Physiology of vision_4

Neurophysiology

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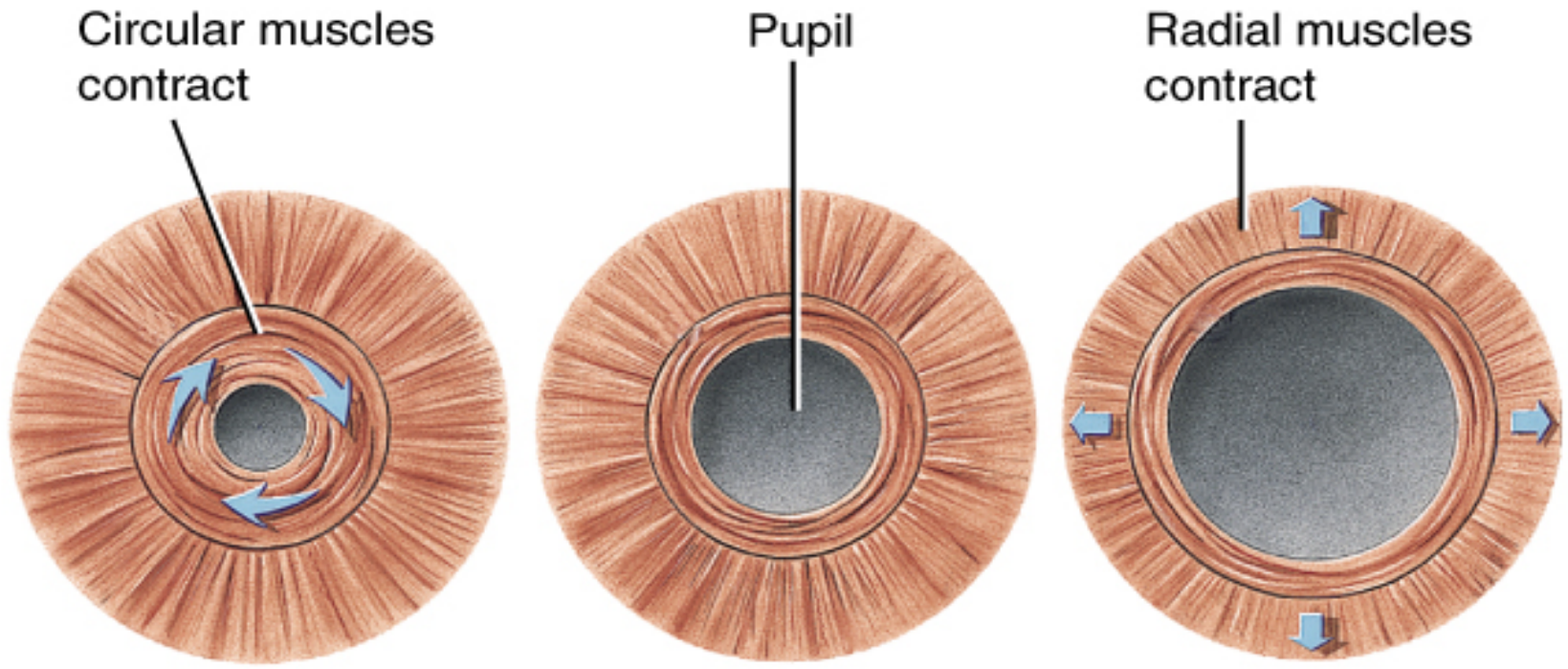
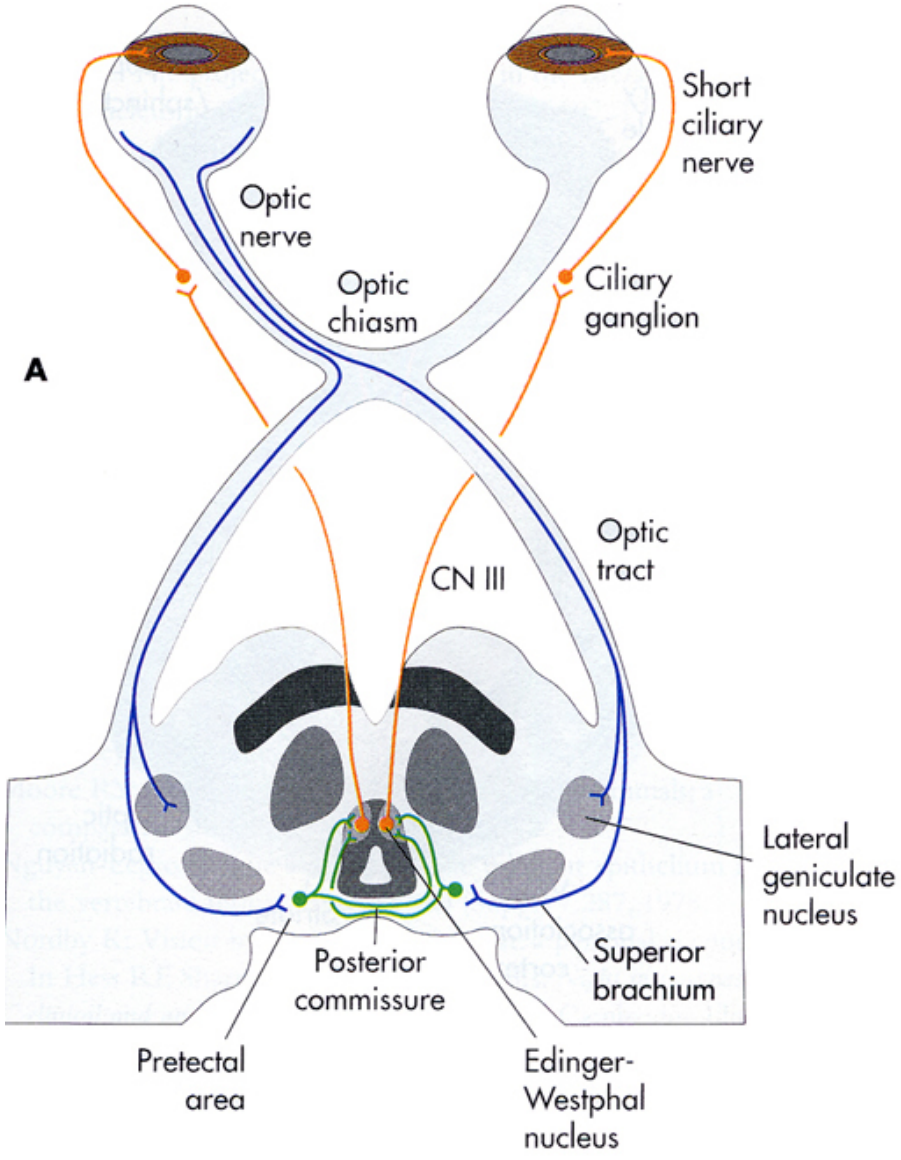
Pupil reflexes and accomodation

IL TARSIUS (nocturnal primate)



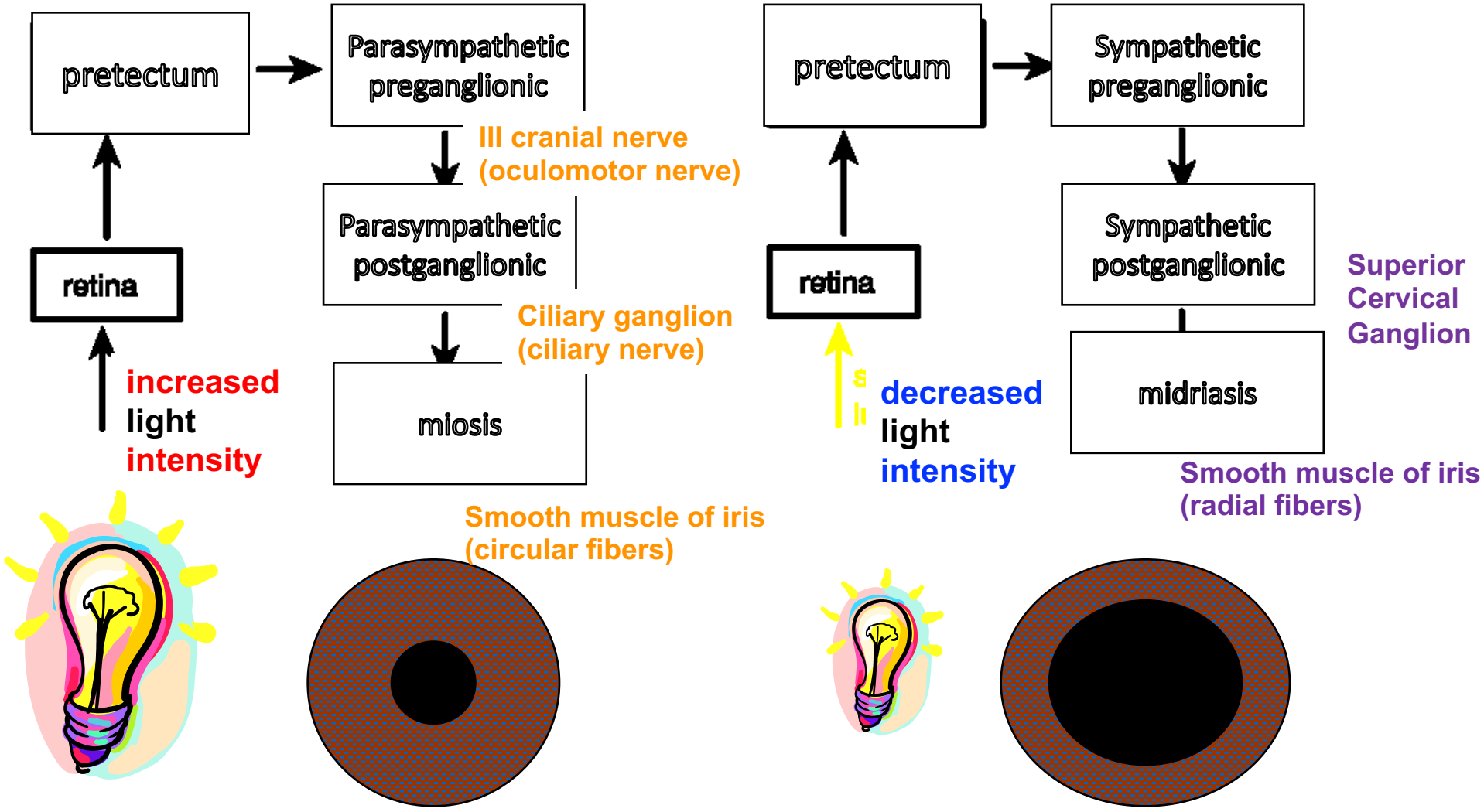
Smooth muscle

Pretectum (midbrain)



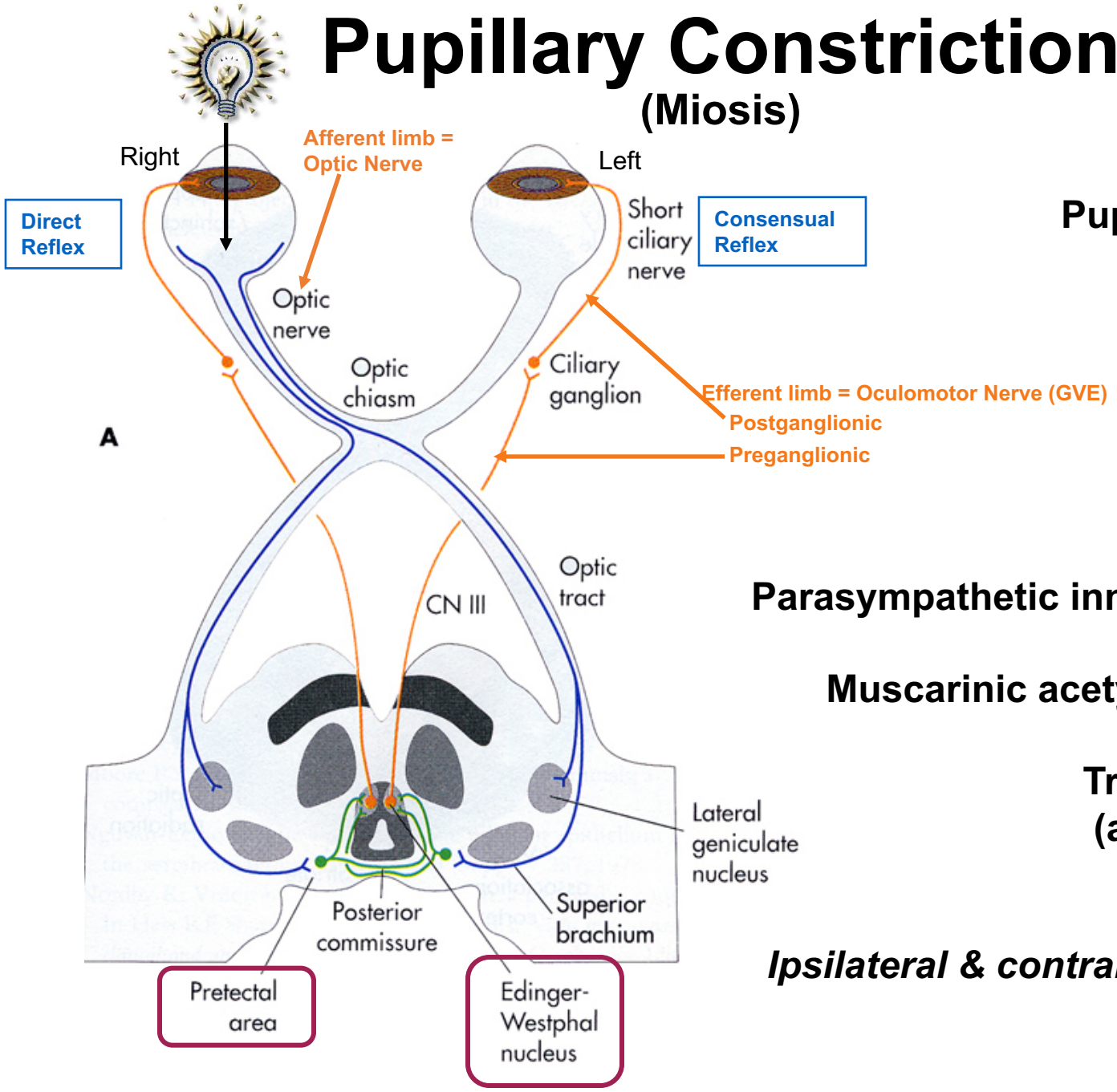
Pretectum and hypothalamus receive from specific GCs with melanopsin as photopigment

Response to luminance changes (not to luminance contrast)



Photic reflex - direct - consensual

Pupillary Constriction
(Miosis)



Pupillary Light Reflex

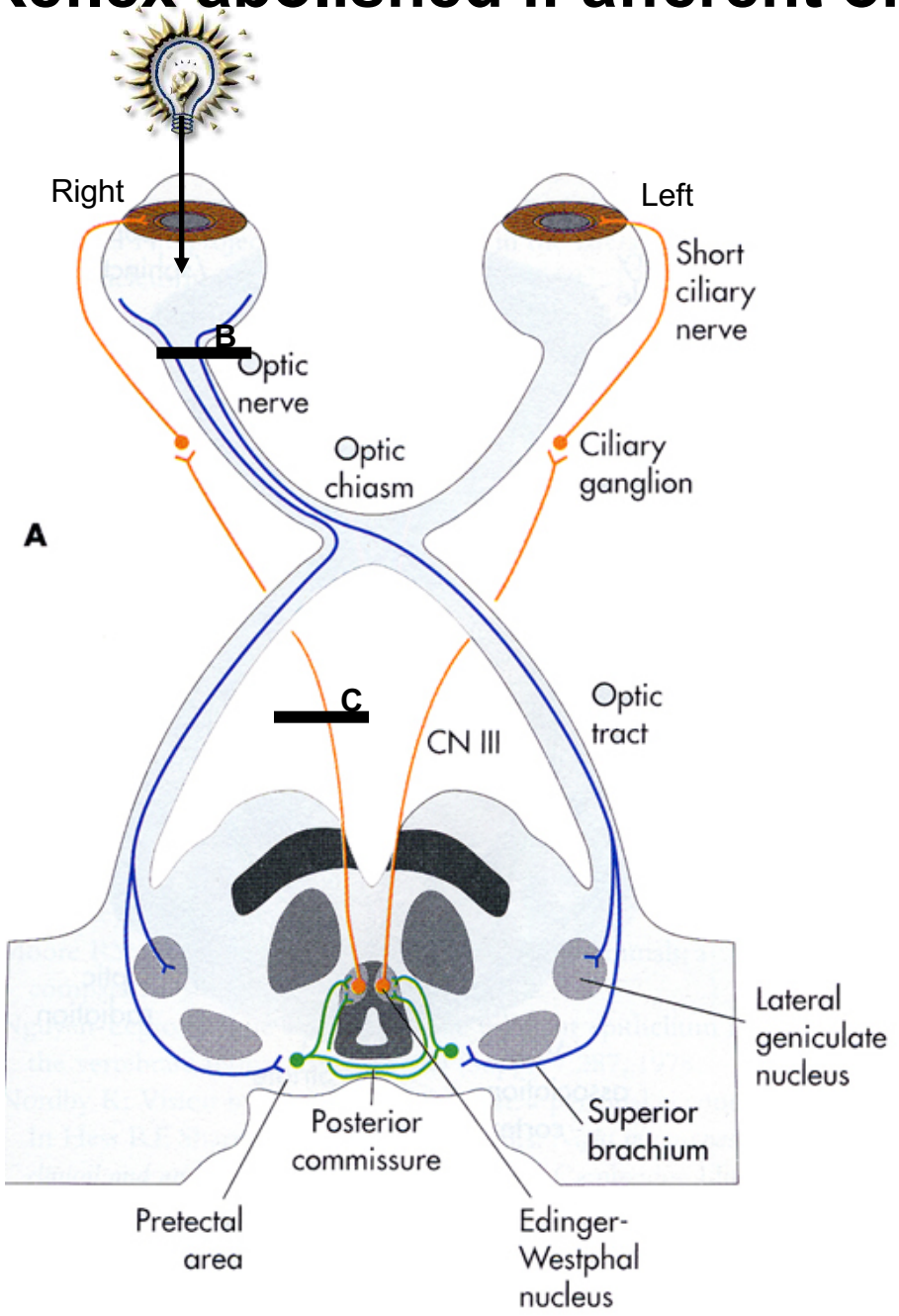
Parasympathetic innervation of the eye

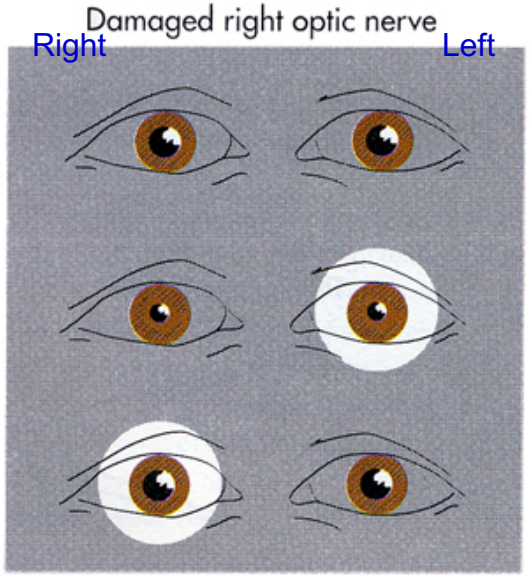
Muscarinic acetylcholine receptors

Trigger constrinction (antagonist: atropin)

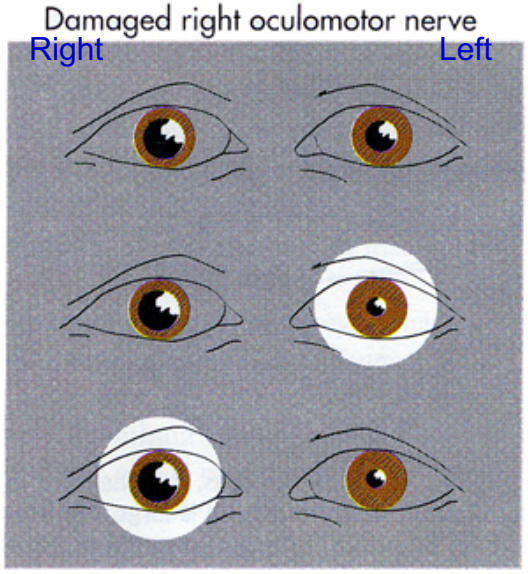
Ipsilateral & contralateral efferent limb

Reflex abolished if afferent or efferent is damaged.



