Systems Neuroscience
11.11.2025

Vestibular system

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http: www.ini.unizh.ch/~kiper/system_neurosci.html

VESTIBULAR SYSTEM

A central role in the maintenance of equilibrium and gaze stability.

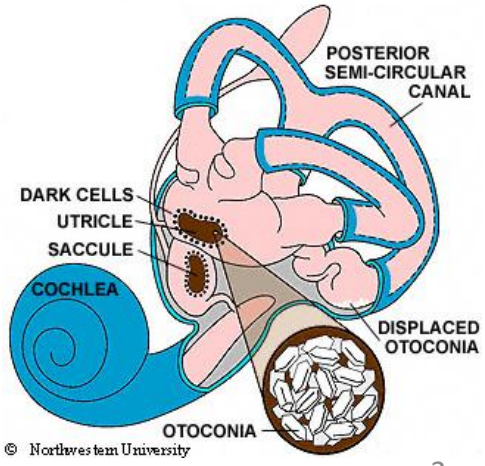
The vestibular system, by means of its receptors for the perception of linear and angular acceleration, plays a central role in orientation.

Designed to answer two basic questions:

Which way is up?
In which direction am I moving?

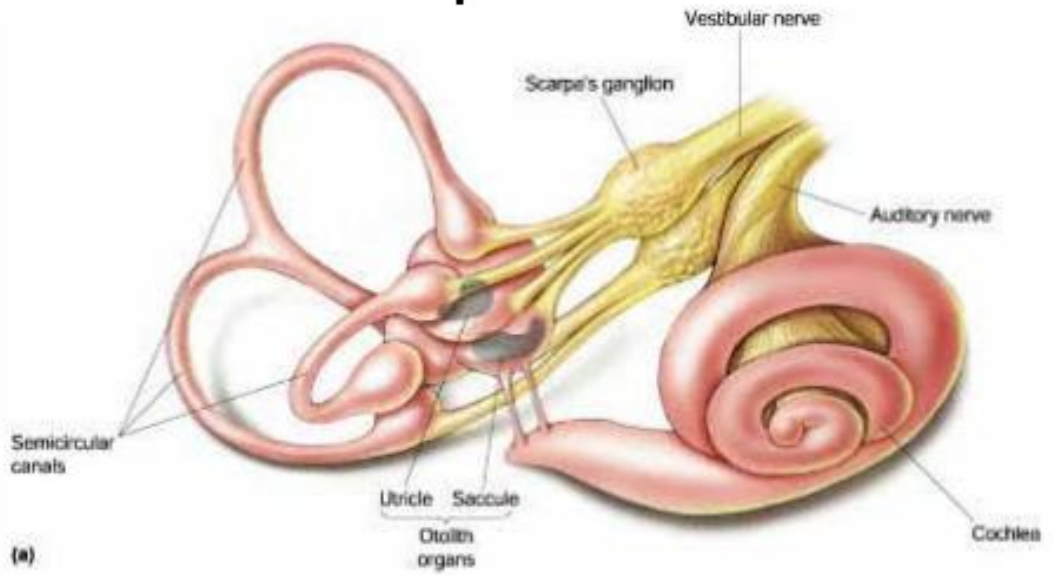
VESTIBULAR SYSTEM

- Very elusive to test
- Five peripheral “receptors” (three semicircular canals, utricule, saccule)
- Nerve (sub-divisions)
- Central connections
- Cortical area



