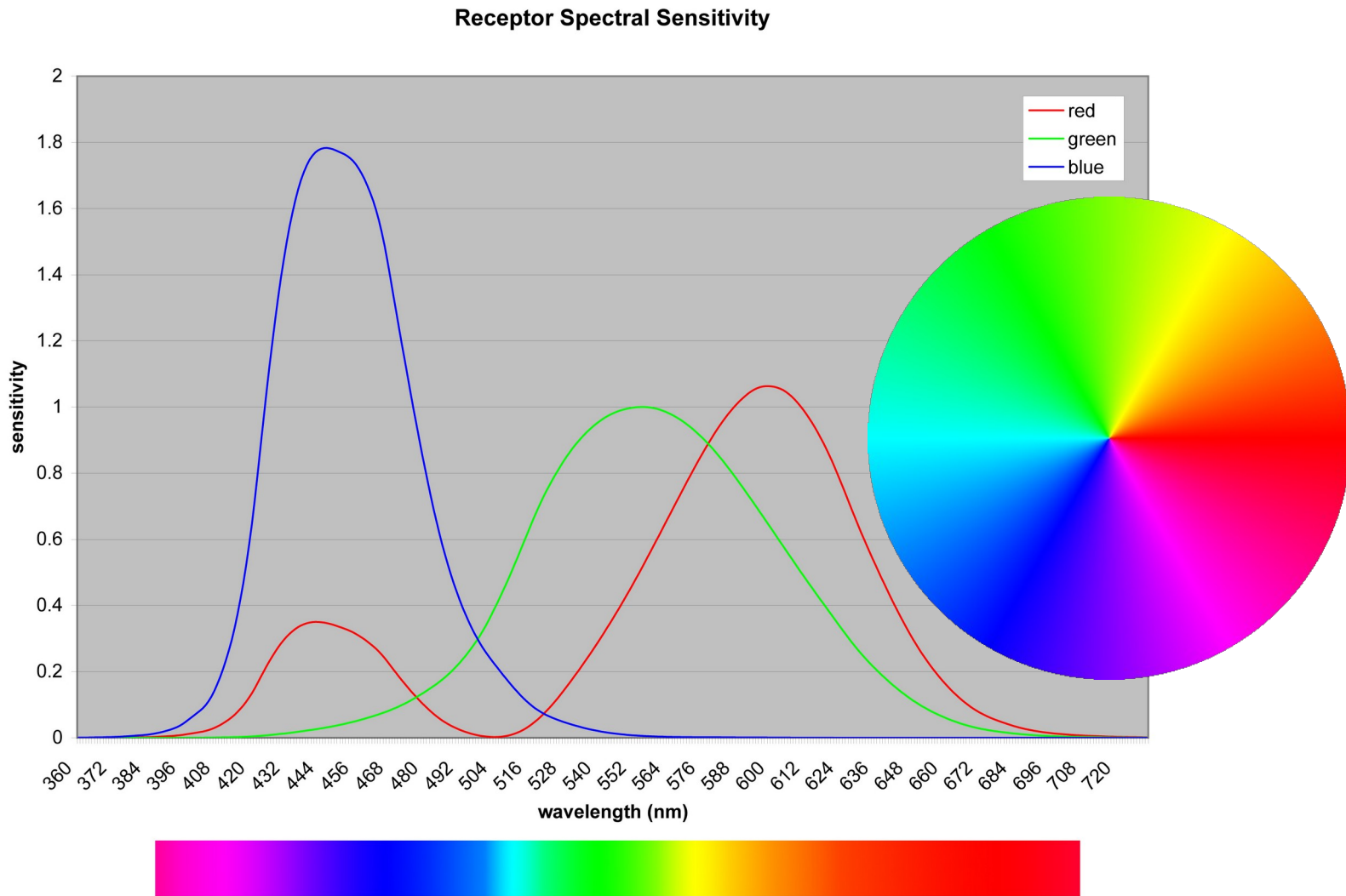
... but different visual information.



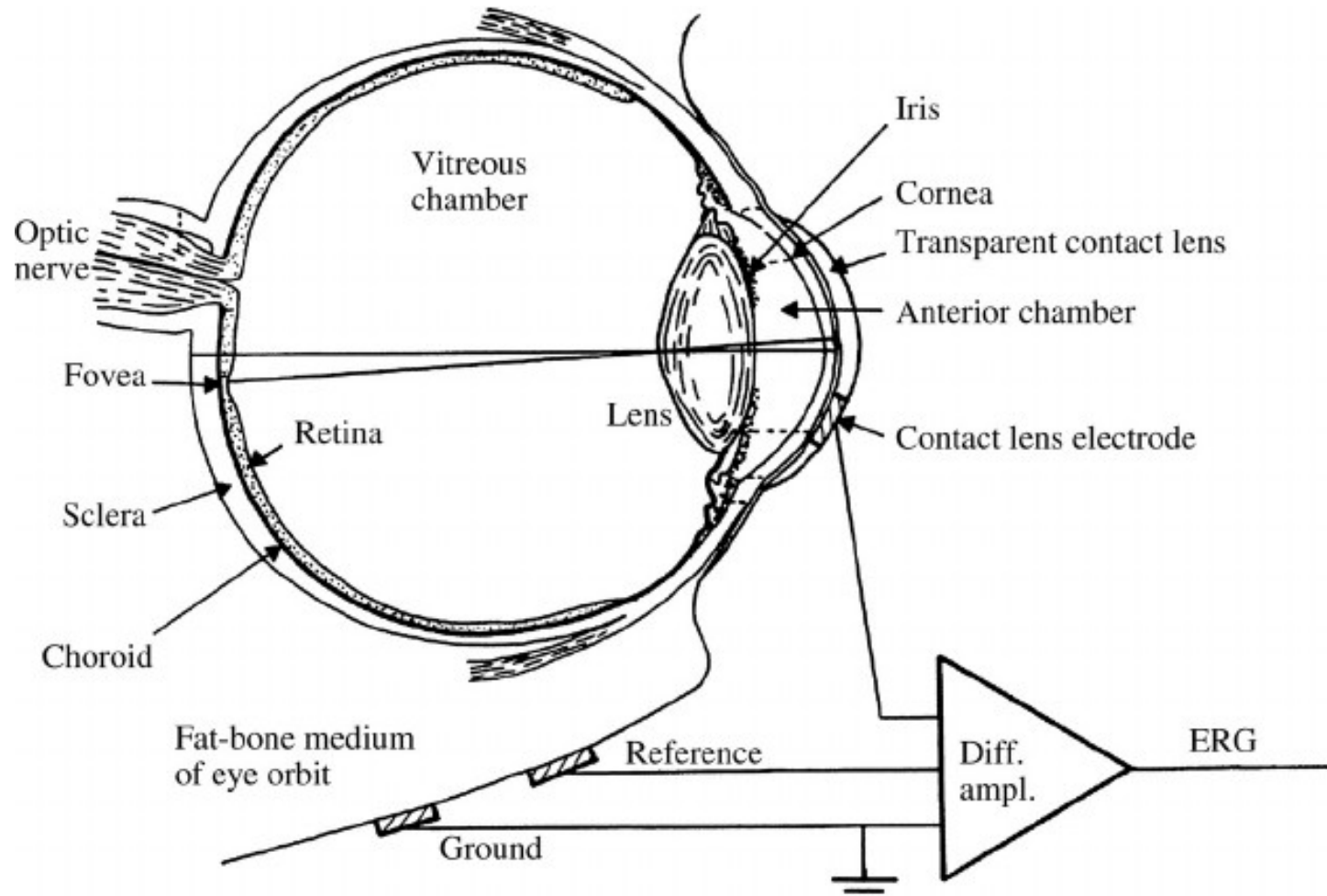
La percezione dei colori



La percezione dei colori



Anatomia



Elettroretinogramma (ERG)