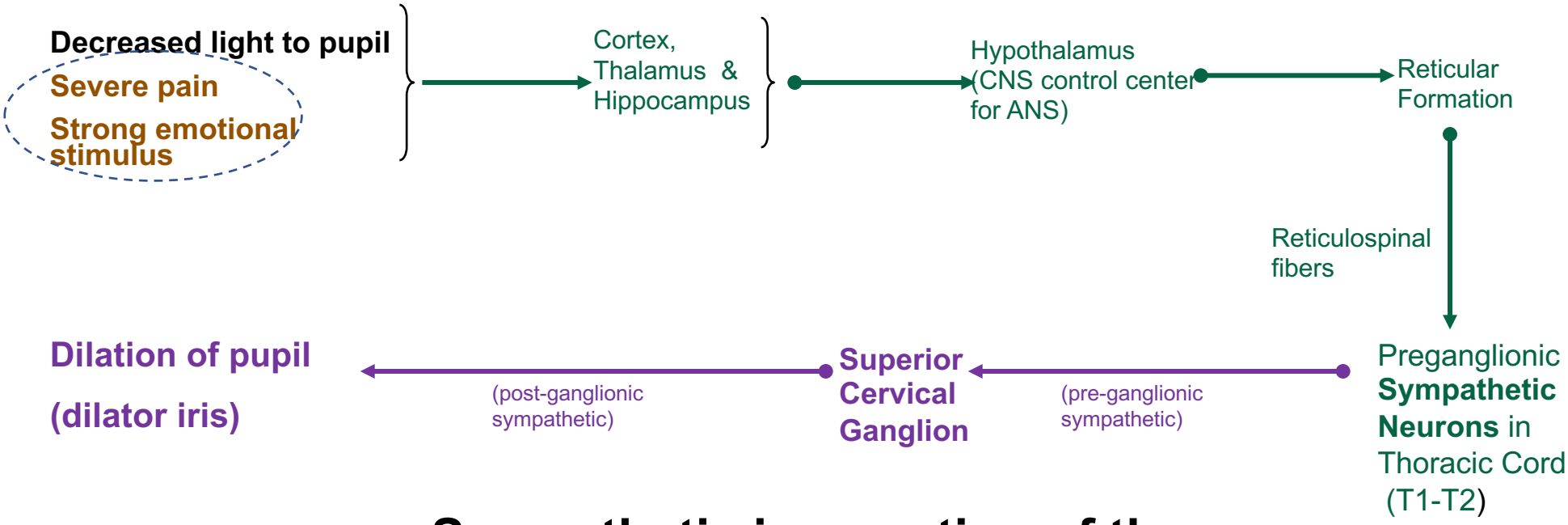


Afferent defect



Efferent defect

Pupillary Dilation
(Mydriasis)



Sympathetic innervation of the eye

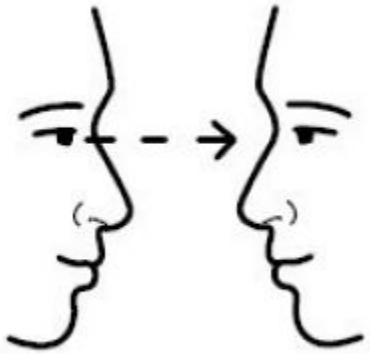
Horner's Syndrome

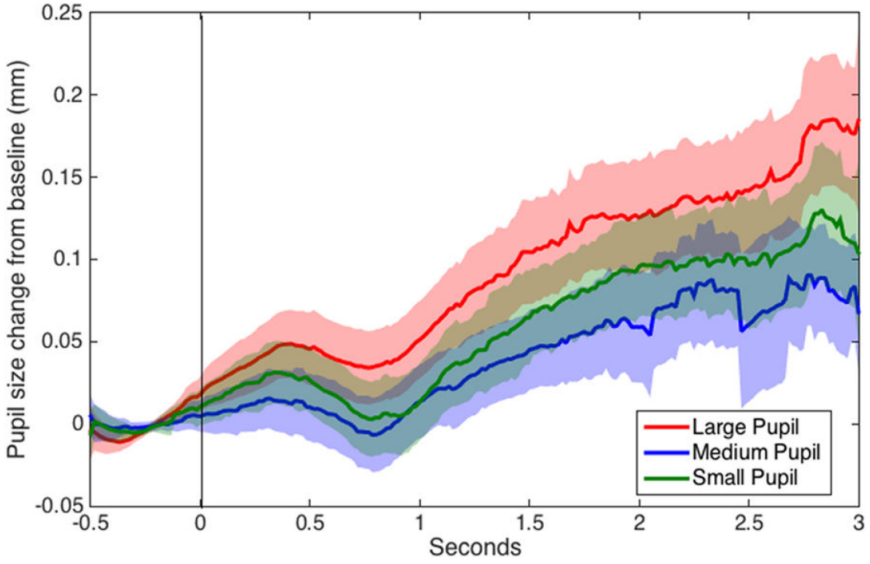
- Pupillary Constriction
- Ptosis
- Flushed & Dry Skin

- Loss of Sympathetics
- Lesion can be in **CNS** or **PNS**
- Deficits ipsilateral to lesion

Miosis	Mydriasis
Parasympathomimetics	Anticholinergics
Cholinergics	Opiates
Nicotine	Sympathomimetics

Pupil size in psychophysiology

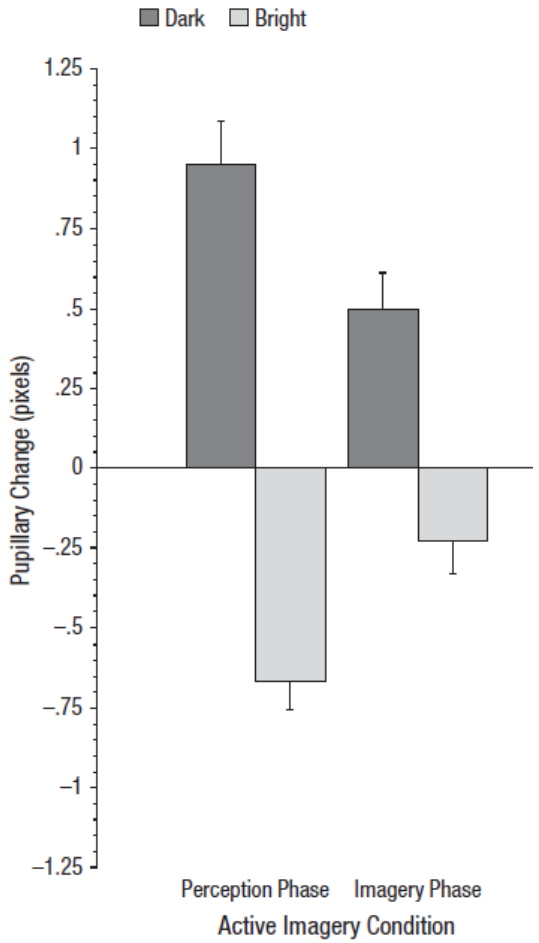




Fawcett et al 2017

Pupil size is contagious…

Pupil size in psychophysiology



Pupil size is modulated by imagery

Laeng & Sulutwedt 2013

Accommodation (or "Near") Reflex

1. Initiated by shift in gaze from far to near.

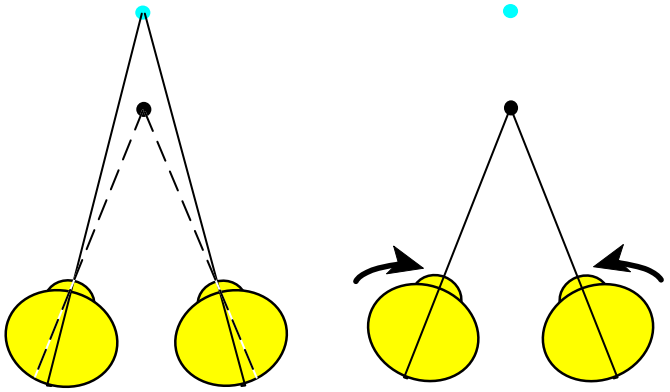
2. Three components:
   - **Ocular convergence**
   - **Pupillary constriction**
   - **Lens thickening *(ciliary nerve)***

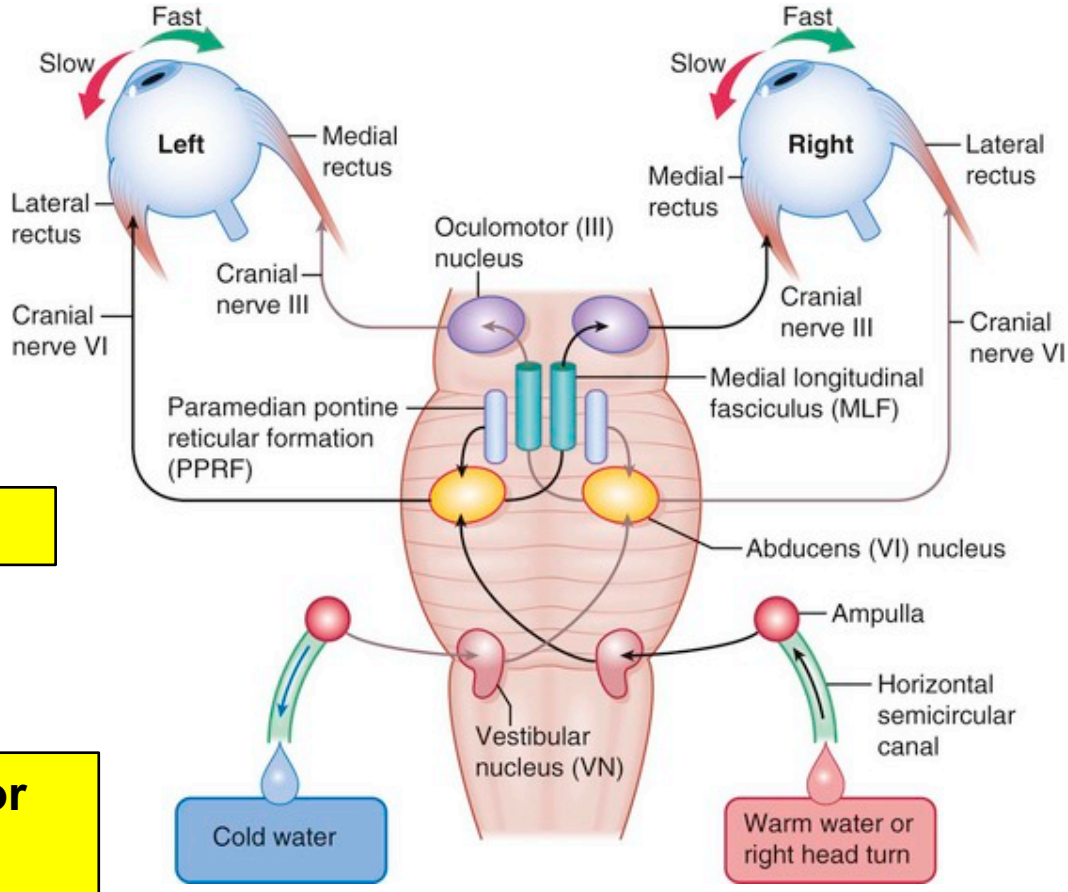
3. Efferent limb: Oculomotor

4. Afferent limb & Central Connections:

Optic nerve ⇒ Optic tract ⇒ Lateral Geniculate Nucleus ⇒ Optic Radiation ⇒ Primary Visual Cortex ⇒ Association Visual Cortex ⇒ Optic Radiation ⇒ Br. of Superior Colliculus ⇒ Superior Colliculus ⇒ Oculomotor Nuclei ⇒ Oculomotor Nerve

Ocular convergence





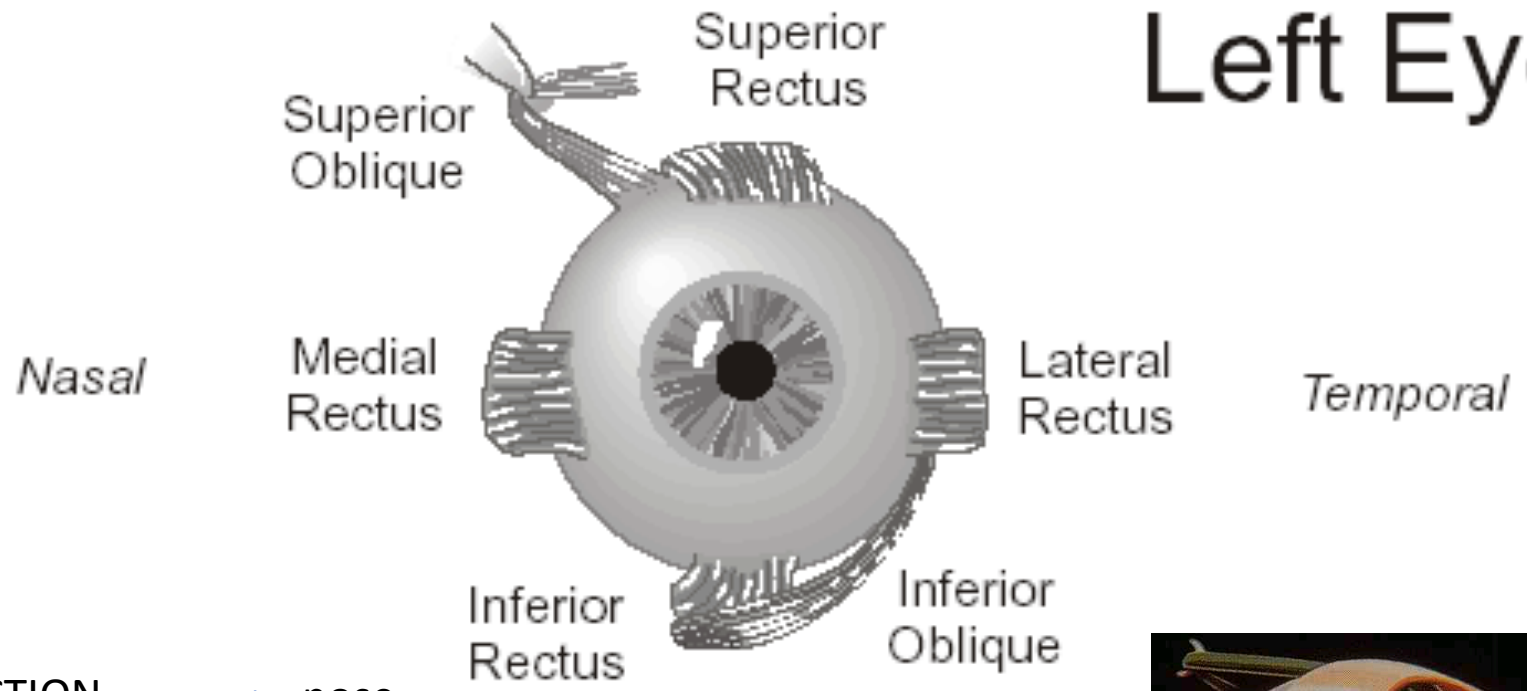
Blurred image (binocular disparity)

Visual cortex

Oculomotor centres Pons Mesencephalon

vergence

The mobile eye

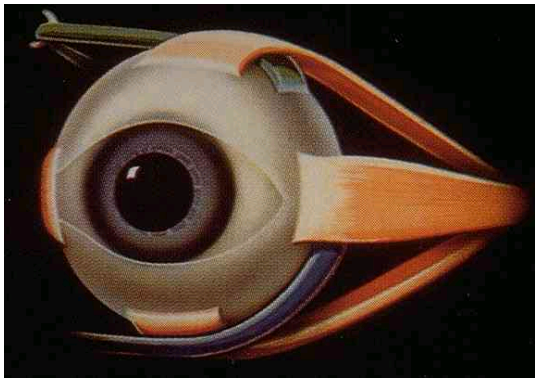


ADDUCTION → nose

ABDUCTION ← nose

VERTICAL M

TORSIONS



Extraocular muscles (skeletal)

The mobile eye

Some half billion years ago, the mobile eye compensated an annoying by-product of a moving organism: it reduced the blur caused by retinal slip.

This *stabilization* function is accomplished by the ***VOR***

Stabilization of the image on the retina.

The mobile eye

Visual exploration of the world is mediated by rapid shifts of the gaze (on average 2-5 per second) that direct the high-acuity foveal region to certain parts of the visual field. This *exploration* (or *visual search*) function is accomplished by ***saccades.***.

Saccades maximize *fixation* time.

Types of eye movements

Gaze-holding reflexes

VOR
OKR

Gaze-shifting movements

Saccades
Smooth pursuit eye movements
Vergence

Plus:

Fixational eye movements (microsaccades, tremor, drift)

N.B. **Gaze** direction depends on the combined action of **eye** and **head** movements!

1) Saccades Voluntary and involuntary, fast e balistic with change of the fixation point

2) Smooth pursuit Slower movements to keep a moving stimulus on the fovea – under voluntary control – only for moving stimuli

3) Convergence Maintains the visual axes on the point of fixation when it moves near or far - only not consensual

4) Vestibular Reflex (VOR) When the head rotates, eyes rotate in the opposite direction to stabilize the focus on the retina (visual stimulus is not needed).

5) Optokinetic reflex (OKR) VOR does not work well for long and persistent movements. OKR is activated when images slip on a large retinal portion and produces the perception of movement.