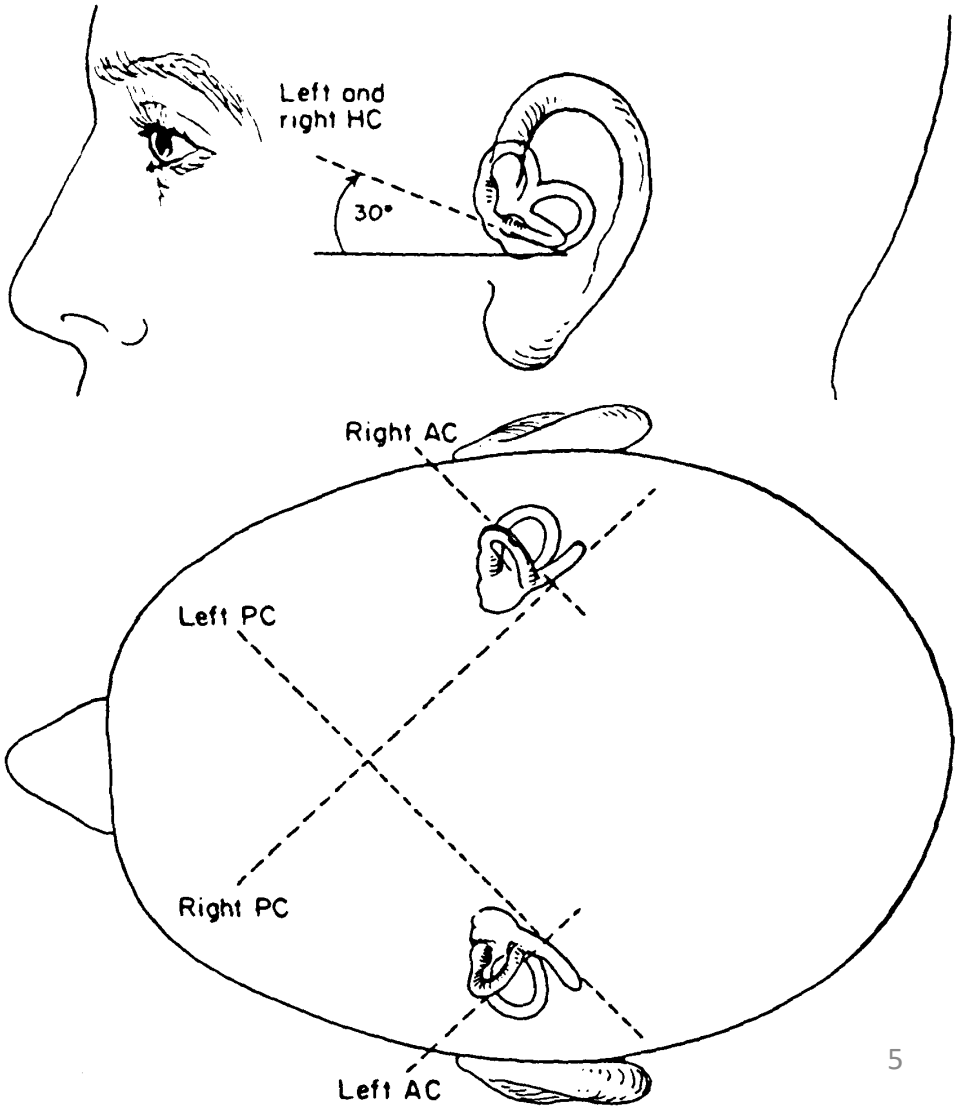
Vestibular system

- Semicircular canals: respond to rotation acceleration of the head
- Otolith organs: respond to linear acceleration and static position