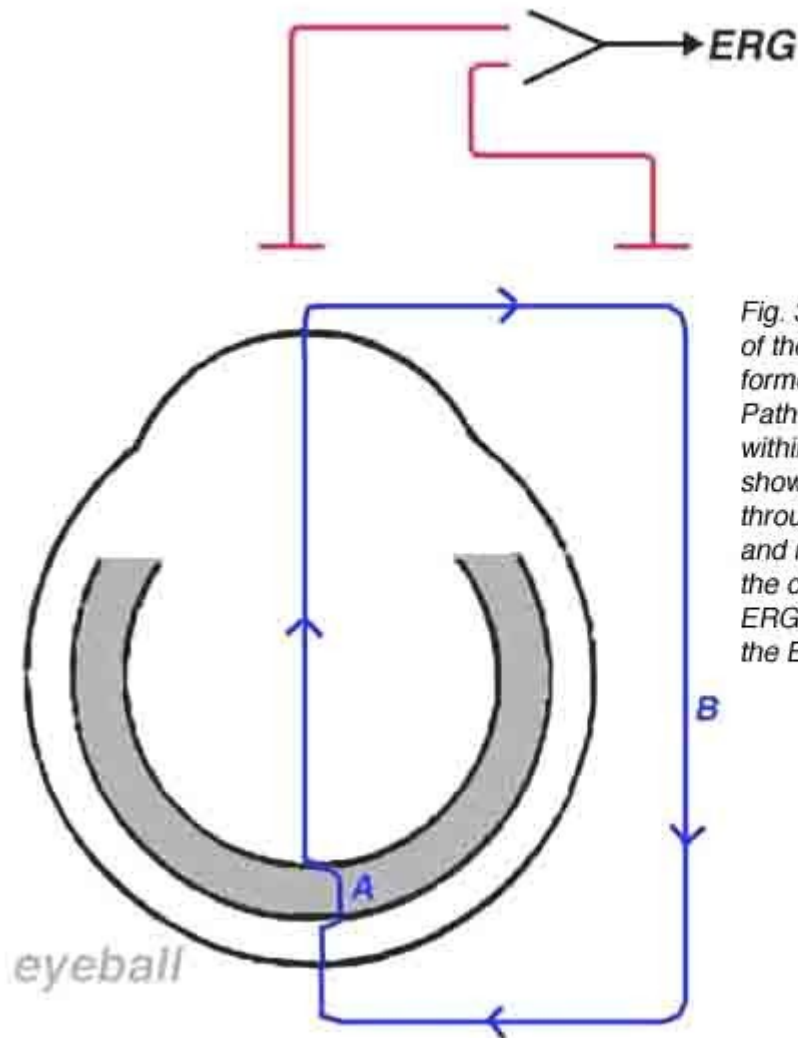
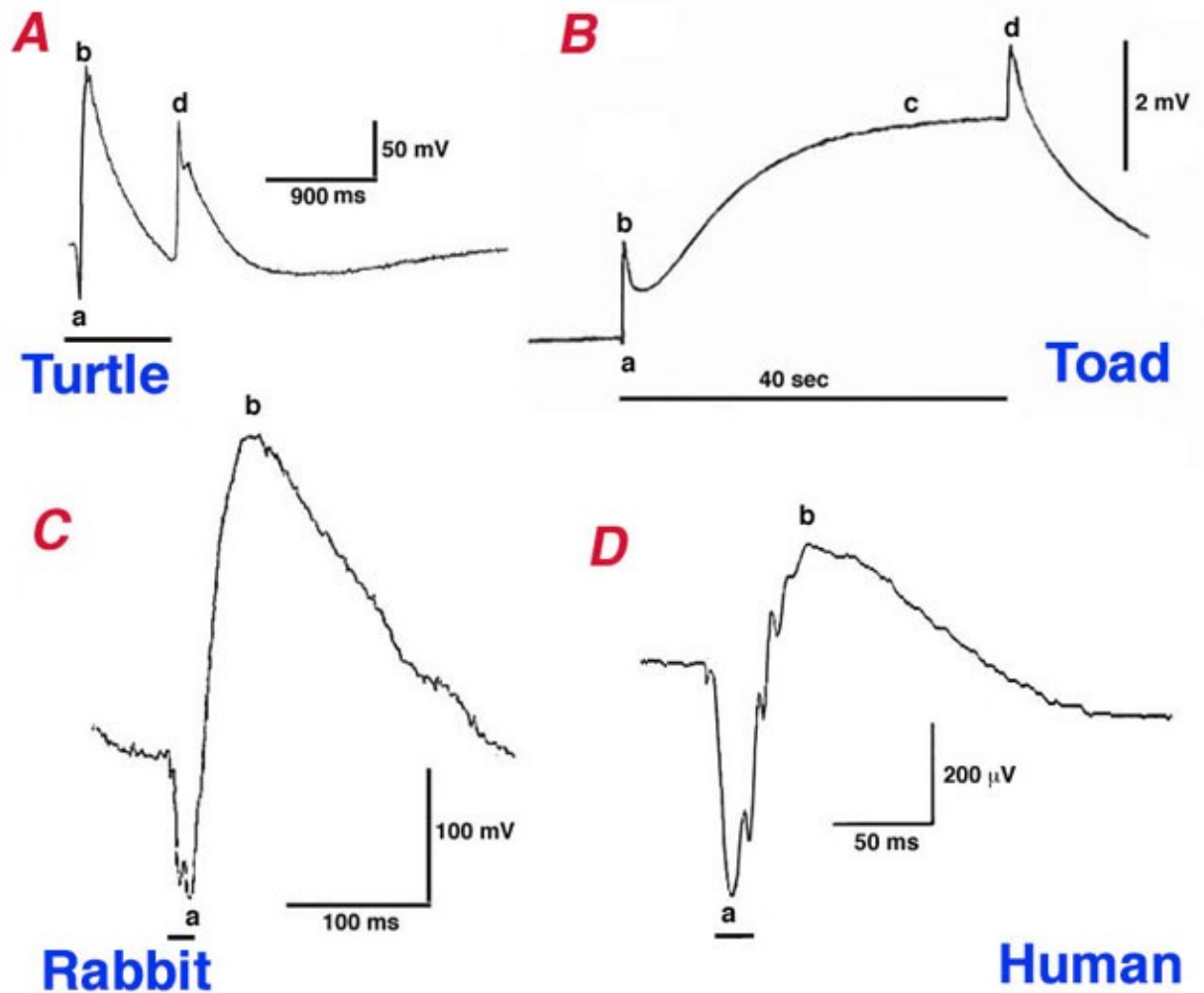