Miniature eye movements

- Micro-saccades (<0.4 deg)
- Tremor (30-100 Hz)
- Drift (<0.1 deg/s)

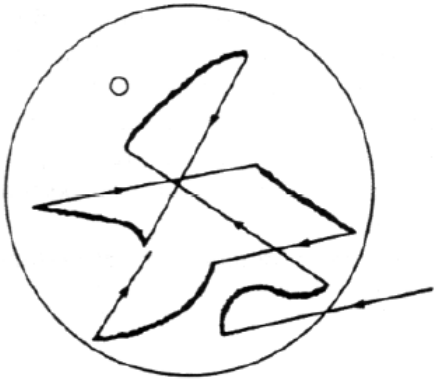
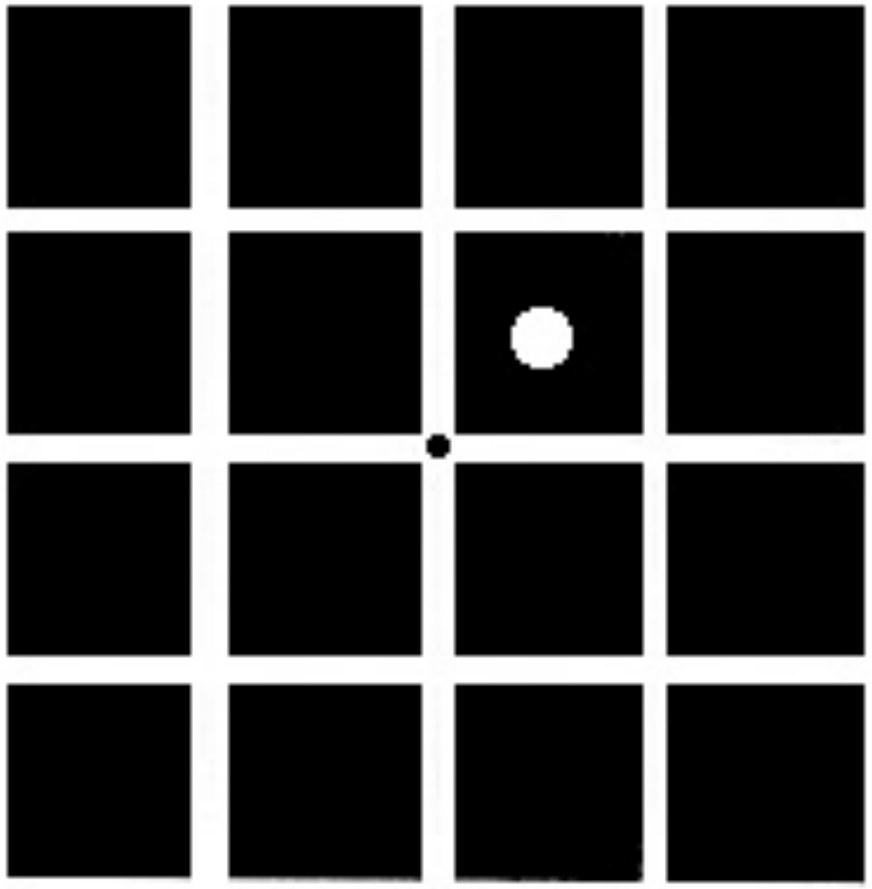


Fig. 6.8 Movimenti oculari in miniatura durante le fissazioni. Cerchio piccolo: distanza fra due coni nella fovea. Il cerchio grande ha un diametro di 0.17° (*fonte*: Pritchard, 1964)

Miniature eye movements



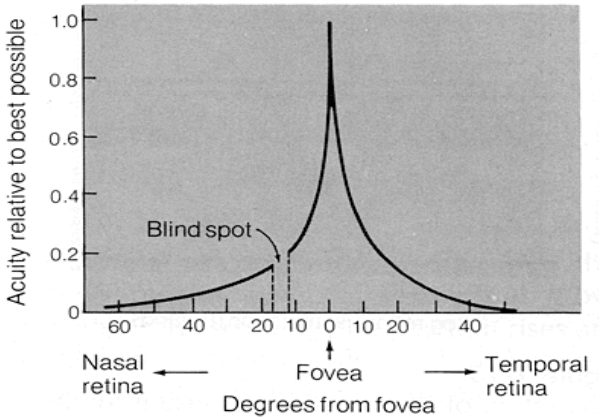
Saccades

Two functions:

Two functions:

Foveating

Orienting

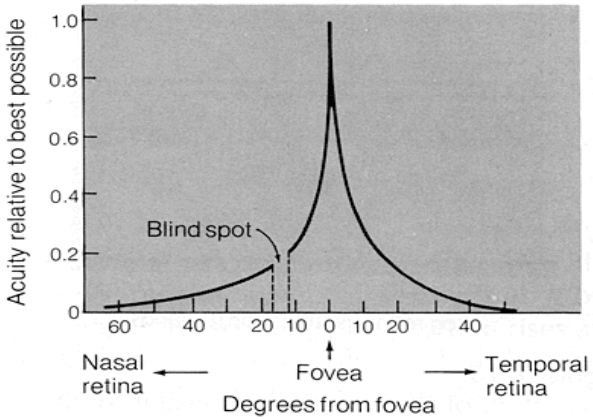


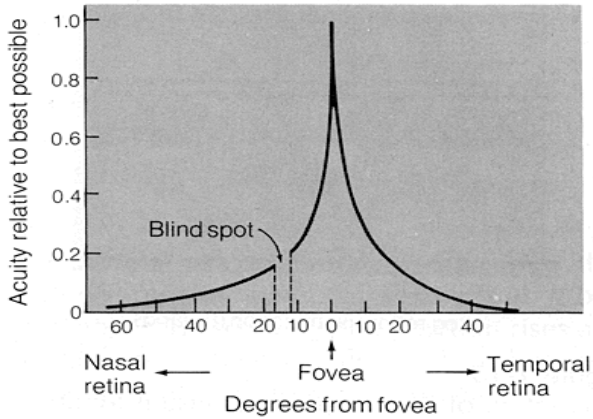
[redacted]

Two functions:

Foveating

Orienting

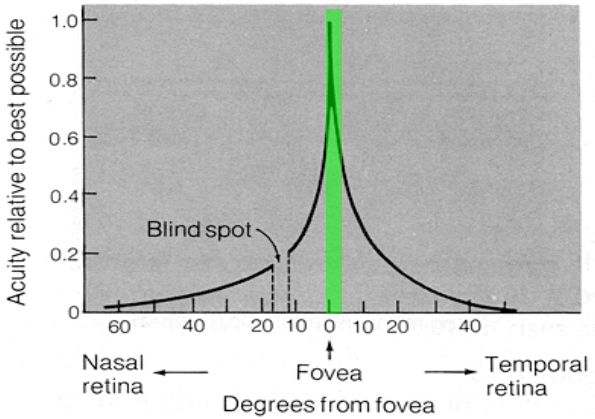


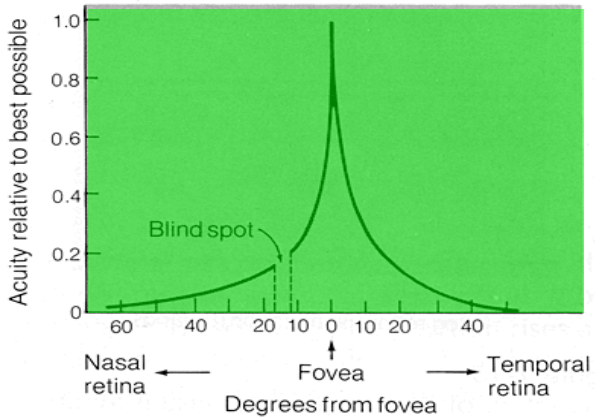


Two functions:

Foveating

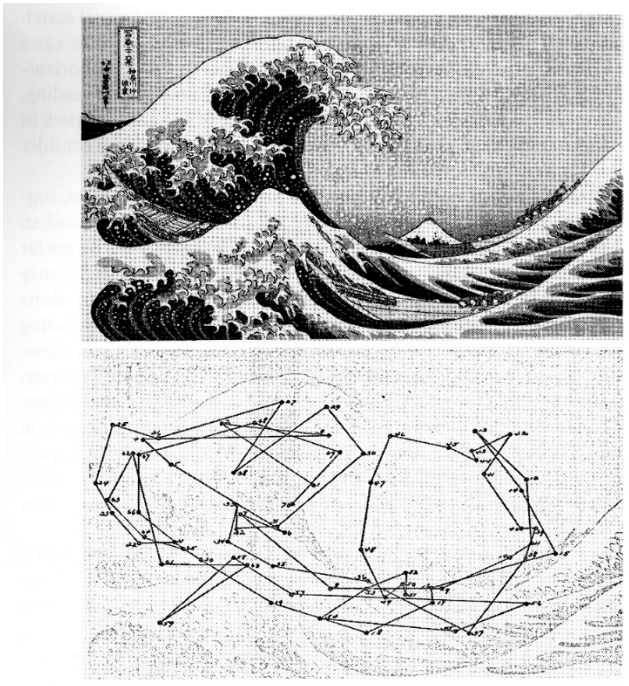
Orienting



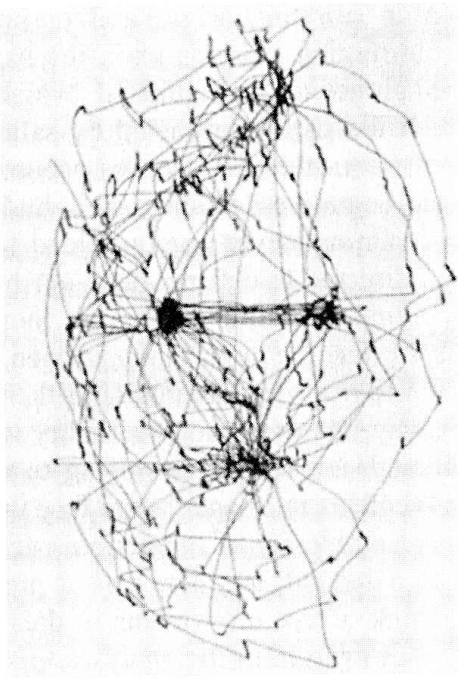


Saccades

We scan the visual world with sequences of alternating saccades and fixations



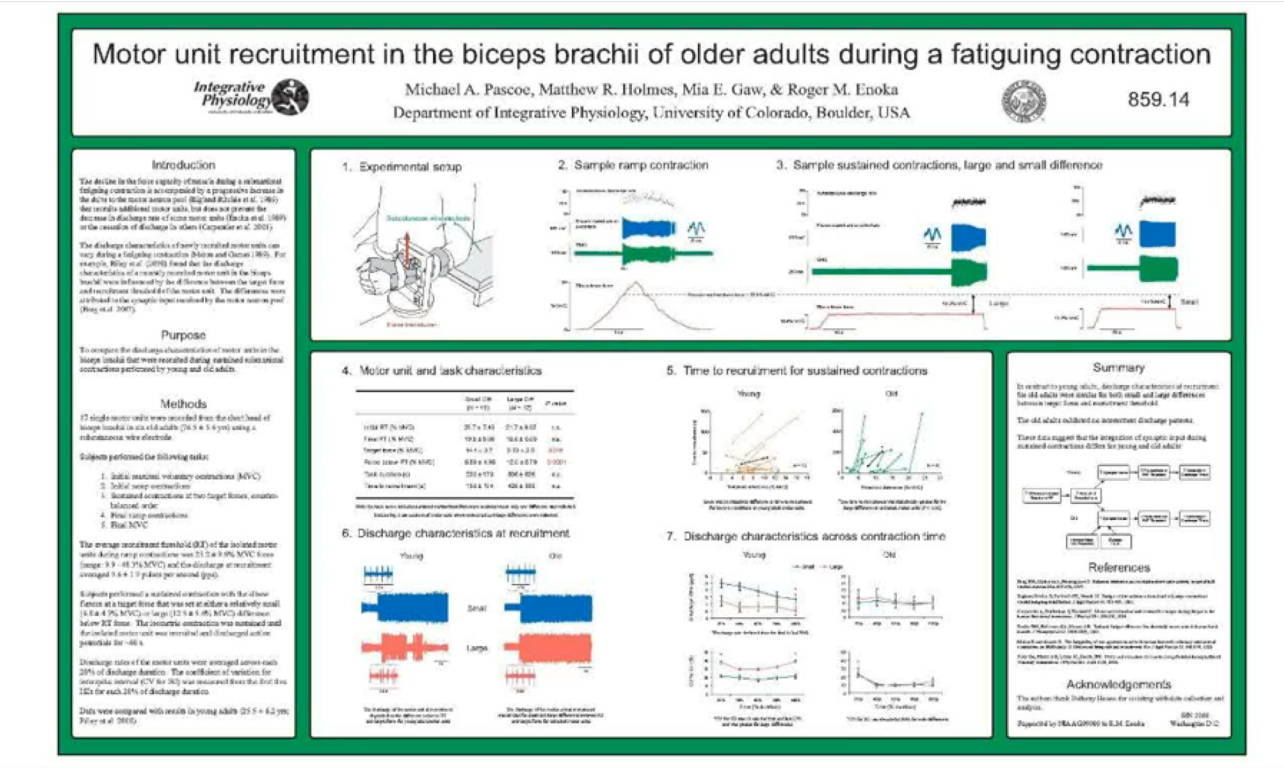
Buswell, 1935



Yarbus , 1967

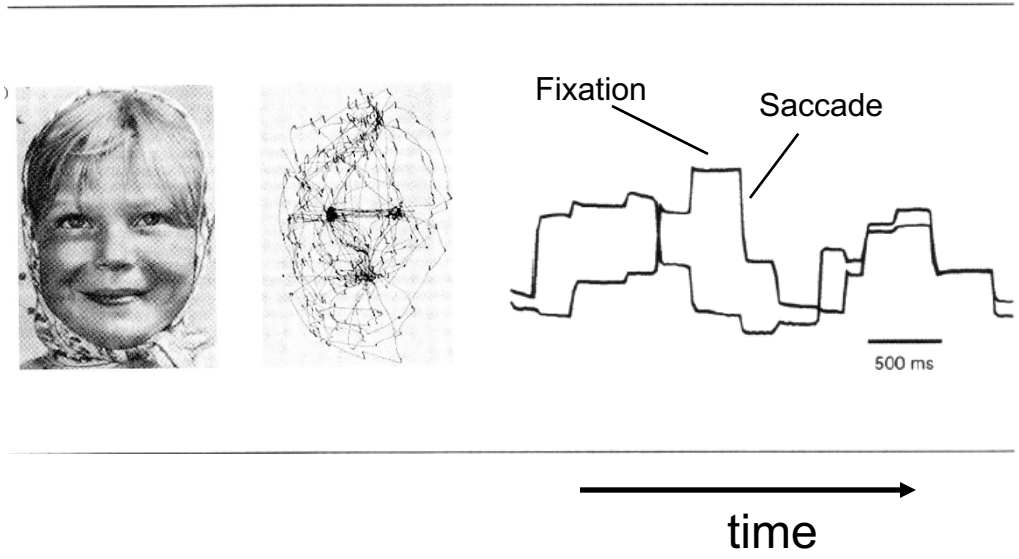
Saccades

We scan the visual world with sequences of alternating saccades and fixations



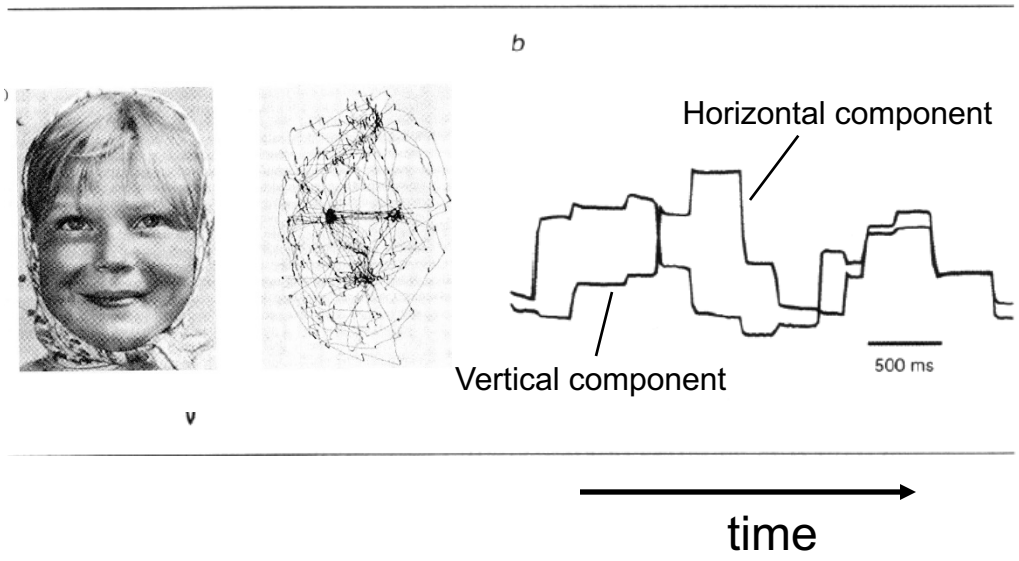
Saccades

We scan the visual world with sequences of alternating saccades and fixations

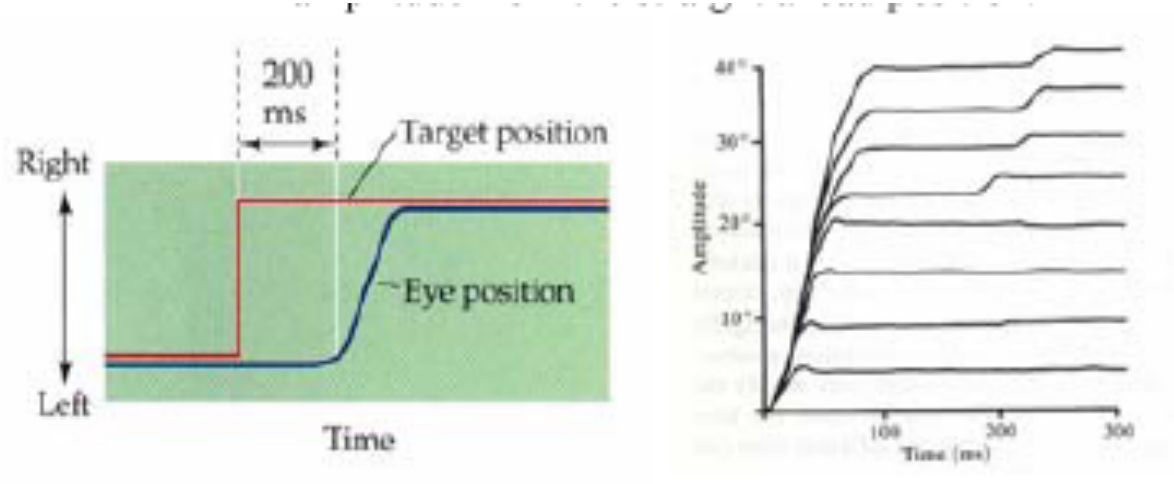


Saccades

We scan the visual world with sequences of alternating saccades and fixations



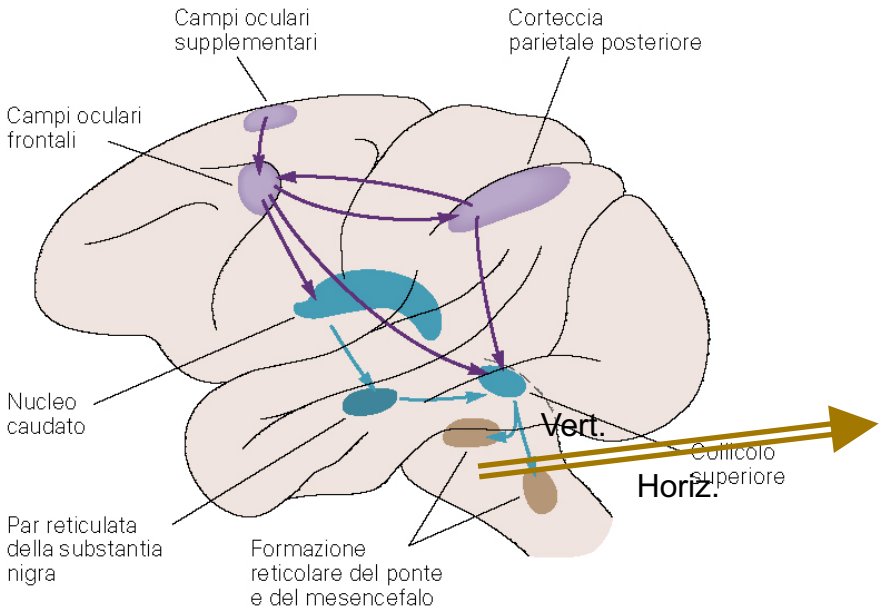
SACCADES

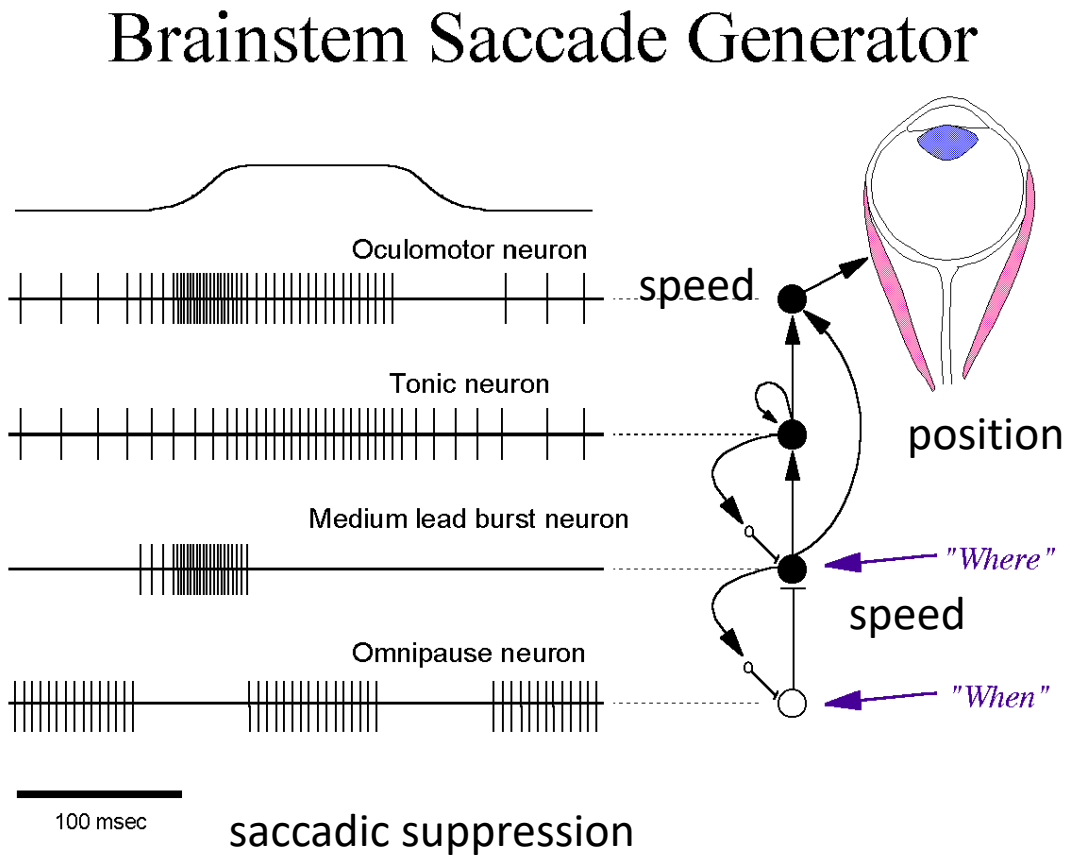


Under the control of 3 areas:

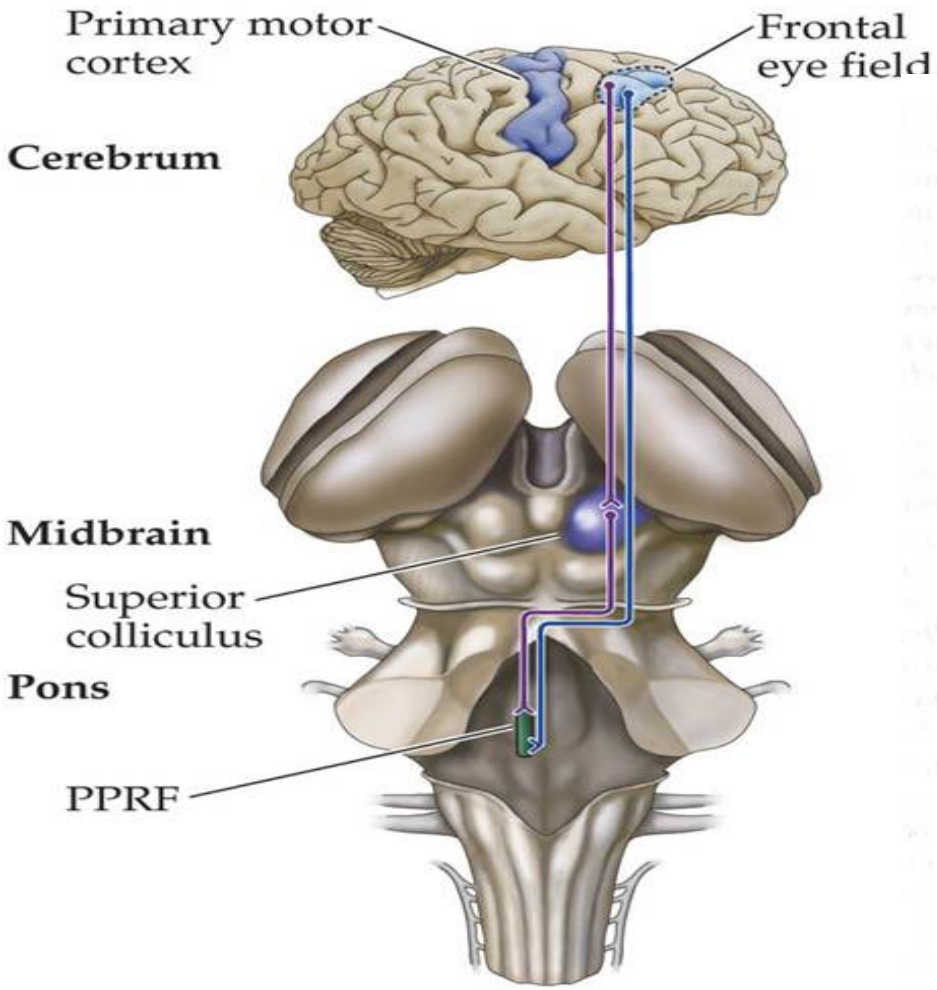
- **Voluntary saccades – frontal ocular fields (Brodmann's area 8)**
- **Involuntary saccades to complex stimuli – parietal lobe (Brodmann's area 7)**
- **Involuntary saccades to simple stimuli – superior colliculus**

Saccades


Campi oculari supplementari
Corteccia parietale posteriore
Campi oculari frontali
Nucleo caudato
Vert.
Horiz.
Collicolo superiore
Par reticulata della substantia nigra
Formazione reticolare del ponte e del mesencefalo

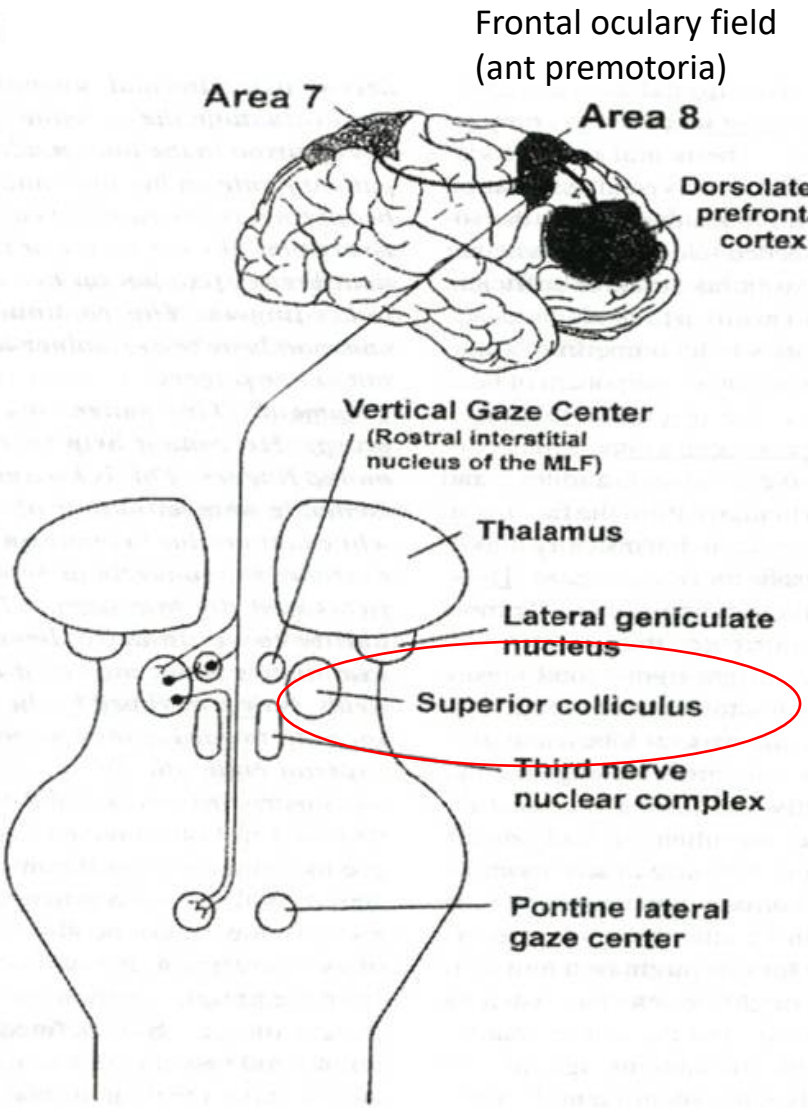

Brainstem Saccade Generator
Oculomotor neuron
speed
Tonic neuron
position
Medium lead burst neuron
"Where"
speed
Omnipause neuron
"When"
100 msec
saccadic suppression