  - Utricle
  - Saccule



The Semicircular Canals

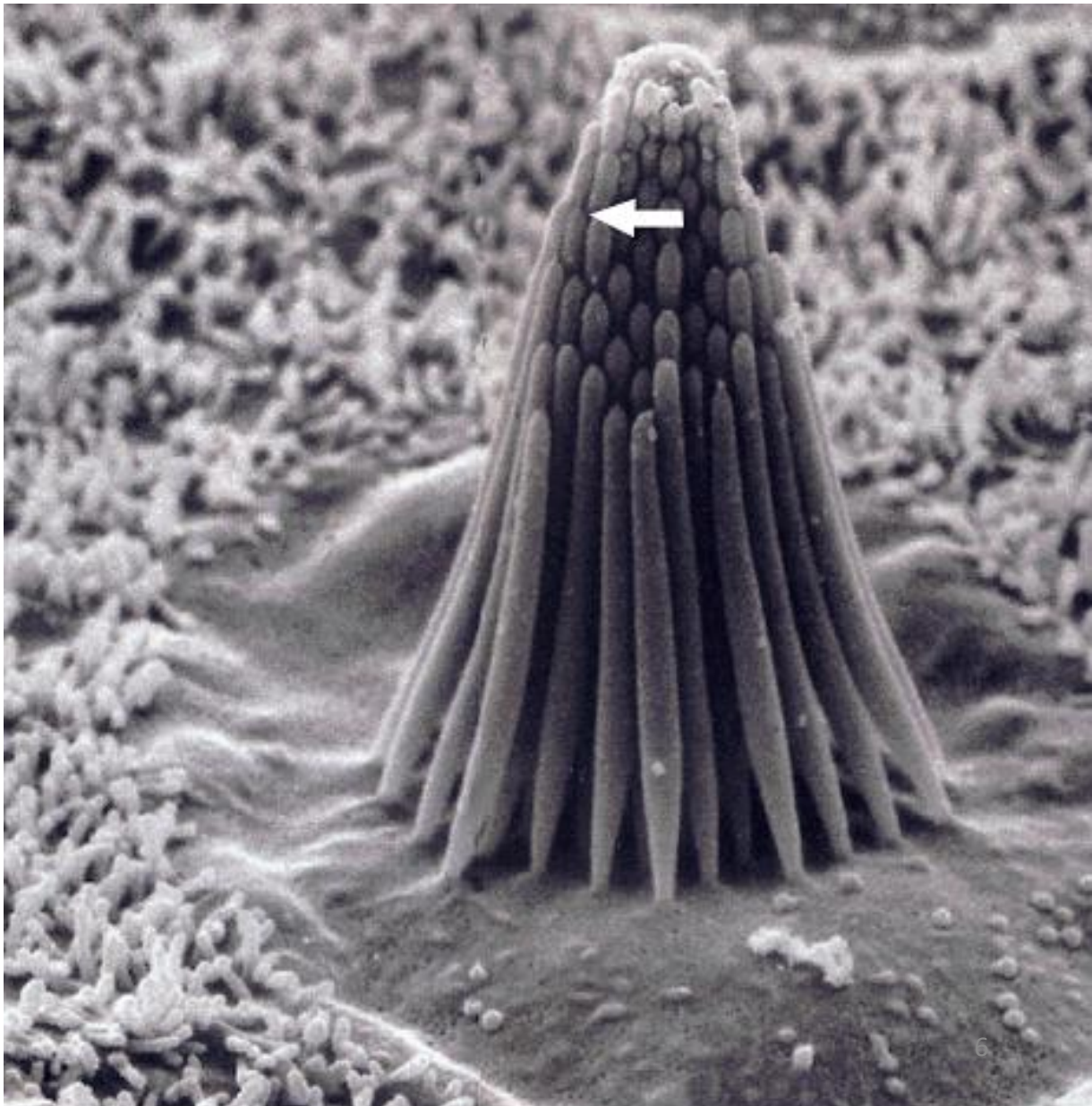
- posterior canal shares plane with contralateral anterior canal.
- horizontal canals share plane.