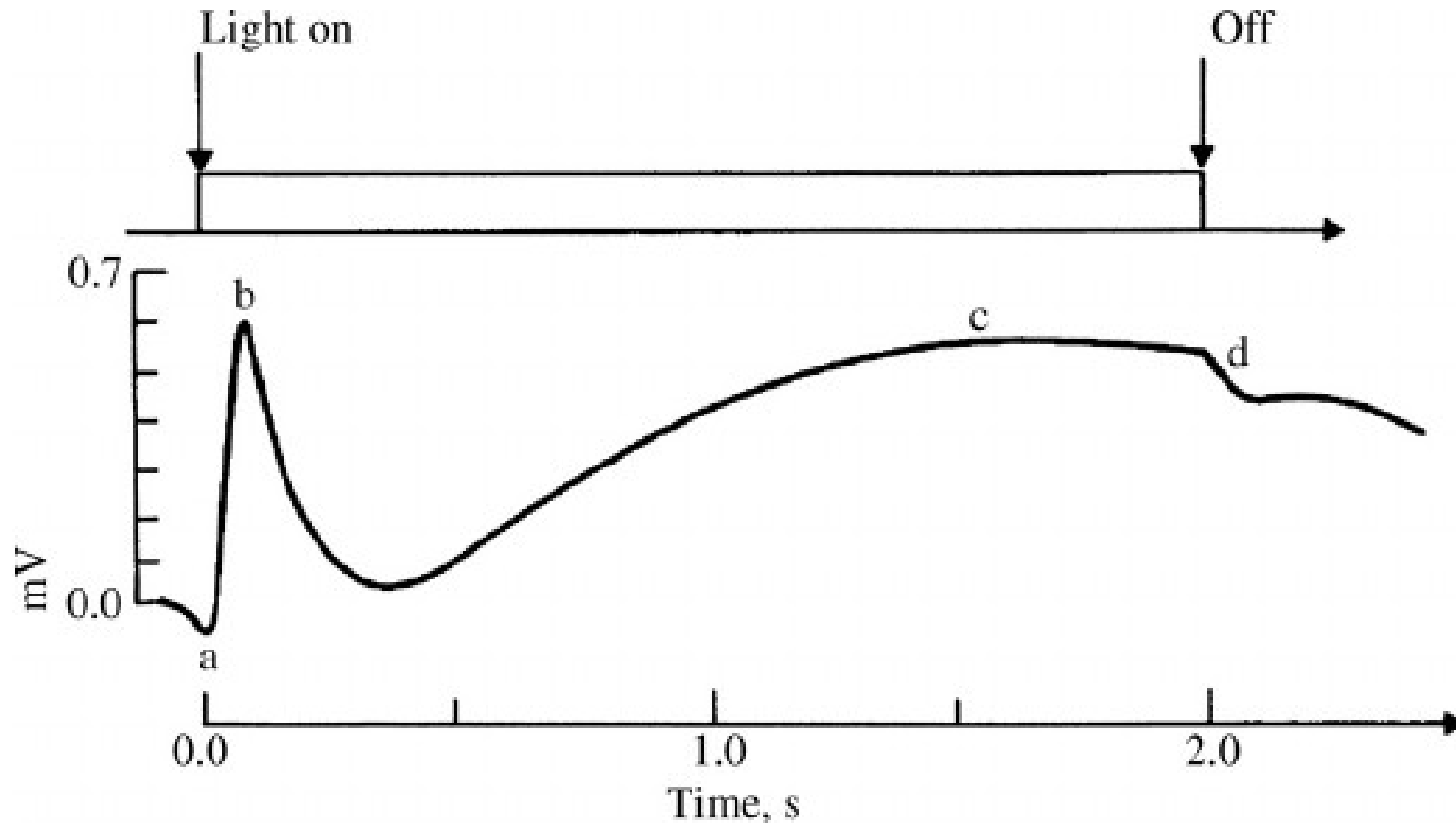
Fig. 3a. A schematic representation of the extracellular currents that are formed following light stimulation. Pathway A represents local currents within the retina, while pathway B shows the currents leaving the retina through the vitreous and the cornea and returning to the retina through the choroid and the pigment epithelium. ERG recording in human is done along the B path.

<http://webvision.med.utah.edu/book/electrophysiology/the-electroretinogram-erg/>

Elettroretinogramma (ERG)



Elettroretinogramma (ERG)



Nei mammiferi si identificano 4 fasi: a, b, c, e d.

Elettroretinogramma (ERG)

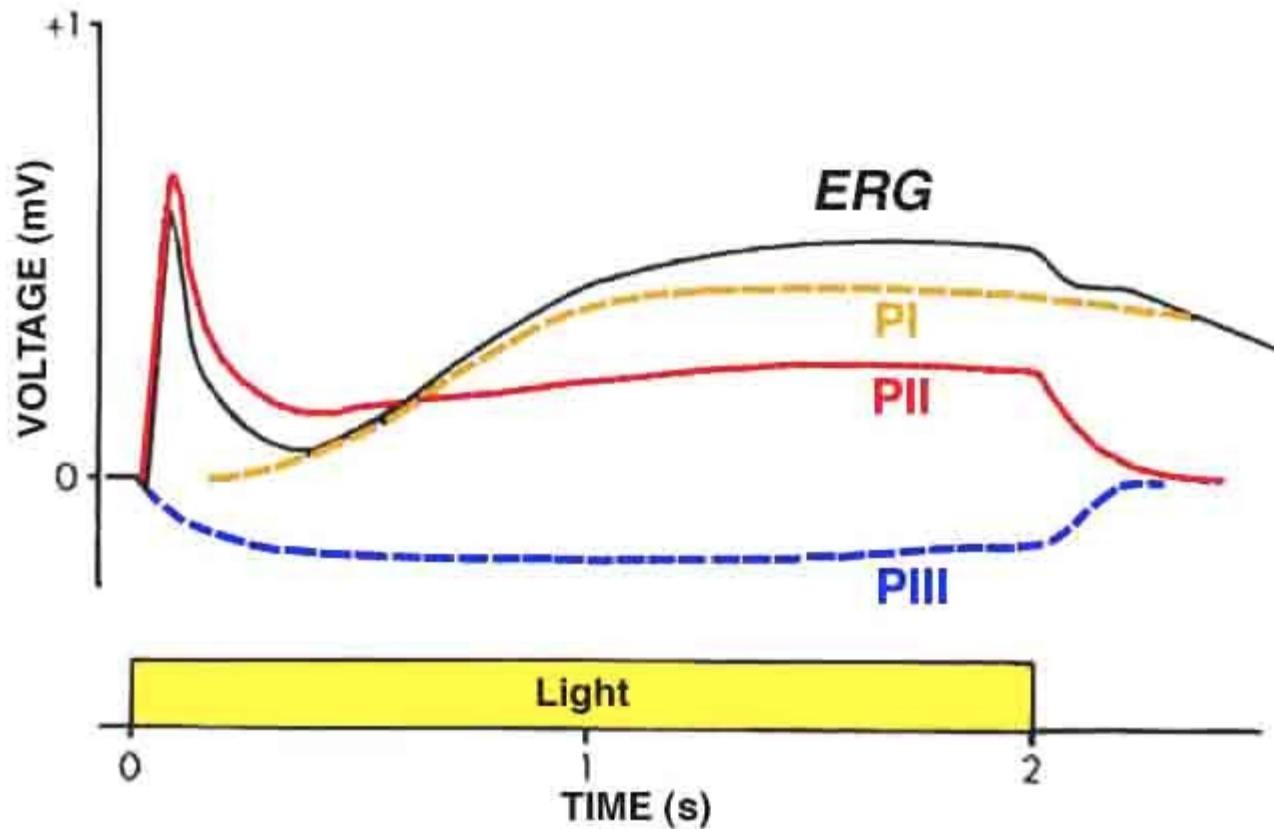


Fig. 2b. The ERG of a cat in response to a 2 sec light stimulus. The components, P-I, P-II and P-III, have been isolated by deepening the state of anesthesia (Granit, 1933).