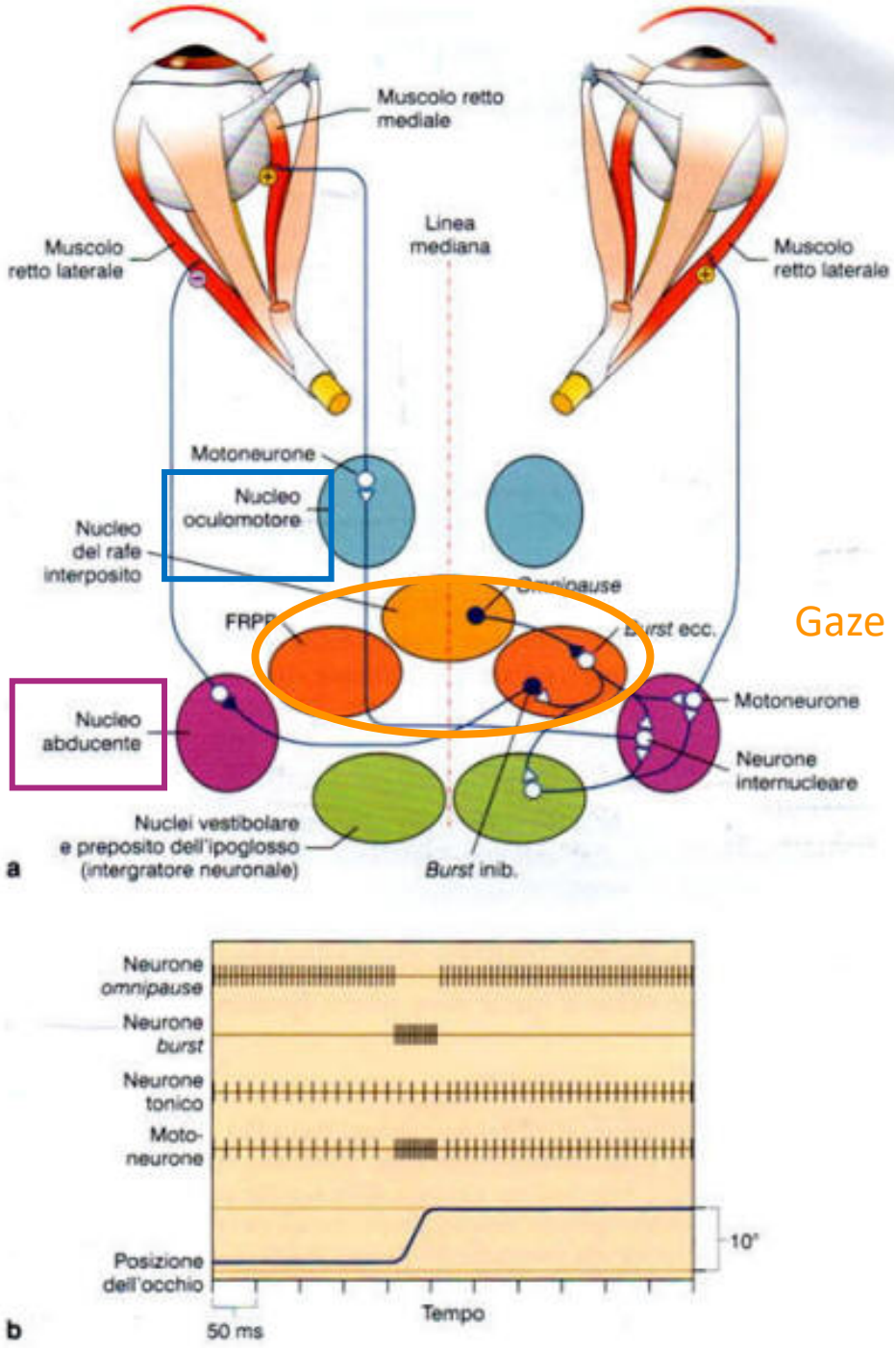
Voluntary saccades



Movement vs contralateral space

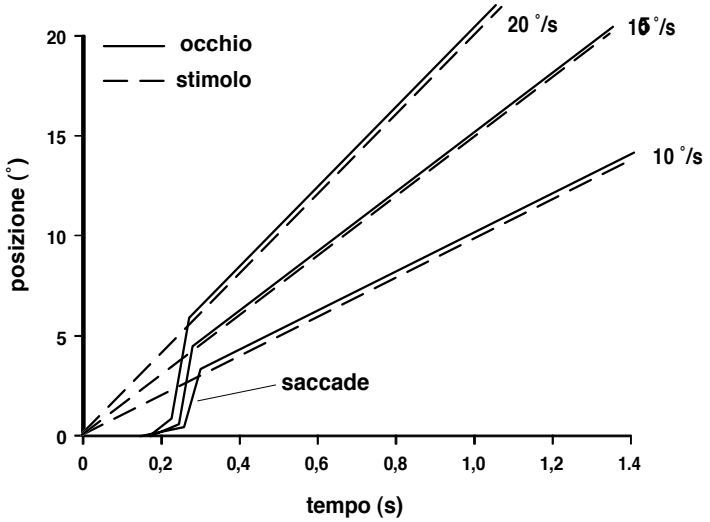
Involuntary saccades

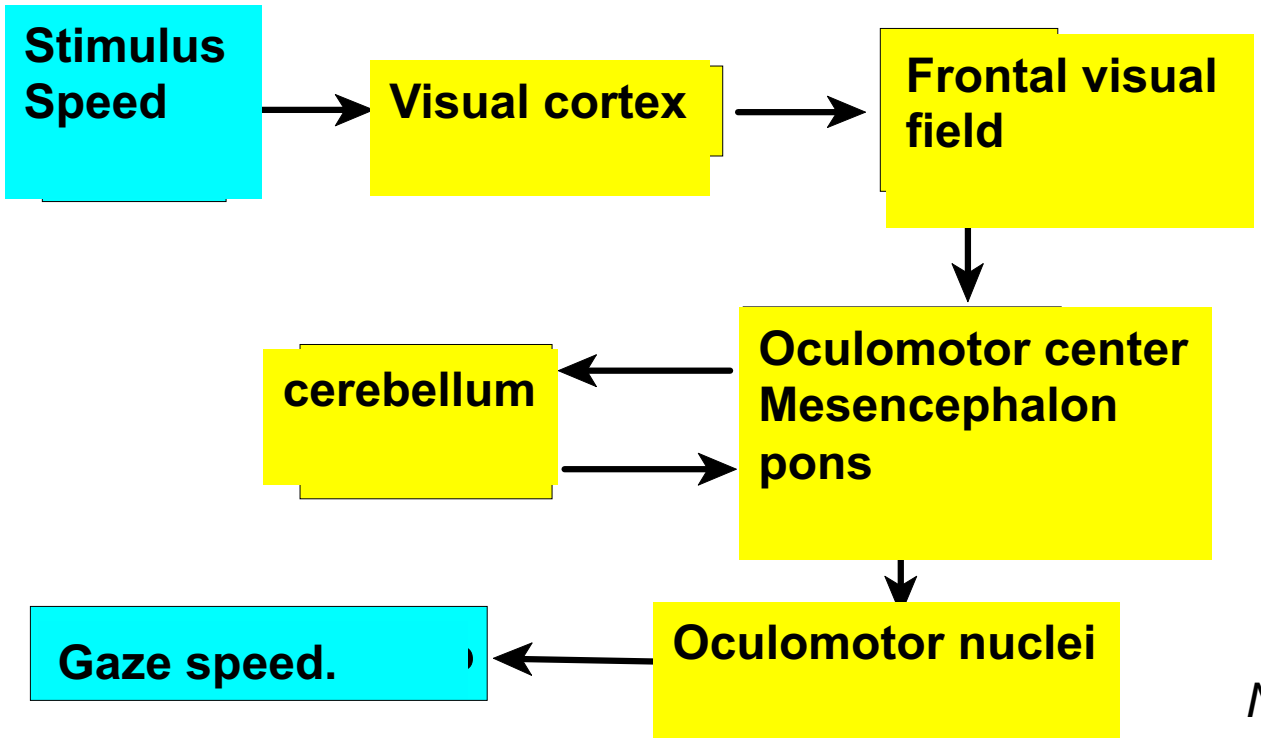




Gaze center- brainstem

SMOOTH PURSUIT MOVEMENT

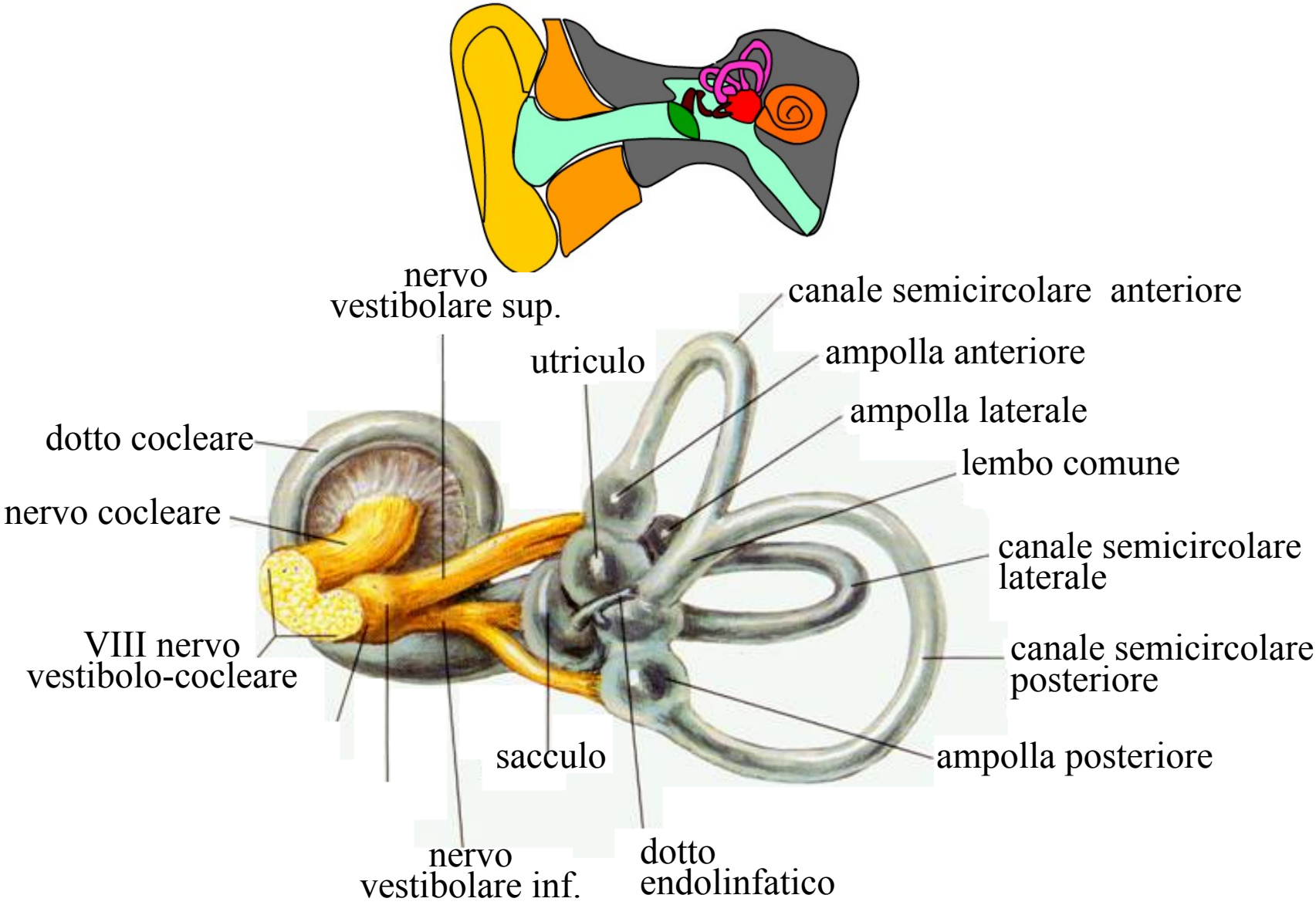




No collicolus

VOR

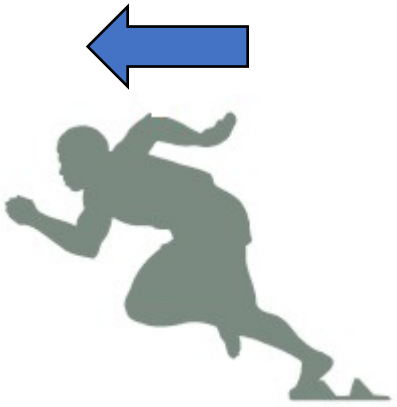
The vestibular system – inner ear



Semicircular canals

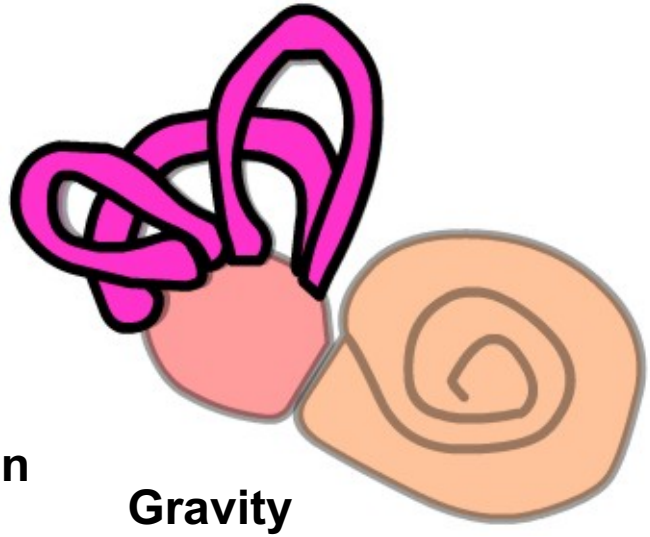
Angular acceleration
(rotational movements)

Linear accelleration

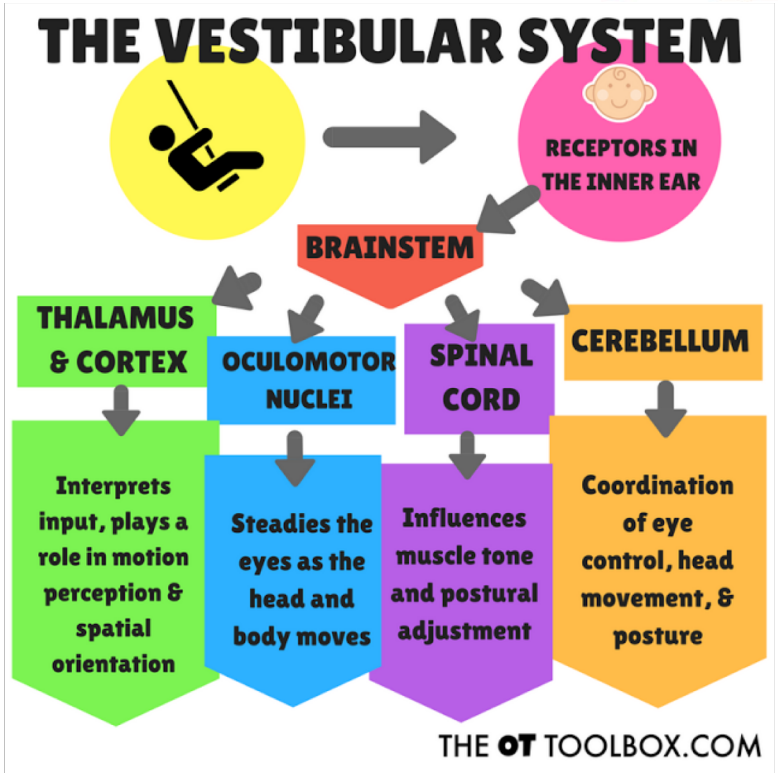


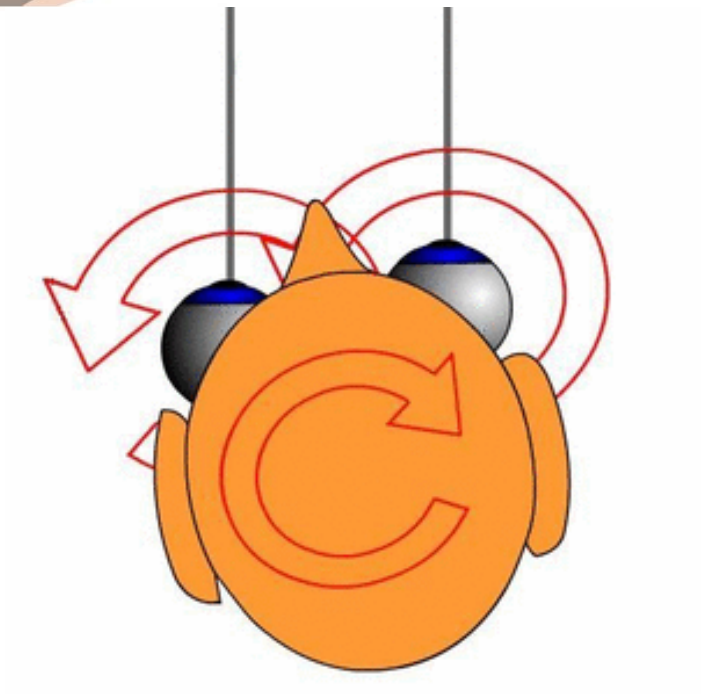
Otholits

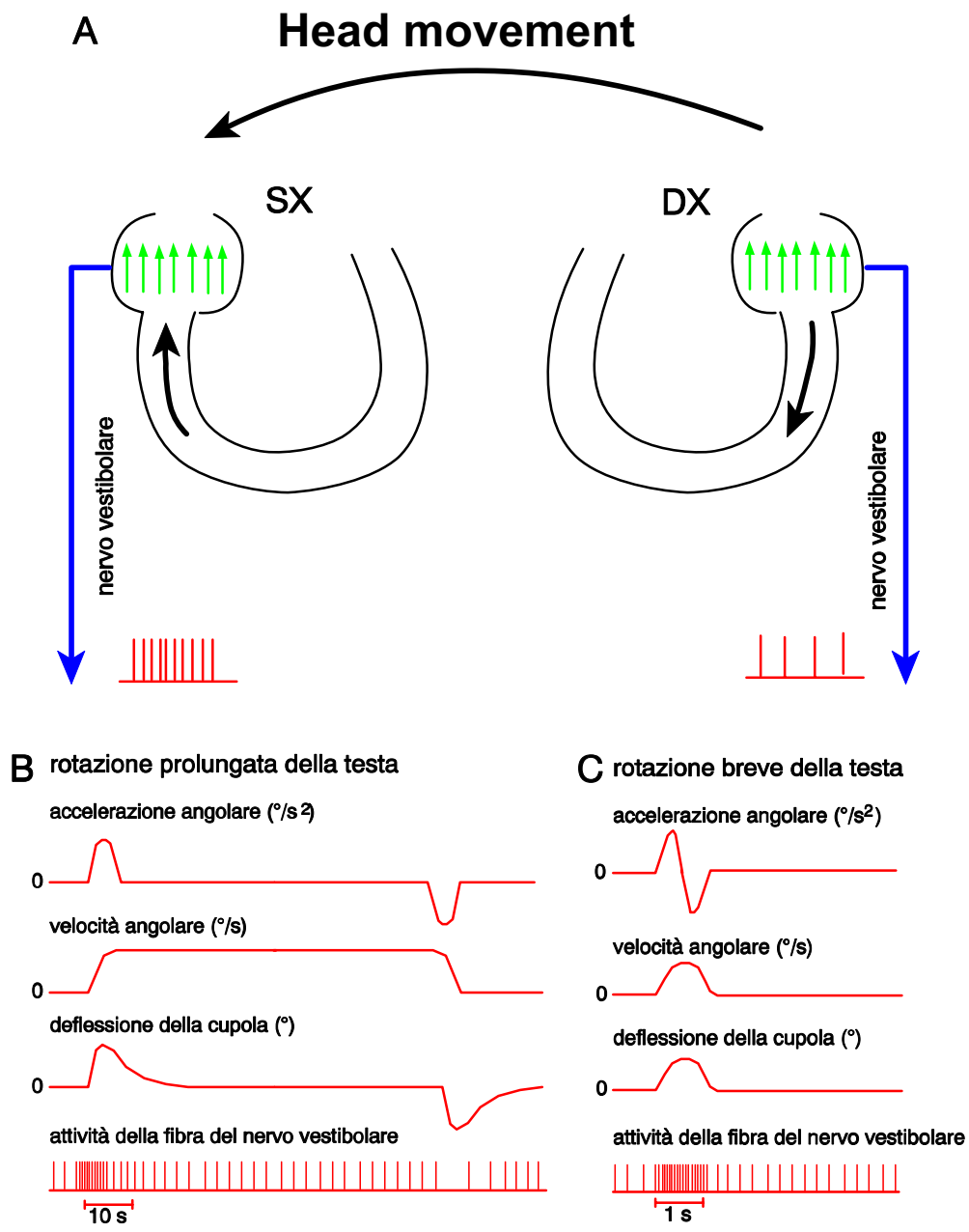
Linear accelleration

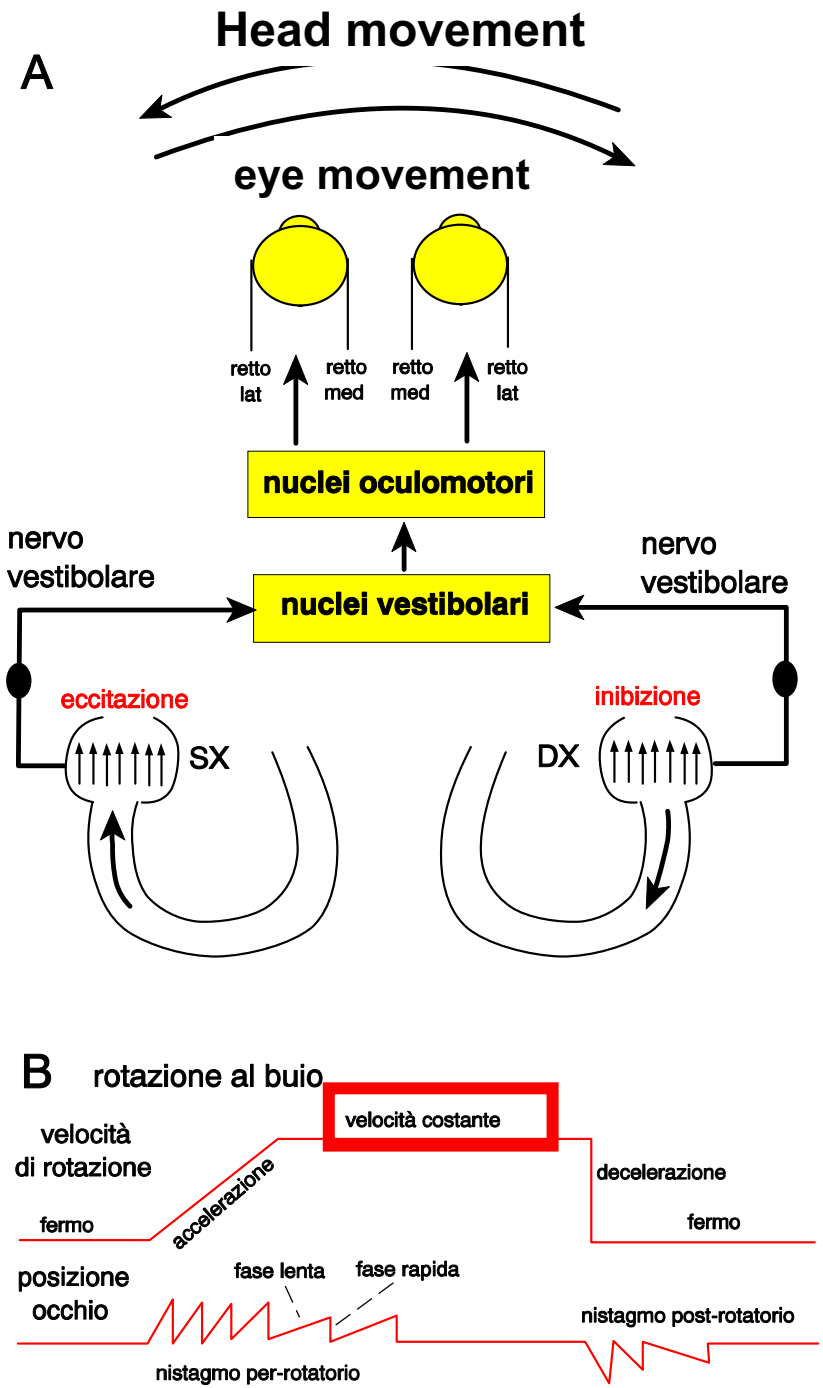


Gravity


THE VESTIBULAR SYSTEM
RECEPTORS IN THE INNER EAR
BRAINSTEM
THALAMUS & CORTEX
OCULOMOTOR NUCLEI
SPINAL CORD
CEREBELLUM
Interprets input, plays a role in motion perception & spatial orientation
Steadies the eyes as the head and body moves
Influences muscle tone and postural adjustment
Coordination of eye control, head movement, & posture
THE OT TOOLBOX.COM

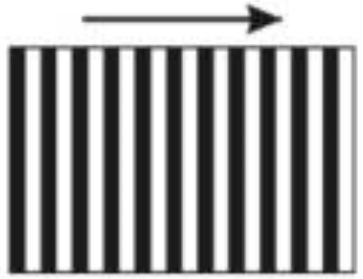


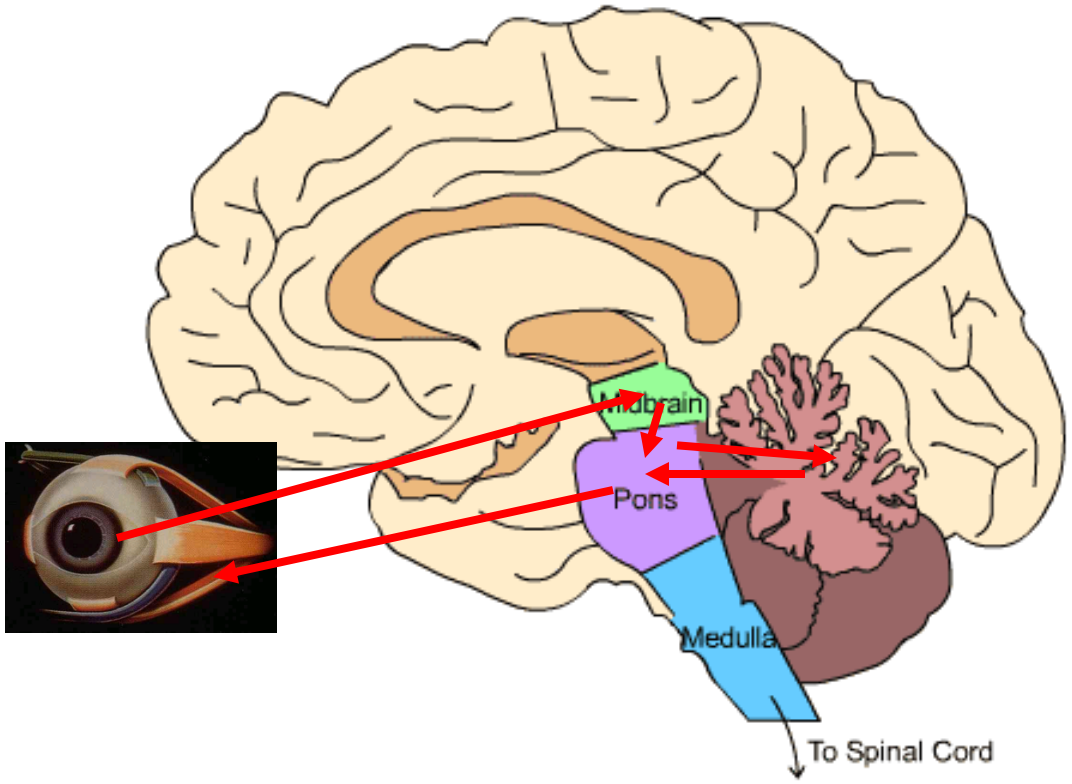

A
Head movement
SX
DX
nervo vestibolare
nervo vestibolare
B rotazione prolungata della testa
accelerazione angolare (°/s 2)
0
velocità angolare (°/s)
0
deflessione della cupola (°)
0
attività della fibra del nervo vestibolare
10 s
C rotazione breve della testa
accelerazione angolare (°/s2)
0
velocità angolare (°/s)
0
deflessione della cupola (°)
0
attività della fibra del nervo vestibolare
1 s

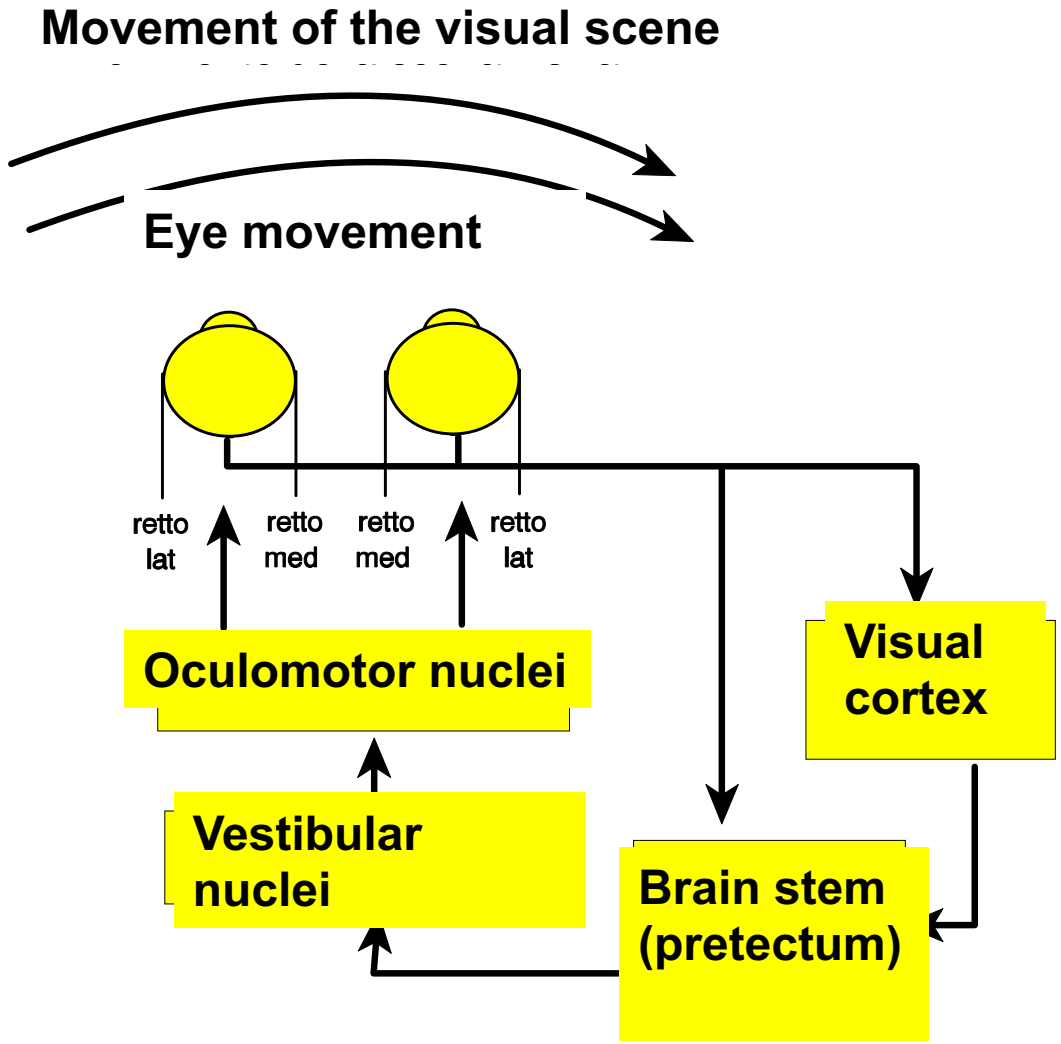

A
Head movement
eye movement
retto lat
retto med
retto med
retto lat
nuclei oculomotori
nervo vestibolare
nuclei vestibolari
nervo vestibolare
eccitazione
SX
inibizione
DX
B
rotazione al buio
velocità di rotazione
velocità costante
accelerazione
decelerazione
fermo
fermo
posizione occhio
fase lenta
fase rapida
nistagmo post-rotatorio
nistagmo per-rotatorio

The Optokinetic Reflex

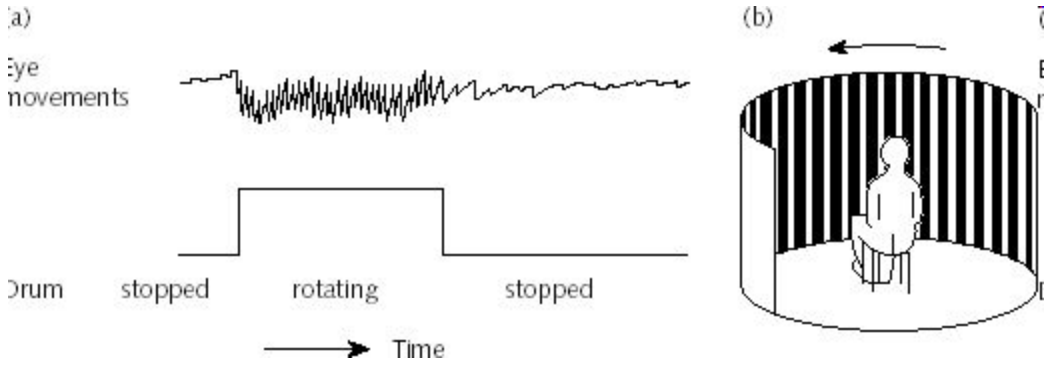
OKR

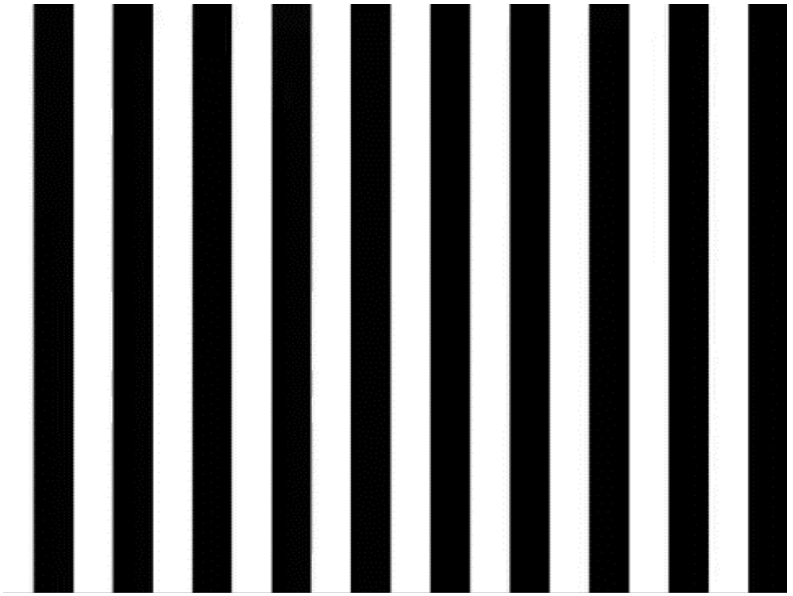





Movement of the visual scene
Eye movement
retto lat
retto med
retto med
retto lat
Oculomotor nuclei
Visual cortex
Vestibular nuclei
Brain stem (pretectum)