Possiamo identificare 3 componenti: PI, PII e PIII.

Segnali costitutivi dell'ERG

- La componente P-I è un'onda lenta e positiva sulla cornea.
- Anche la componente P-II è positiva sulla cornea, ed ha una salita veloce a seguito dello stimolo, successivamente si stabilizza su un valore intermedio durante la permanenza dello stimolo.
- La componente P-III (la più resistente all'anestesia), è un'onda negativa sulla cornea che si sviluppa più rapidamente delle altre due, e permane nel potenziale negativo finché lo stimolo permane.

Segnali costitutivi dell'ERG

Confrontando le componenti e le fasi di un ERG, possiamo stabilire che:

- L'onda a è dovuta principalmente al fronte di discesa della componente negativa P-III.
- L'onda b è la somma delle componenti P-II (positiva) e P-III (negativa).
- L'onda c, che è quella con dinamica più lenta, è dovuta alla somma di P-I e P-III.

Elettroretinogramma (ERG)

Diversi fattori influenzano le caratteristiche del segnale ERG registrato. In particolare:

- Stato di adattamento
- Intensità luminosa
- Colore dello stimolo luminoso
- Frequenza dello stimolo luminoso

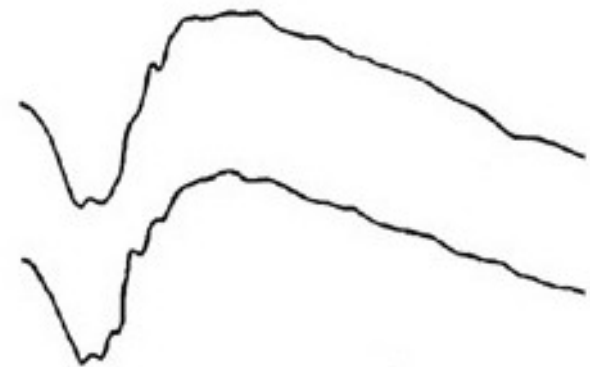
Stato di adattamento

Light Adapted



Stimolo con luce ambientale.
Segnale prevalente dai coni.
Piccola ampiezza ma risposta
veloce (30ms).

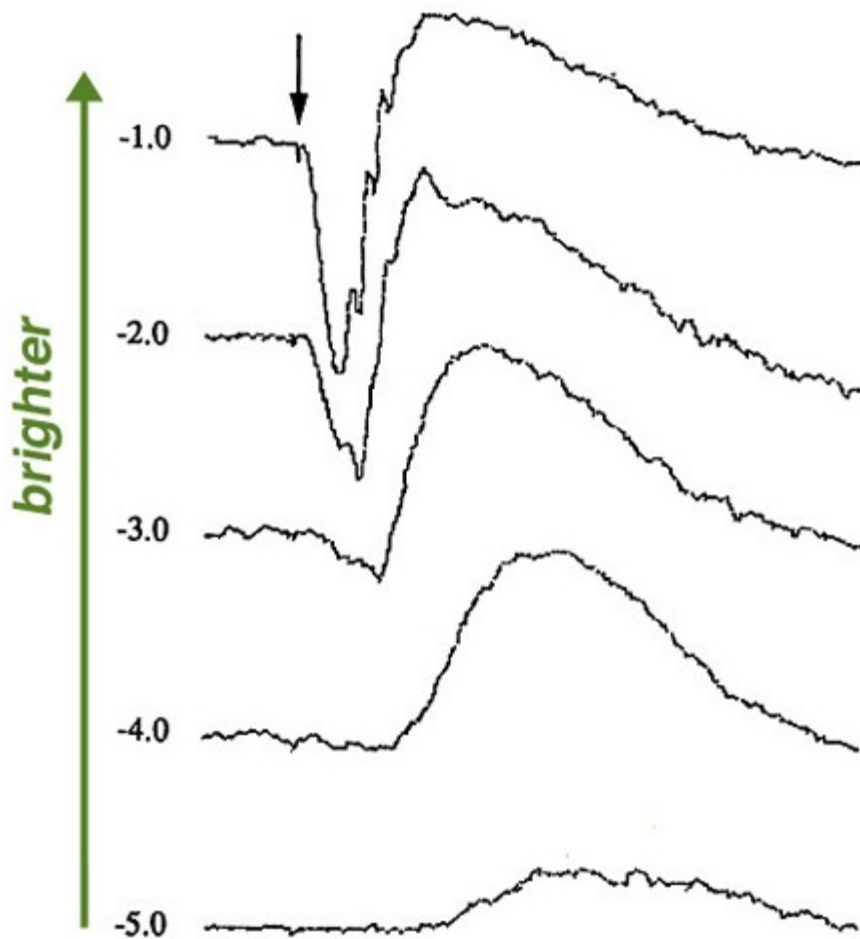
Dark Adapted



Stimolo con assenza di luce
ambientale. Segnale prevalente
dai bastoncelli. Ampiezza
maggiore (4x), risposta lenta
(60ms).

Intensità luminosa

dark-adapted human



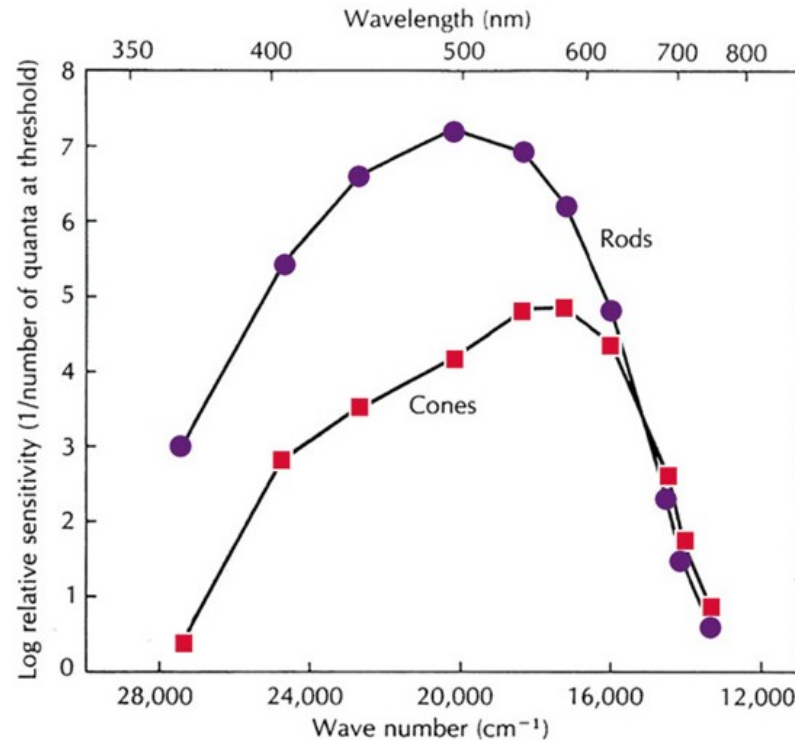
Stimolo di differente intensità in assenza di luce ambientale.