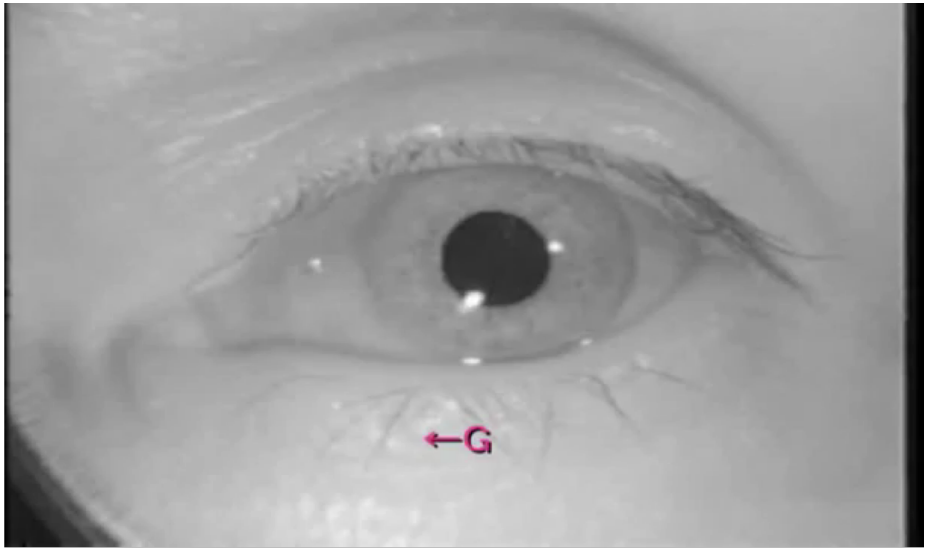
The Optokinetic Reflex



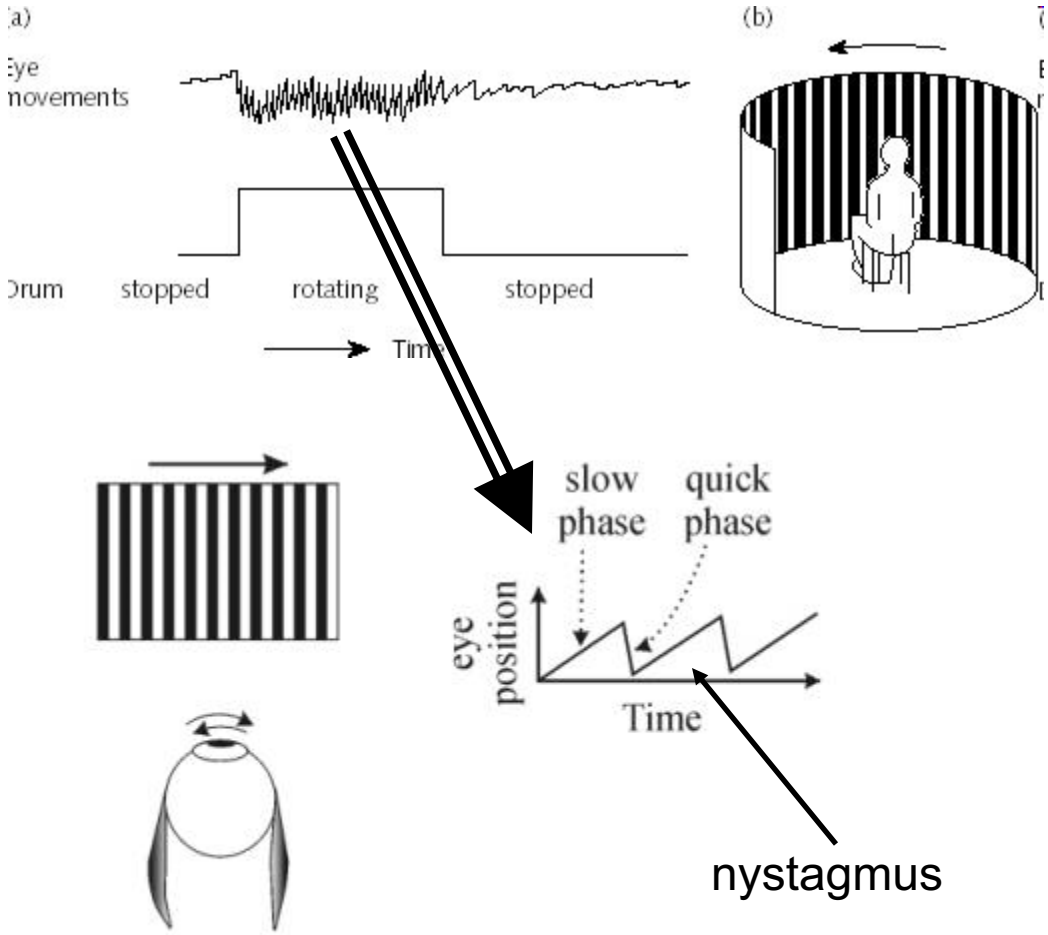


The Optokinetic Reflex

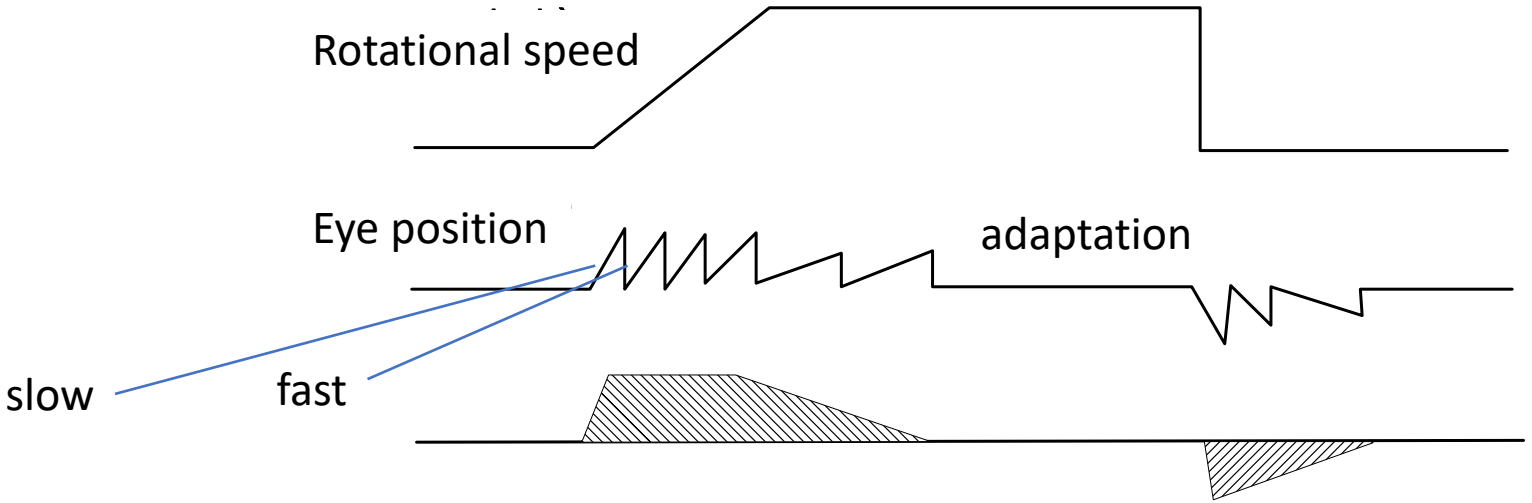
Nystagmus



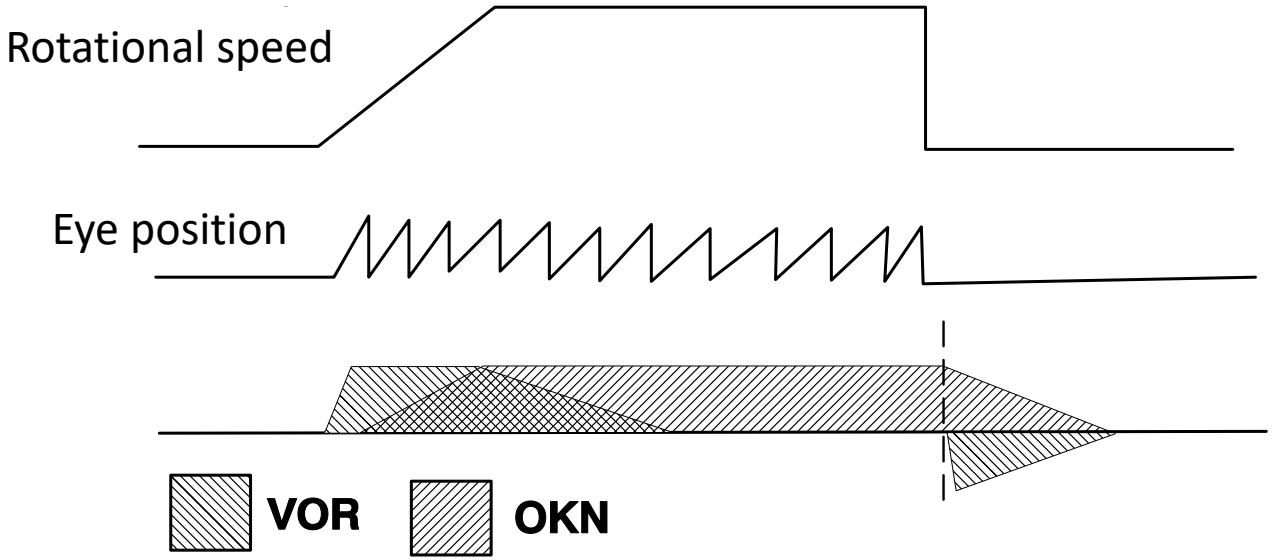
The Optokinetic Reflex



Rotation in the darkness

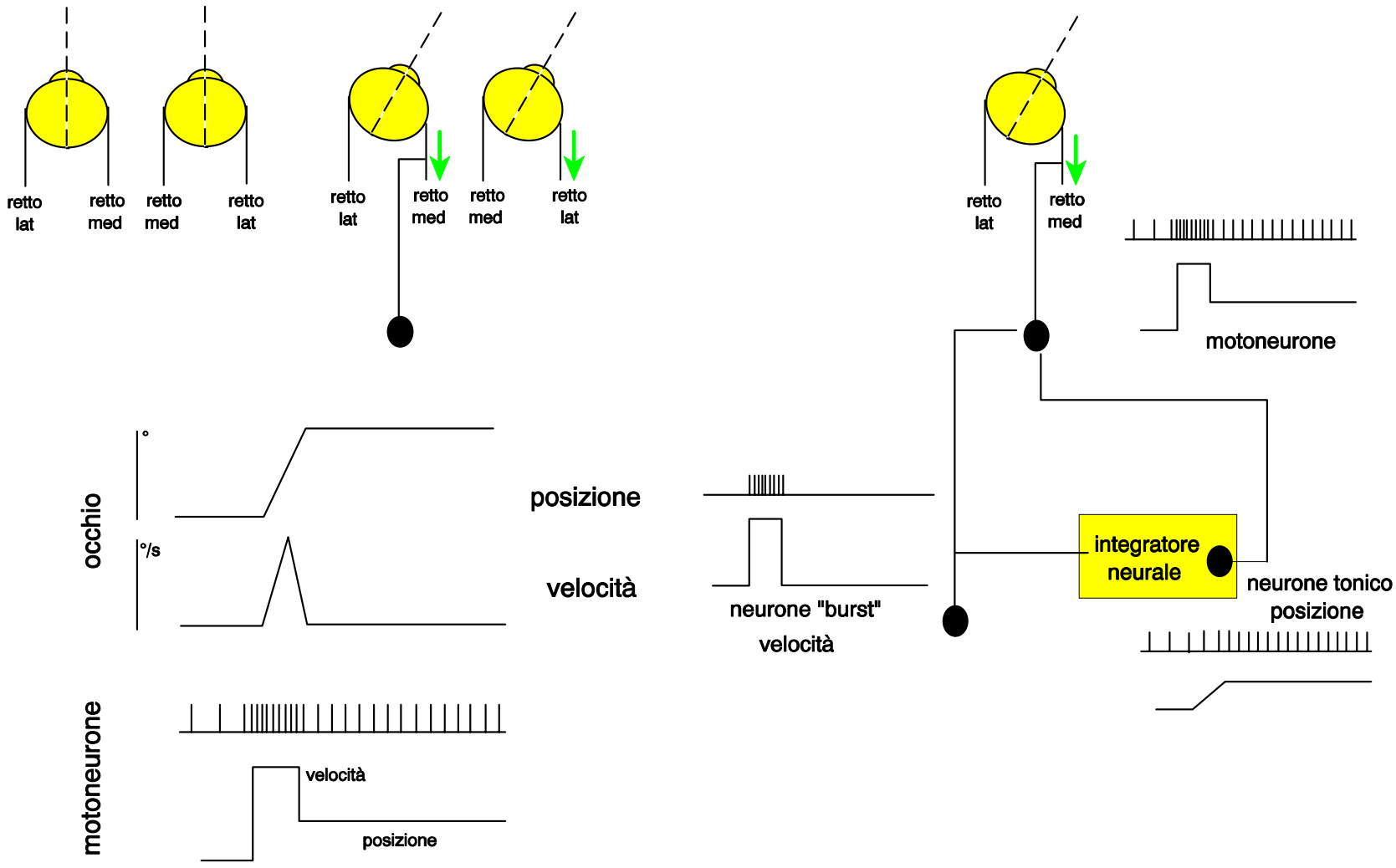


Rotation under illumination

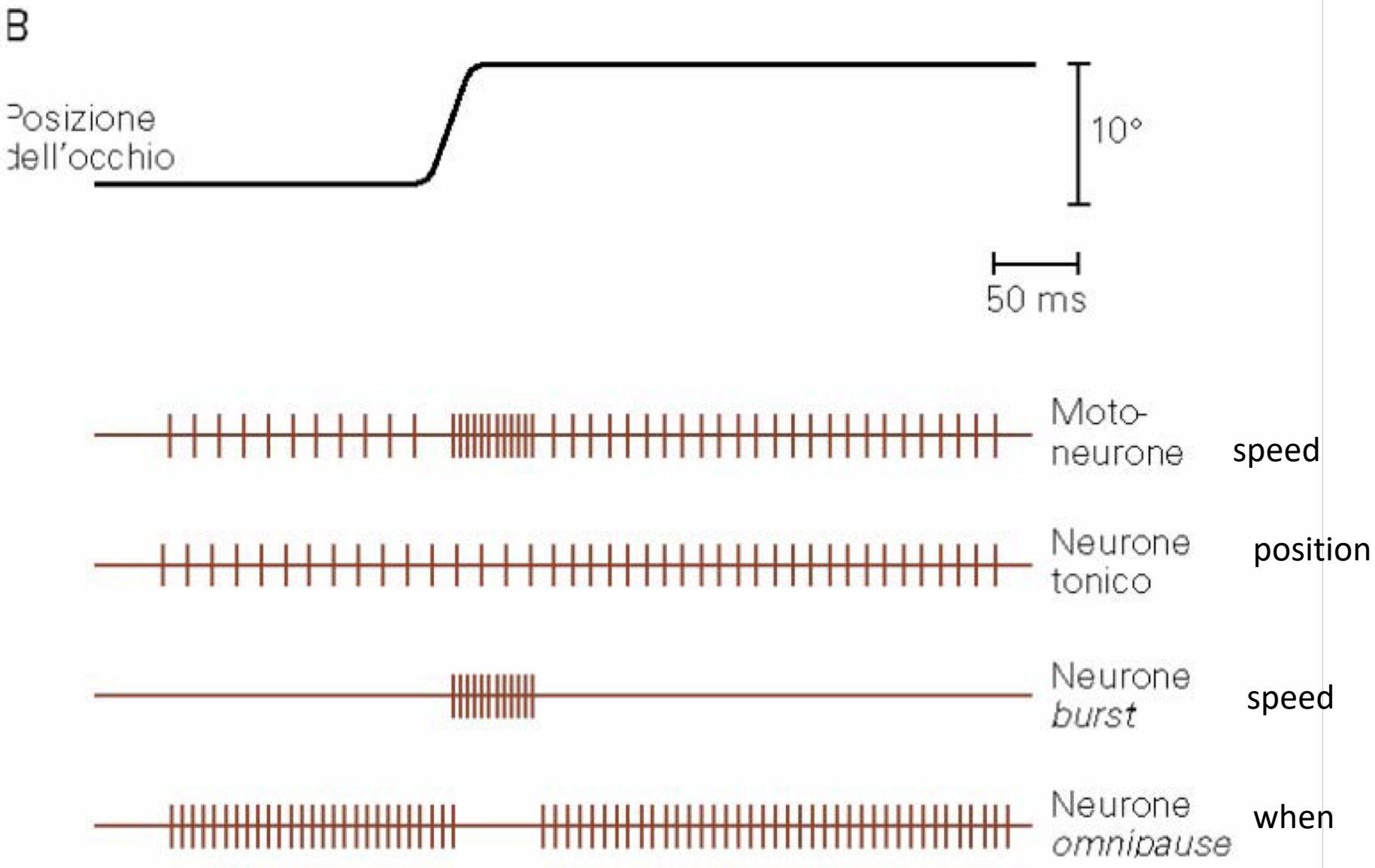


Saccades

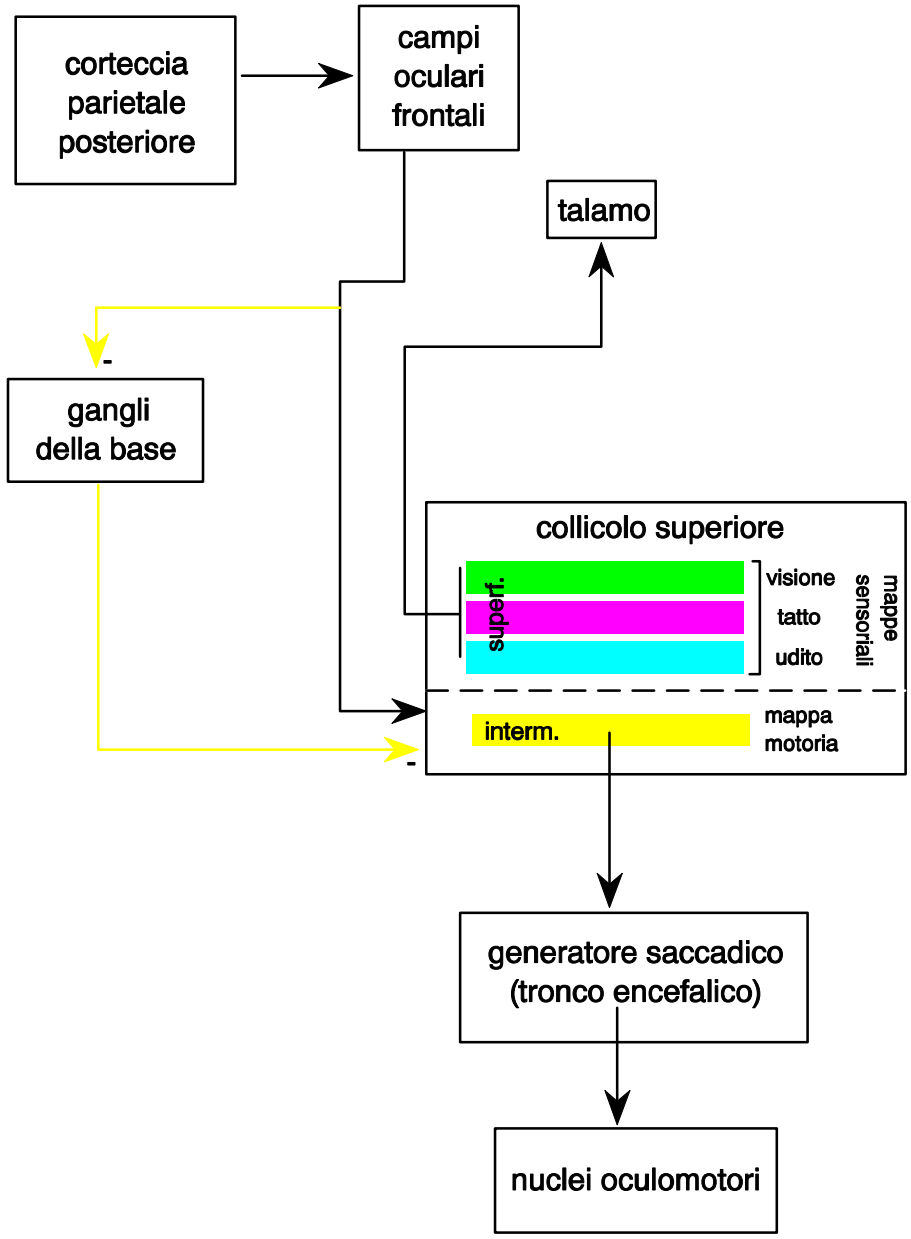
We scan the visual world with sequences of alternating saccades and fixations

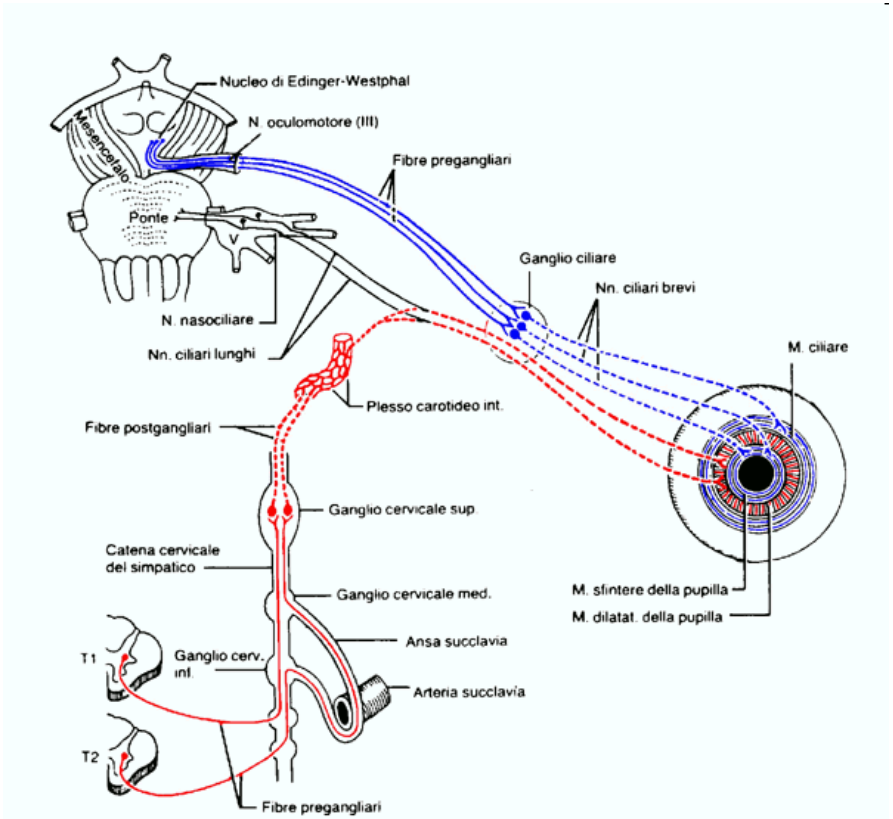

retto lat
retto med
retto med
retto lat
retto lat
retto med
retto med
retto lat
retto lat
retto med
motoneurone
integratore neurale
neurone tonico posizione
neurone "burst" velocità
occhio
°
°/s
posizione
velocità
motoneurone
velocità
posizione

Pontine gaze center



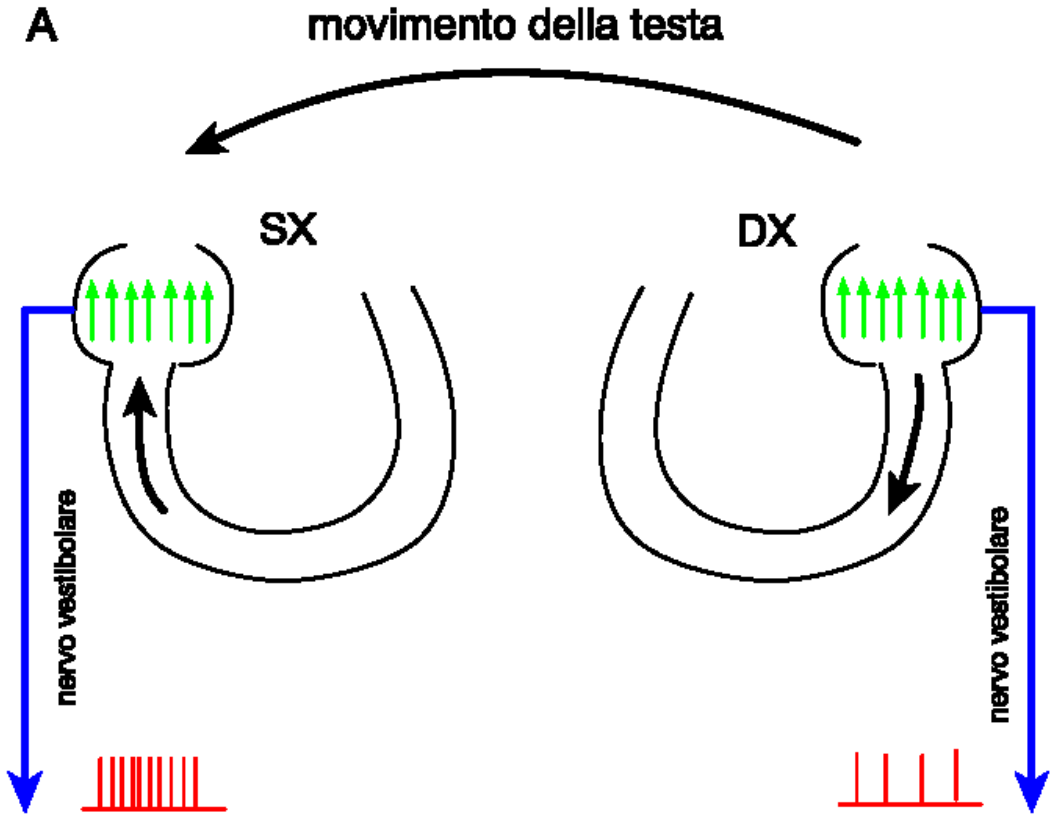
Saccasid suppression


corteccia parietale posteriore
campi oculari frontali
talamo
gangli della base
collicolo superiore
super.
visione
tatto
udito
mappe sensoriali
interm.
mappa motoria
generatore saccadico (tronco encefalico)
nuclei oculomotori



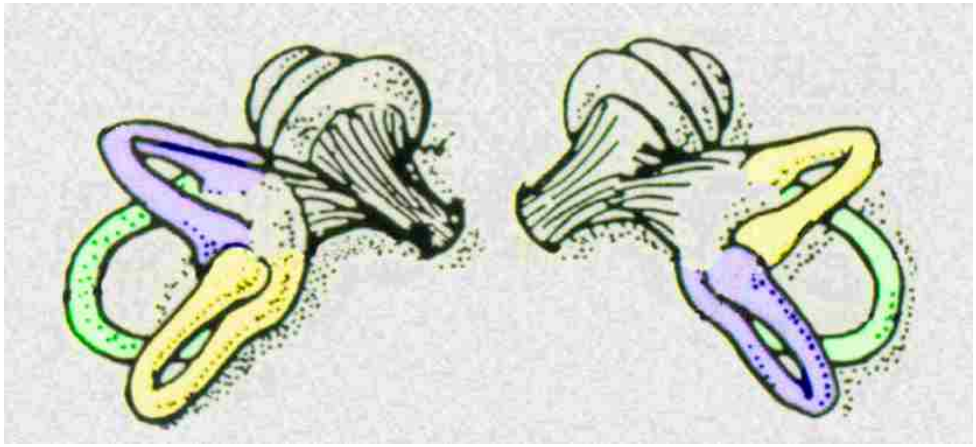
18. Innervazione ortosimpatica (rosso) e parasimpatica (blu) della muscolatura intrinseca dell'occhio.
Le fibre il cui corpo cellulare si trova nel ganglio del trigemino (V) forniscono l'innervazione sensitiva alla cornea, all'iride ed alla coroide.
Da "Enciclopedia Medica Italiana", USES.

occhio.Q1



Rotazione testa in una direzione:

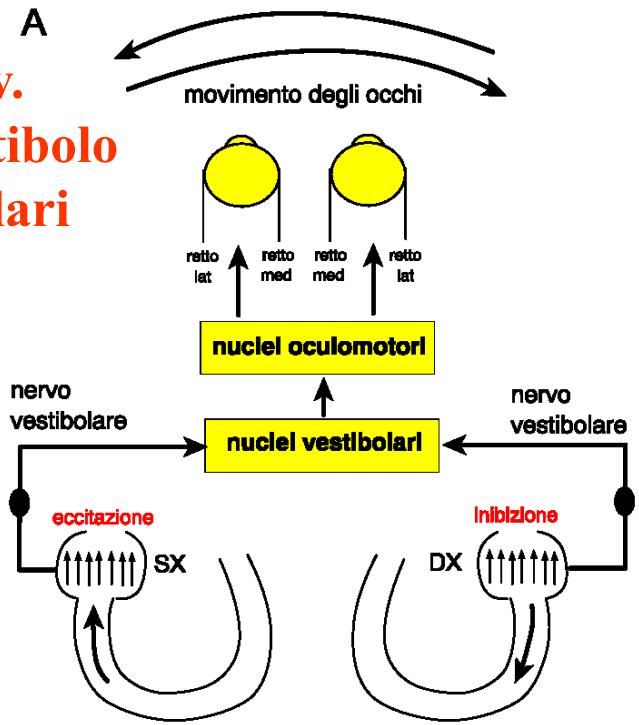
Attiva le cellule cigliate di un lato
Inibisce le cellule cigliate dell'altro

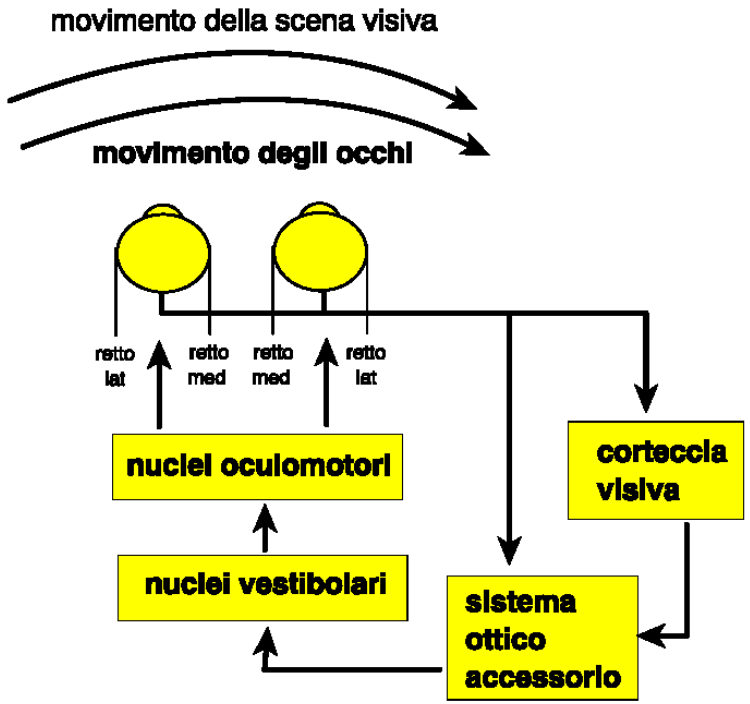


Movimenti vestibolo – oculari e movimenti optocinetici

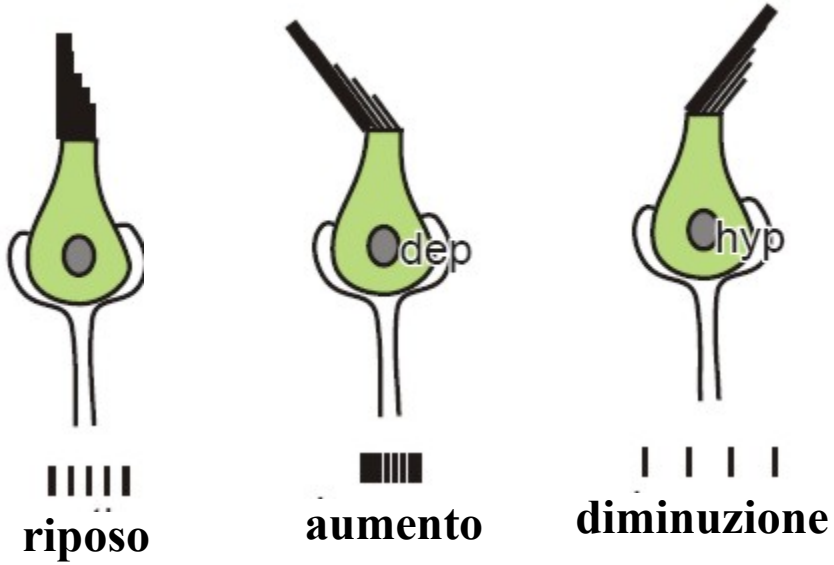
- operano congiuntamente per mantenere stabile lo sguardo (es. durante movimento della testa)
- più antichi filogeneticamente, involontari
- vestibolo-oculari: tramite informazioni dal sistema vestibolare: azione rapida
- optocinetici: tramite informazioni dal sistema visivo: azione lenta

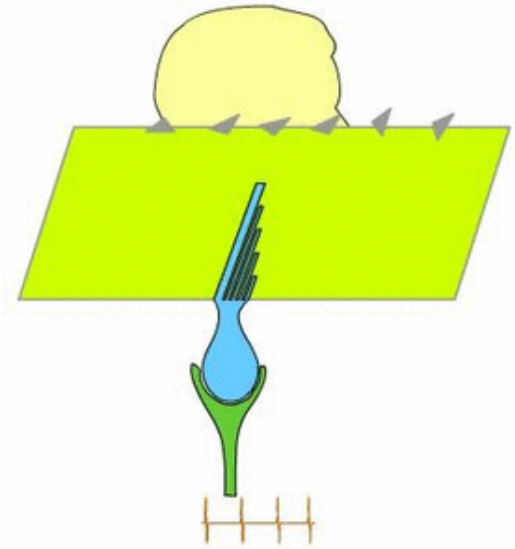
Mov. Vestibolo oculari

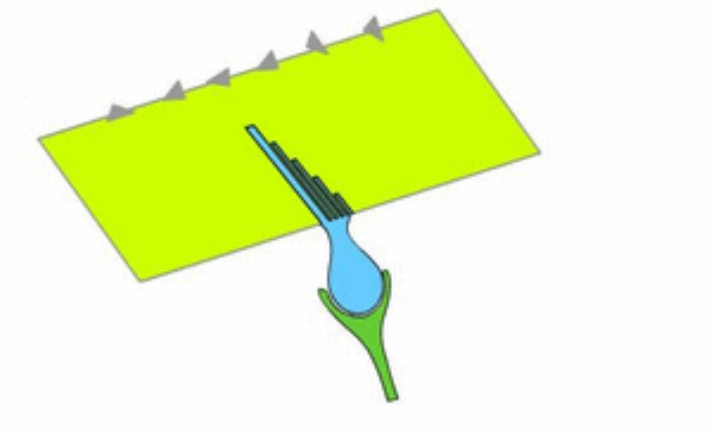


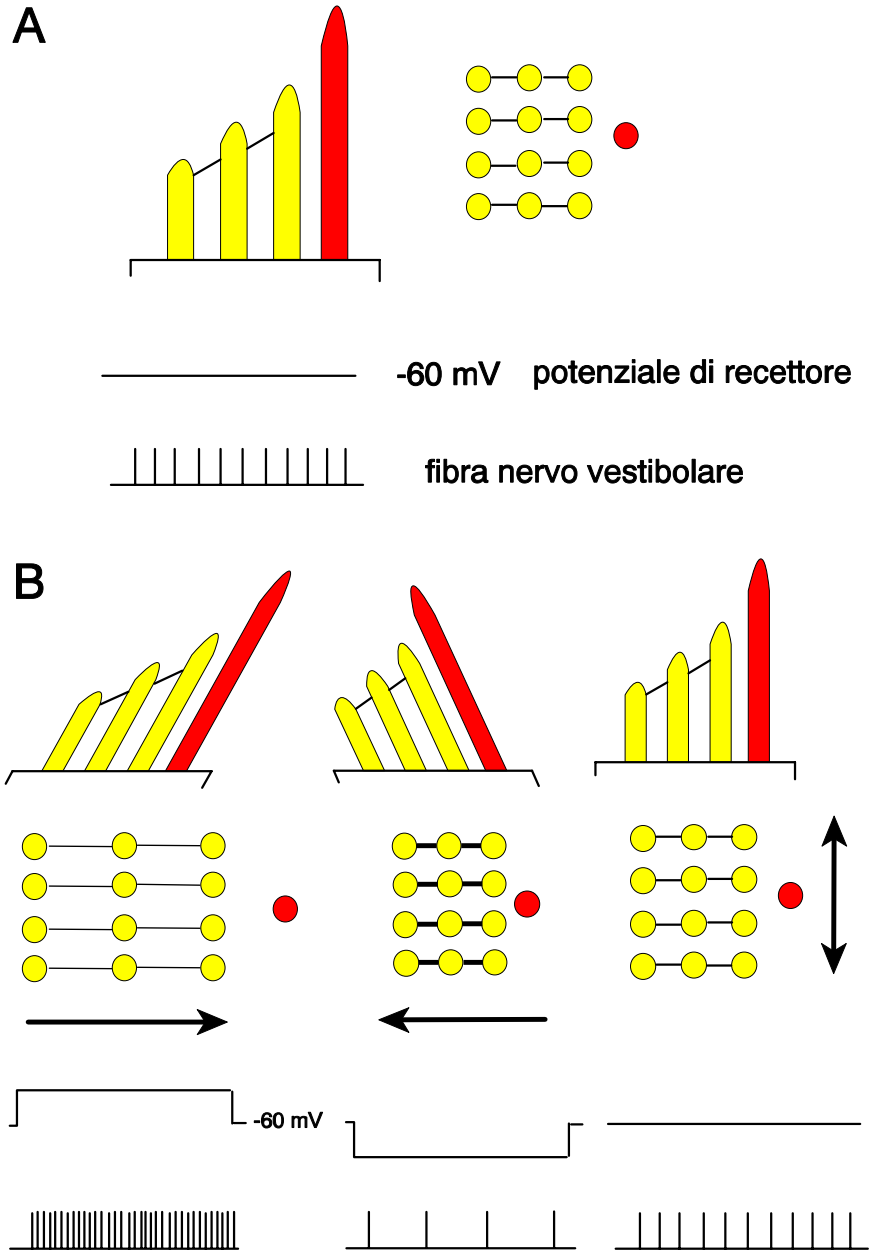


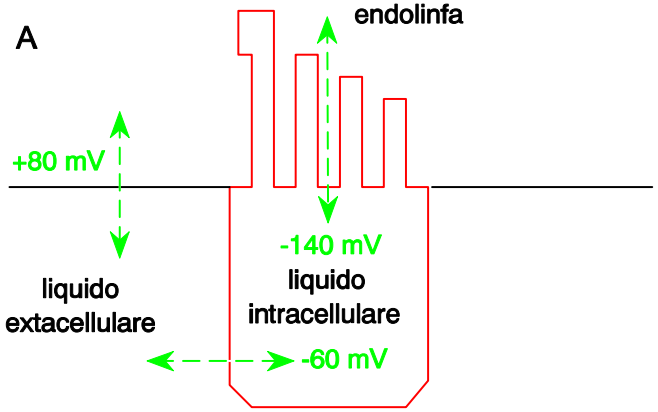

otoliti
chinicilio
sostanza gelatinosa
hair cell
fibra dell'8° nervo cranico

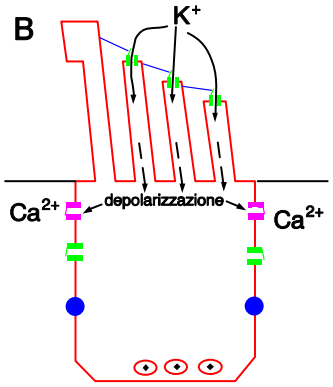

dep
hyp
riposo
aumento
diminuzione

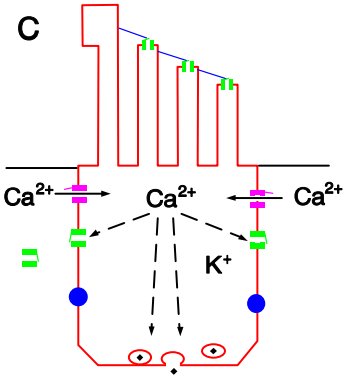


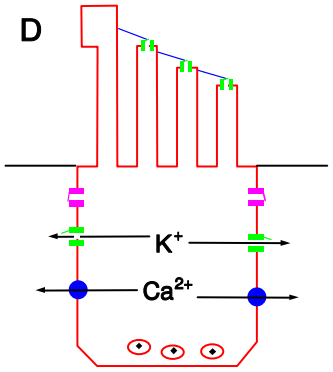


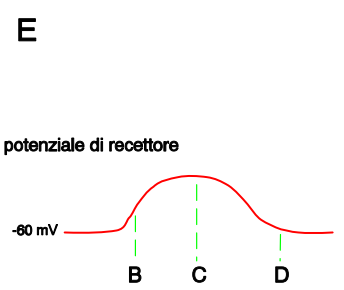

A
-60 mV
potenziale di recettore
fibra nervo vestibolare
B
-60 mV

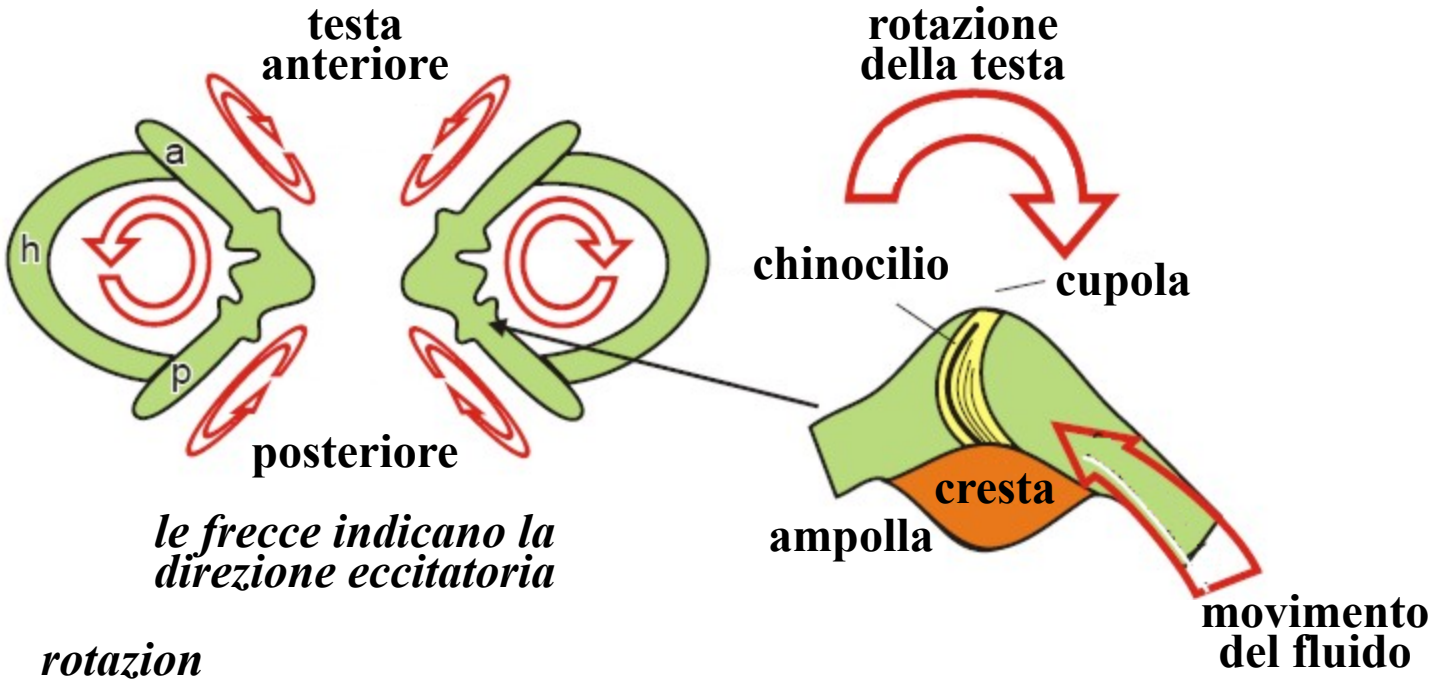

A
endolinfa
+80 mV
-140 mV
liquido
extacellulare
liquido
intracellulare
-60 mV

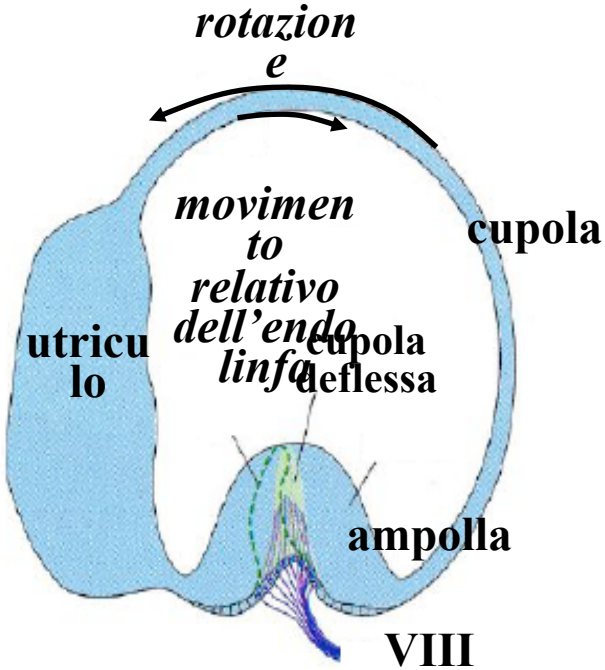

B
K+
Ca2+
depolarizzazione
Ca2+

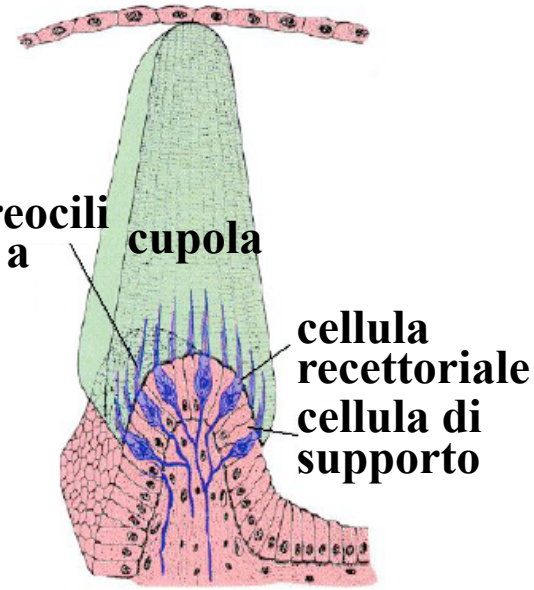

C
Ca2+
Ca2+
Ca2+
K+

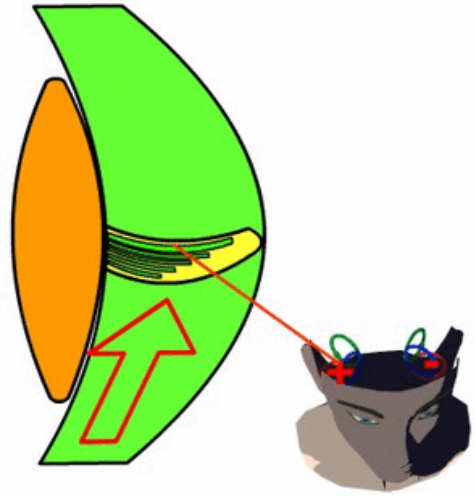

D
K+
Ca2+


E
potenziale di recettore
-60 mV
B
C
D


testa anteriore
rotazione della testa
a
h
p
posteriore
chinocilio
cupola
cresta
ampolla
le frecce indicano la direzione eccitatoria
movimento del fluido

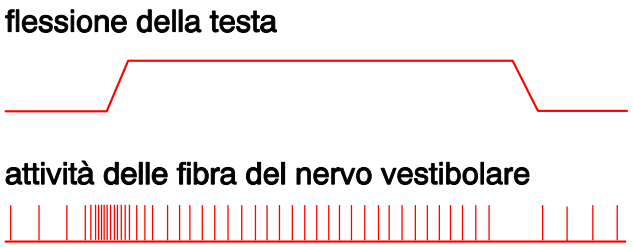

rotazione
movimento relativo dell'endolinfa
cupola
utricolo
cupola deflessa
ampolla
VIII NC

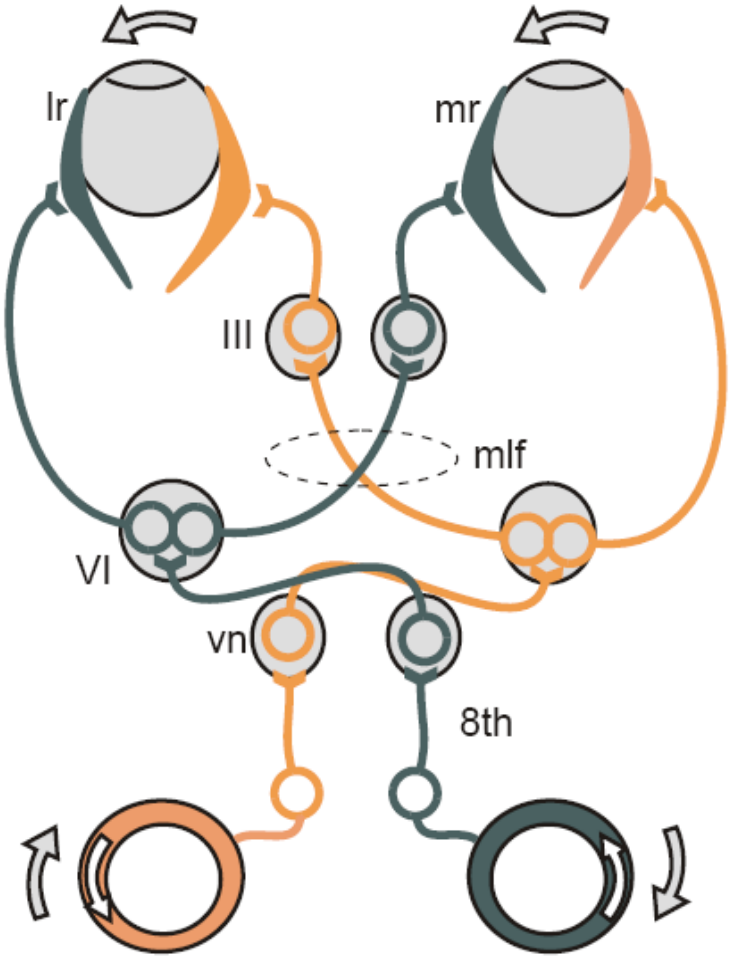

stereocilia
cupola
cellula recettoriale
cellula di supporto



Sequenza degli eventi:

- La testa ruota a destra
- Le cellule ciliate del canale orizzontale di destra si depolarizzano, quelle di sinistra iperpolarizzano.
- L'attività dei neuroni vestibolari afferenti di destra aumenta, mentre quella di sinistra diminuisce
- L'attività del nucleo vestibolare destro aumenta, quella del sinistro diminuisce
- I nervi cranici (motoneuroni ai muscoli extraoculari) VI di sinistra e III di destra diventano più attivi, mentre il III di sinistra e il VI di destra diventano meno attivi.
- I muscoli extraoculari retto laterale sinistro e retto mediale destro si contraggono, mentre il retto mediale sinistro e il retto laterale destro si rilassano.
- Entrambi gli occhi ruotano verso sinistra.





A riposo (testa ferma), l'attività tonica dei canali destro e sinistro si bilancia.