Per basse intensità è evidente solo l'onda b.

Al crescere dello stimolo, aumenta l'intensità dell'onda b e compare l'onda a.

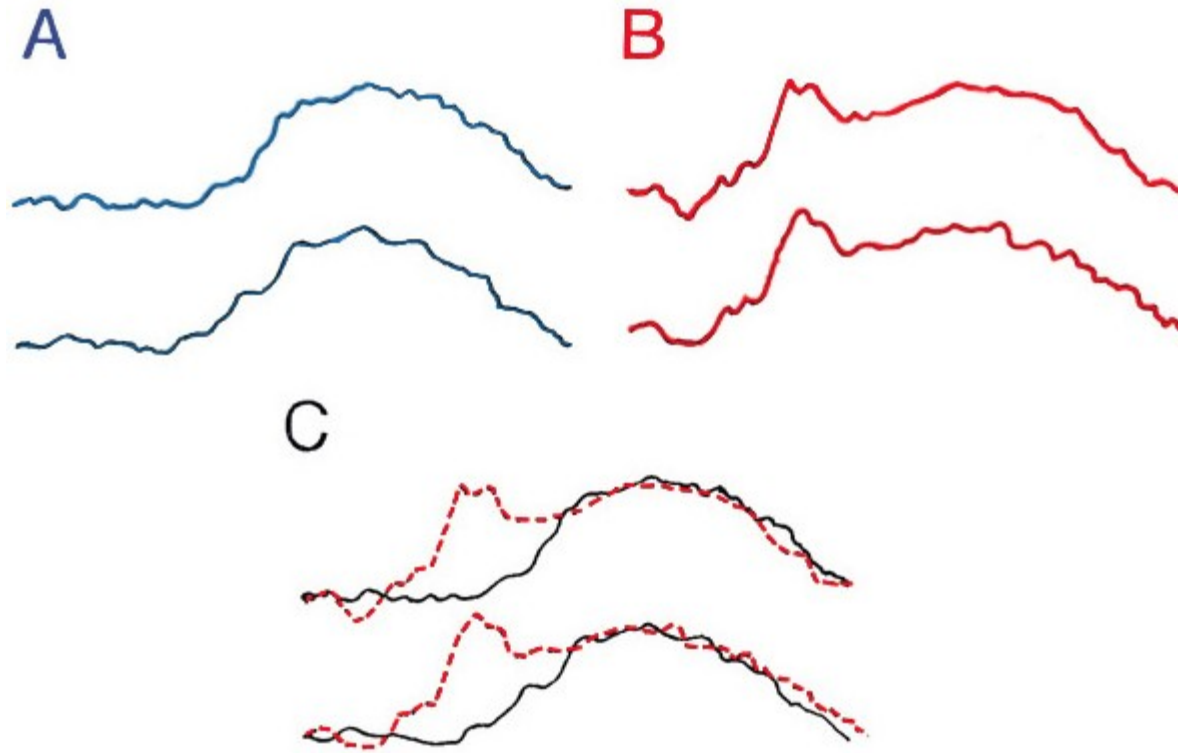
Vanno valutate anche la dilatazione della pupilla, l'opacità del cristallino, etc.

Colore dello stimolo luminoso



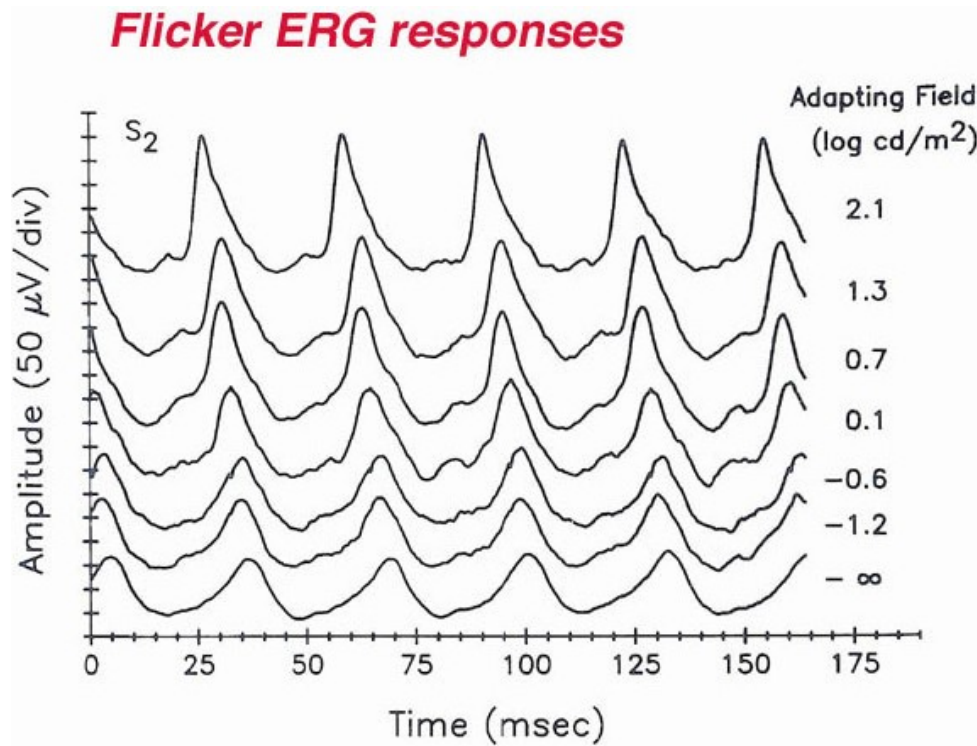
Curve di sensibilità dei coni (arancio) e dei bastoncelli (blu-verde). Il valore massimo varia di mille volte.

Colore dello stimolo luminoso



Stimolo blu poco luminoso (A) e rosso molto luminoso (B).
Raffronto fra i due ERG (C). Risposta di coni e bastoncelli.

Frequenza dello stimolo luminoso



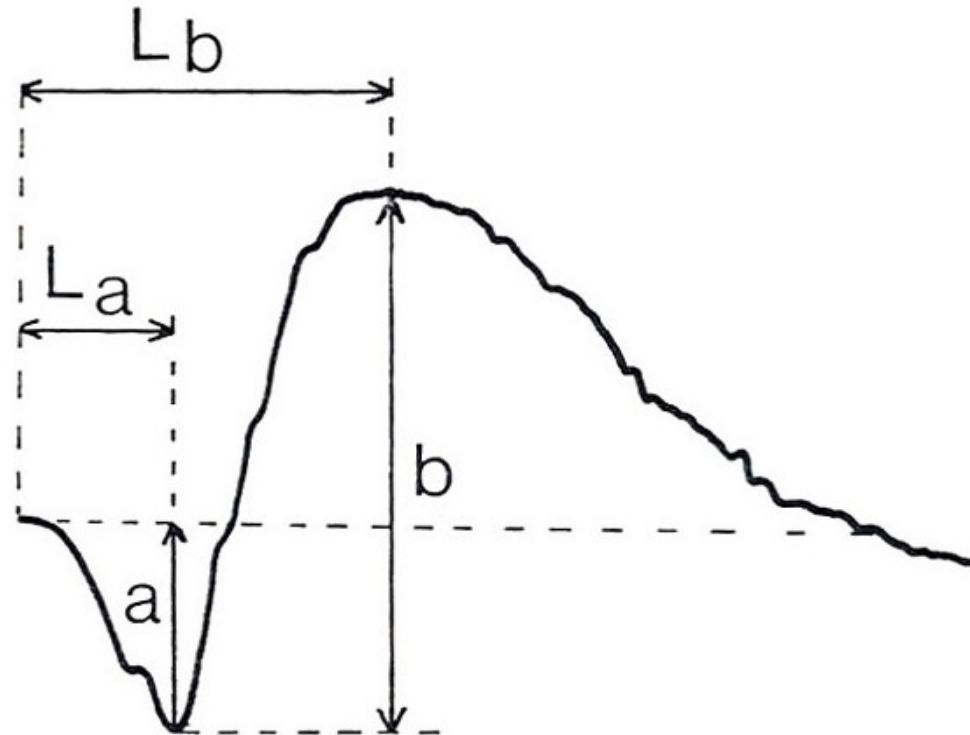
Si misura la Critical Fusion Frequency (CFF), che dipende dalle condizioni di illuminazione (15Hz per i bastoncelli, 50Hz per i coni).

Analisi ERG

Di un ERG i principali parametri caratteristici sono:

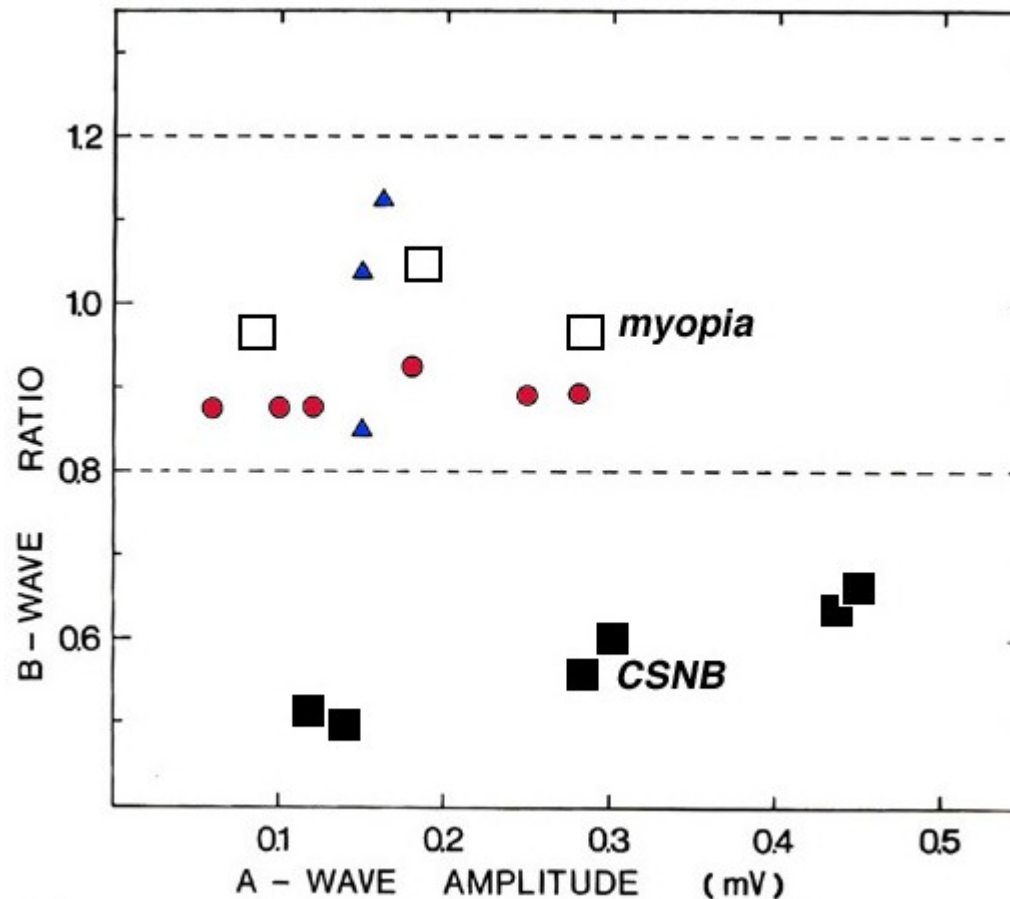
- Ampiezza del segnale
- Temporizzazione
- Rapporto fra onda a ed onda b
- Ricostruzione di P-III
- Ricostruzione di P-II
- Analisi della risposta dei bastoncelli a flash

Analisi ERG



Ampiezza e temporizzazione.

Analisi ERG

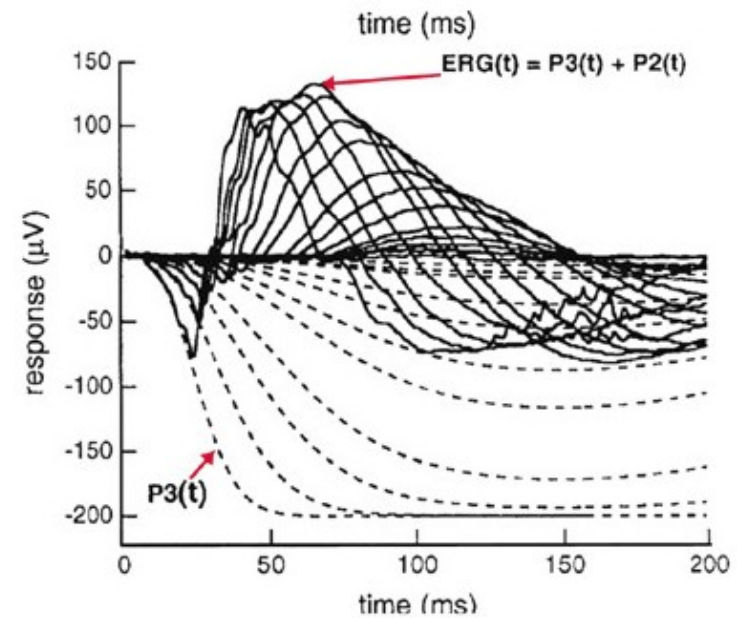
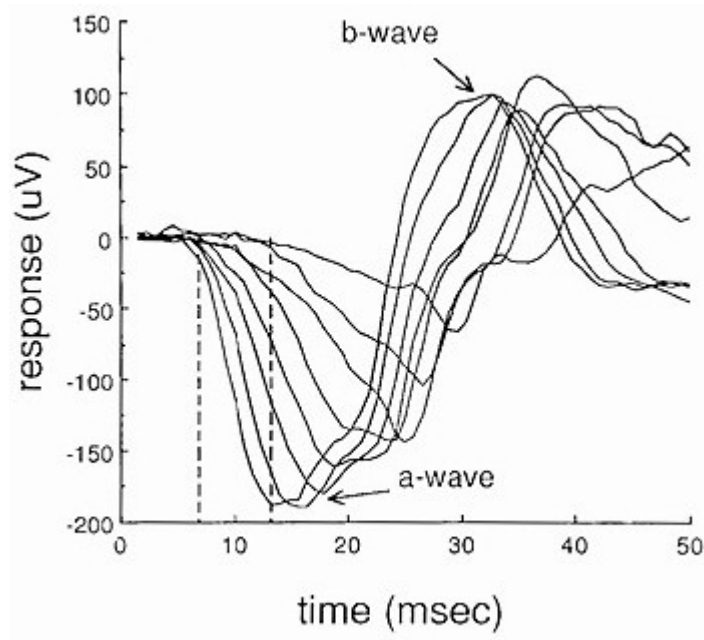


Analisi rapporto fra onda a ed onda b.

(CSNB: Congenital Stationary Night Blindness)

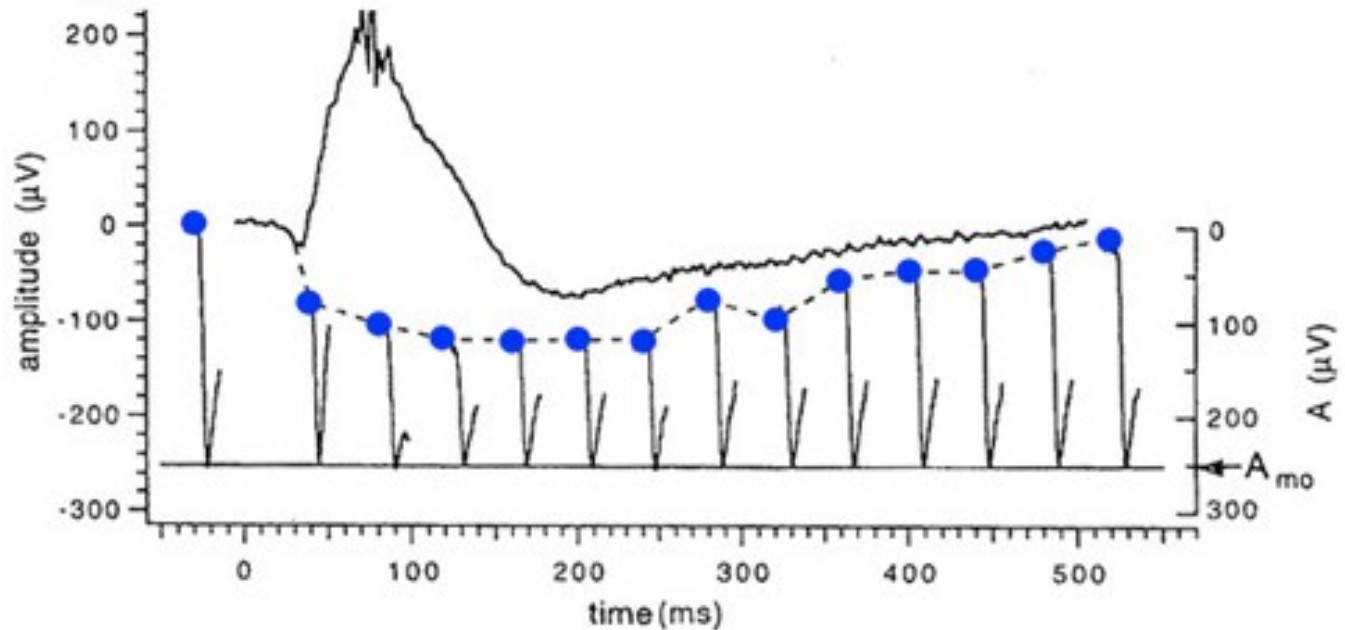


Analisi ERG



Ricostruzione di P-II e di P-III

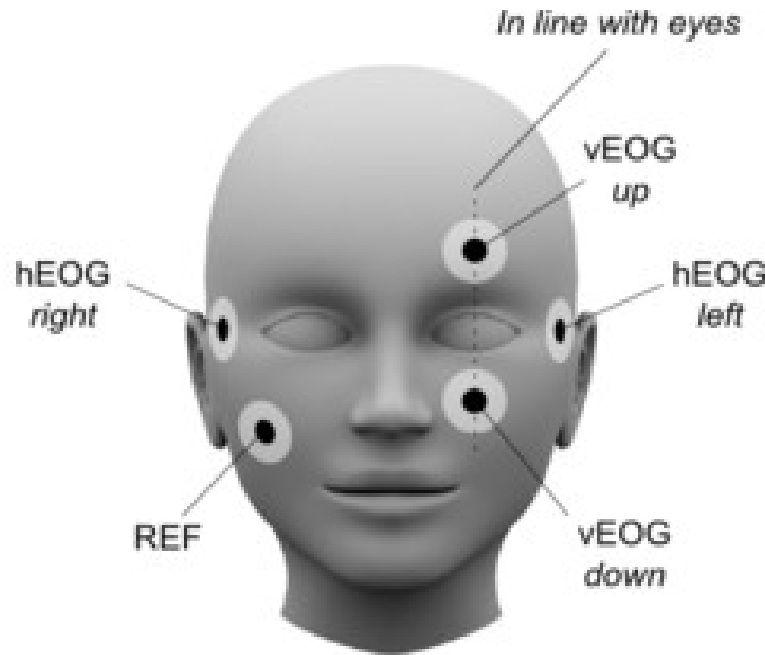
Analisi ERG



Analisi della risposta dei bastoncelli a flash.

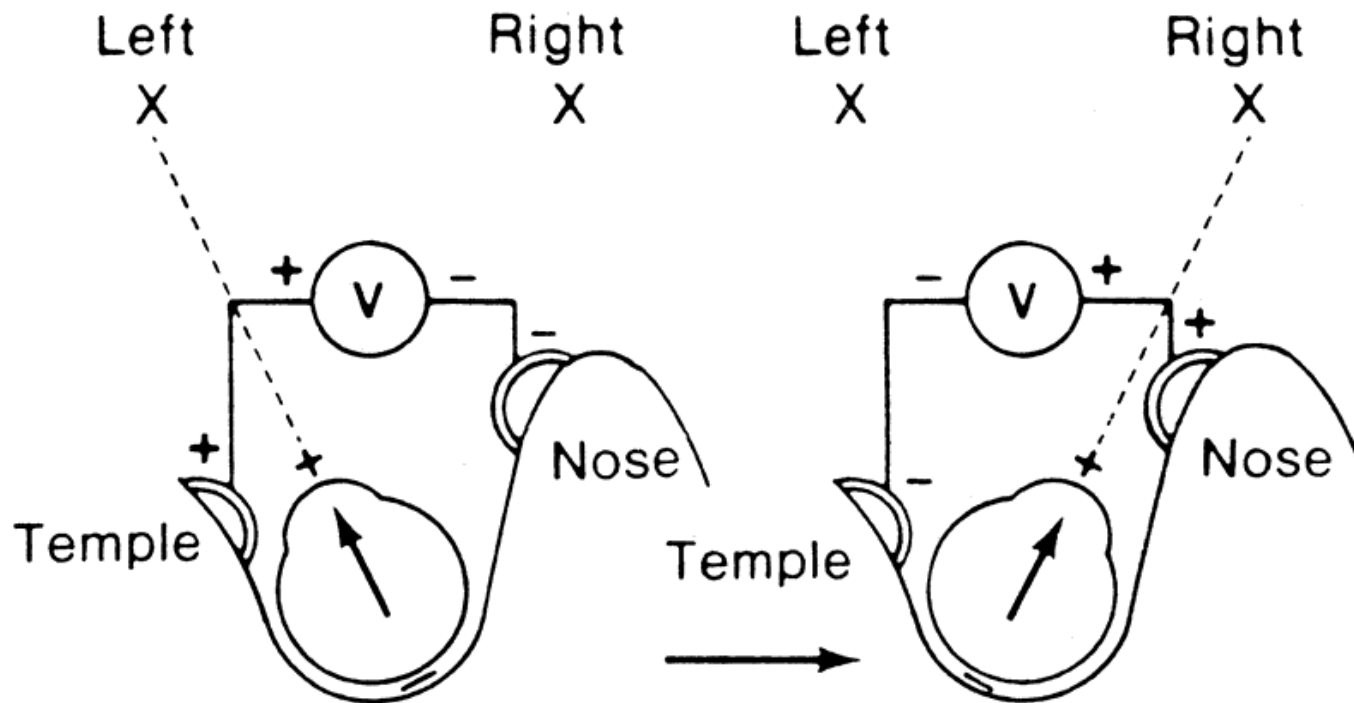
Elettrooculogramma (EOG)

A differenza dell'ERG, l'EOG serve a valutare in tempo reale la posizione (il puntamento) dell'occhio.

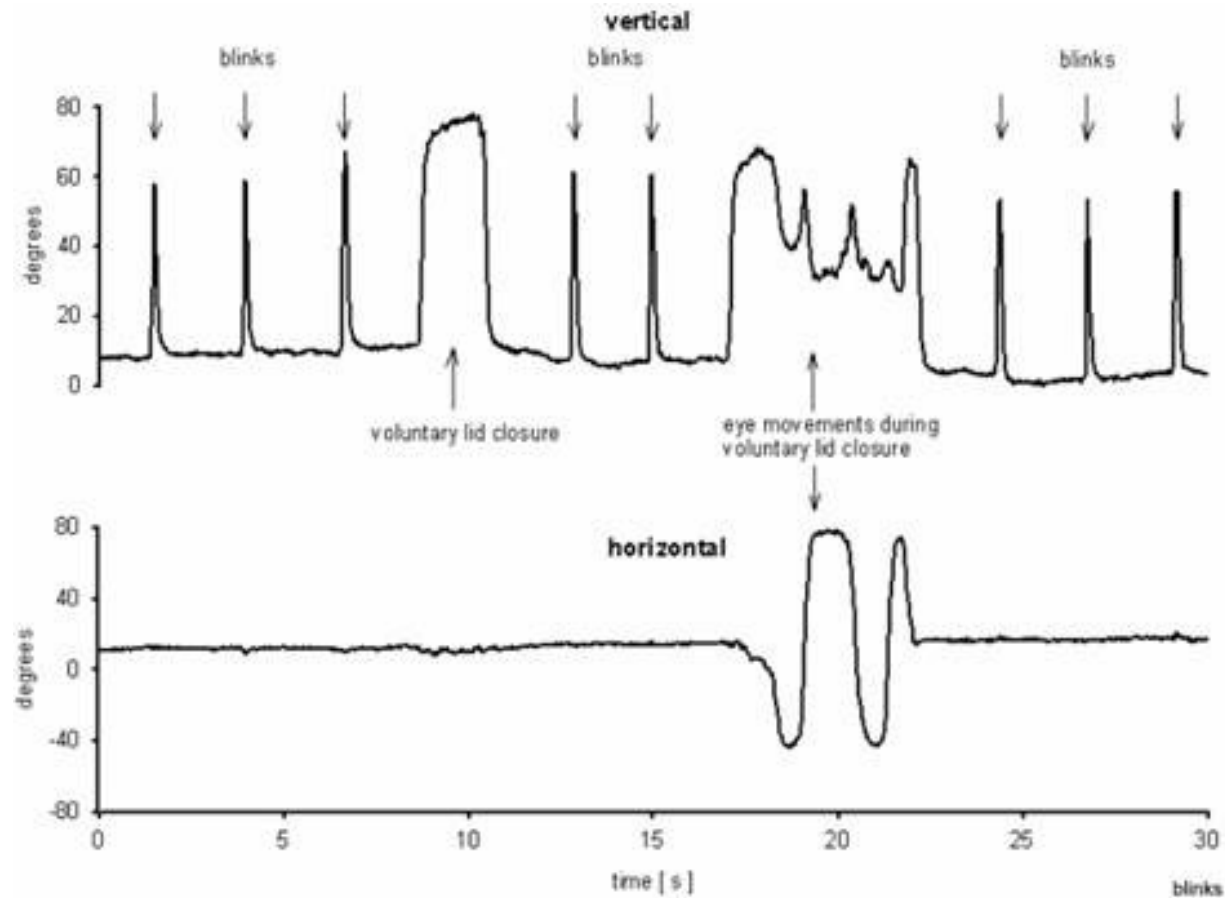


Elettrooculogramma (EOG)

L'occhio può essere considerato come un dipolo, con la parte anteriore a potenziale maggiore della posteriore.



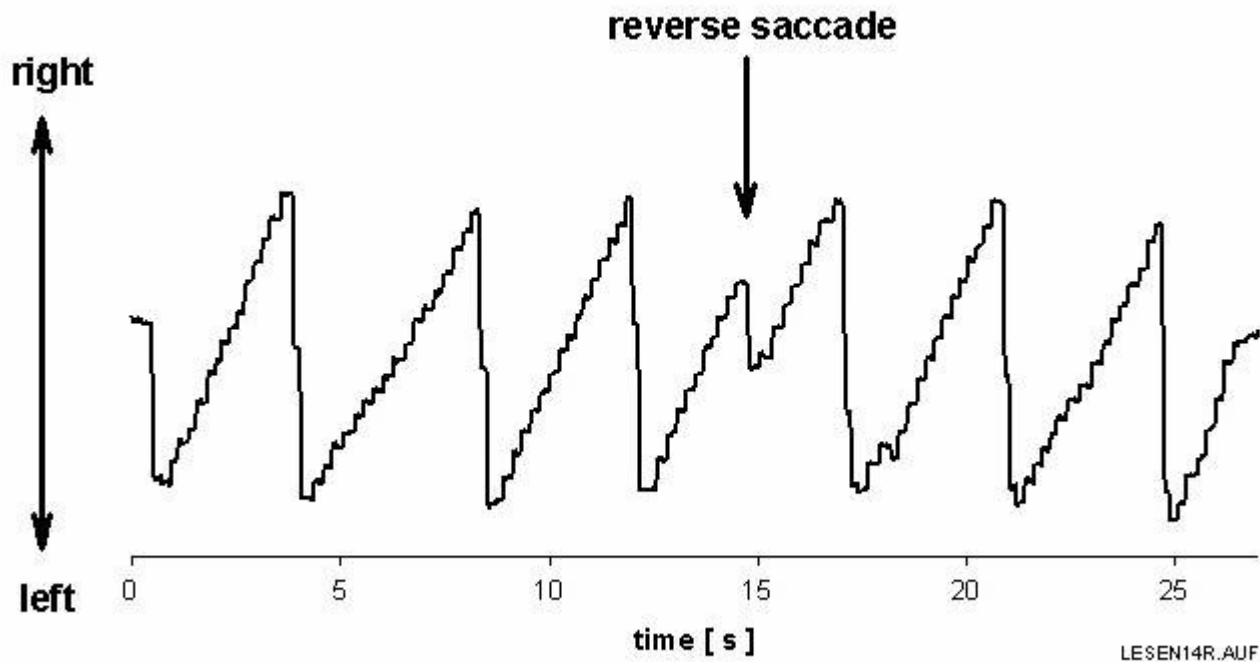
Elettrooculogramma (EOG)



Esempio di EOG.

Fondamenti di bioingegneria

Elettrooculogramma (EOG)



EOG durante la lettura.