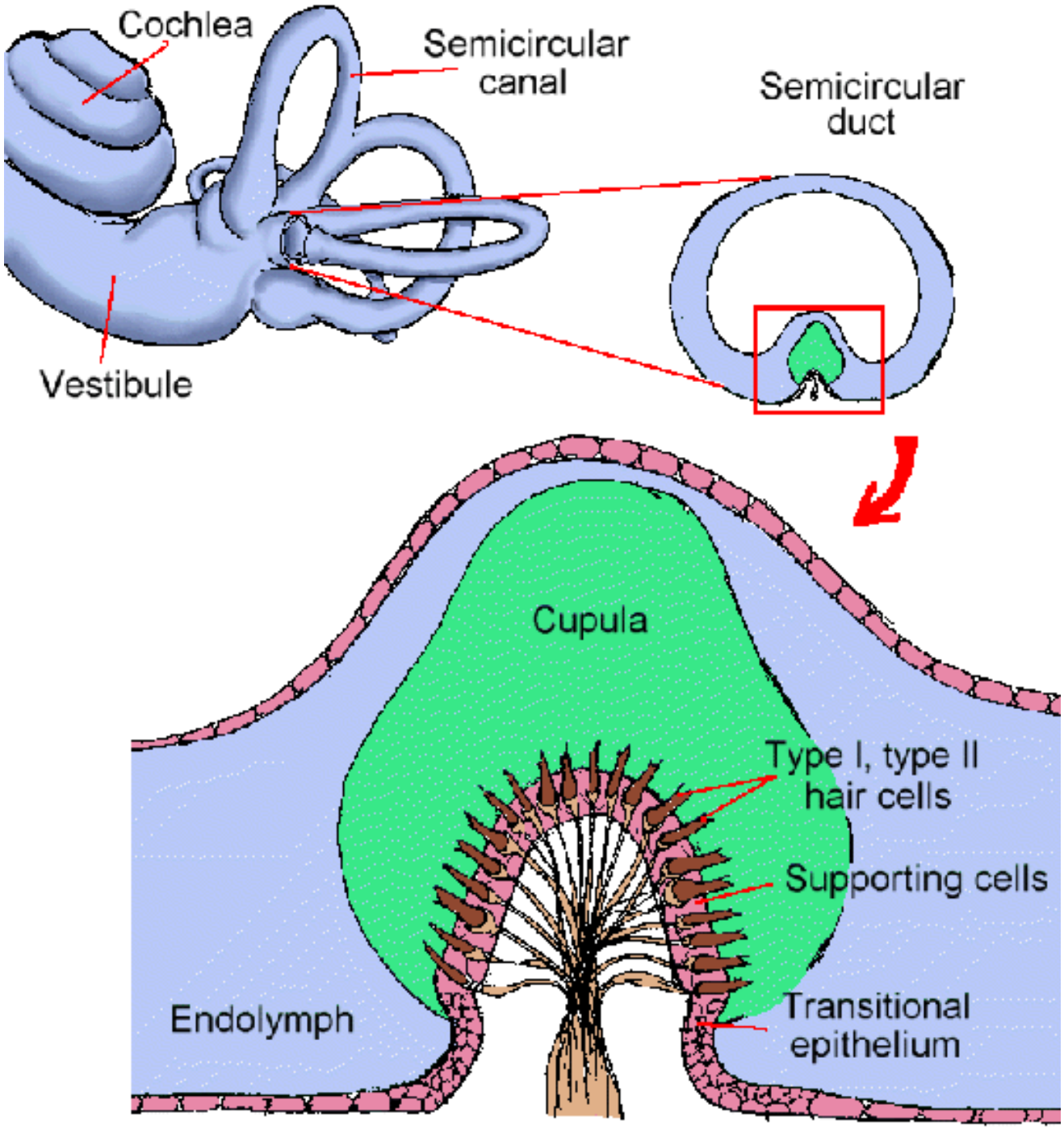


Vestibular Hair Cells

- Type I
  (aka inner)
- Type II
  (aka outer)

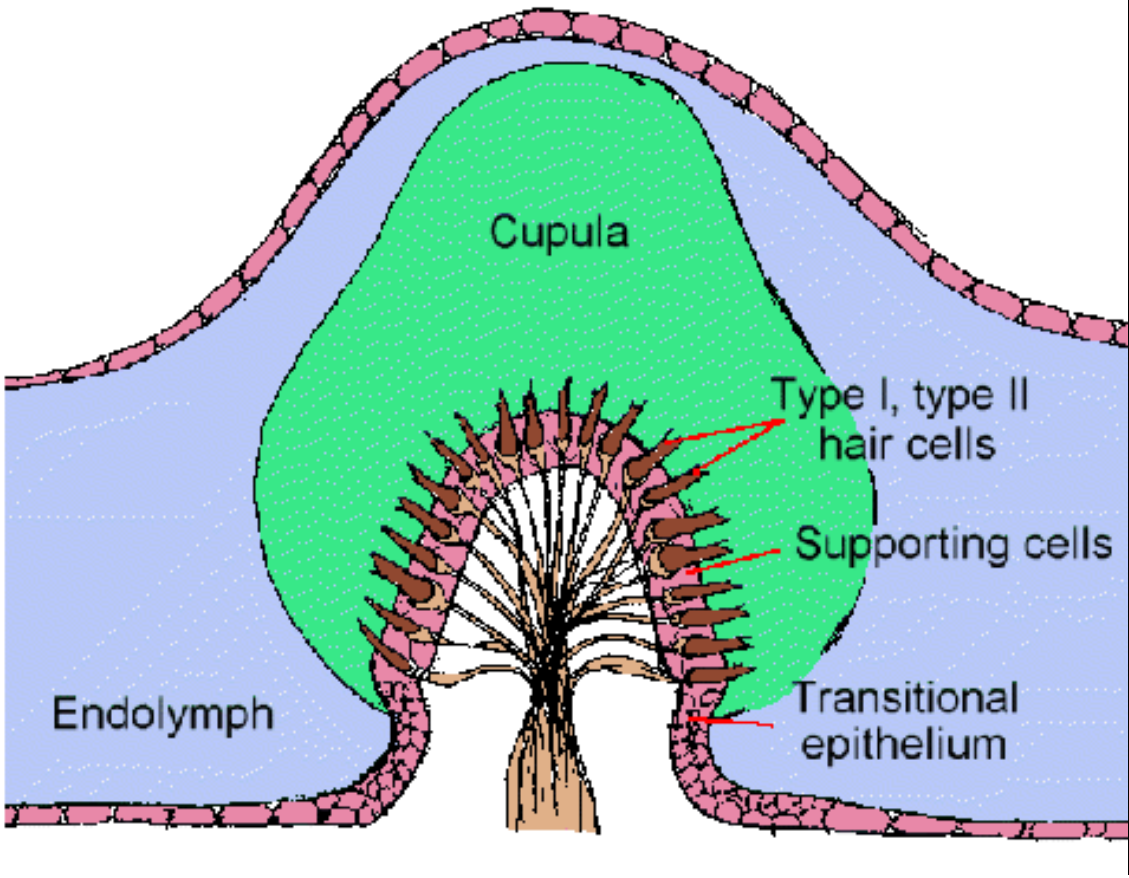
With
Kinocilium



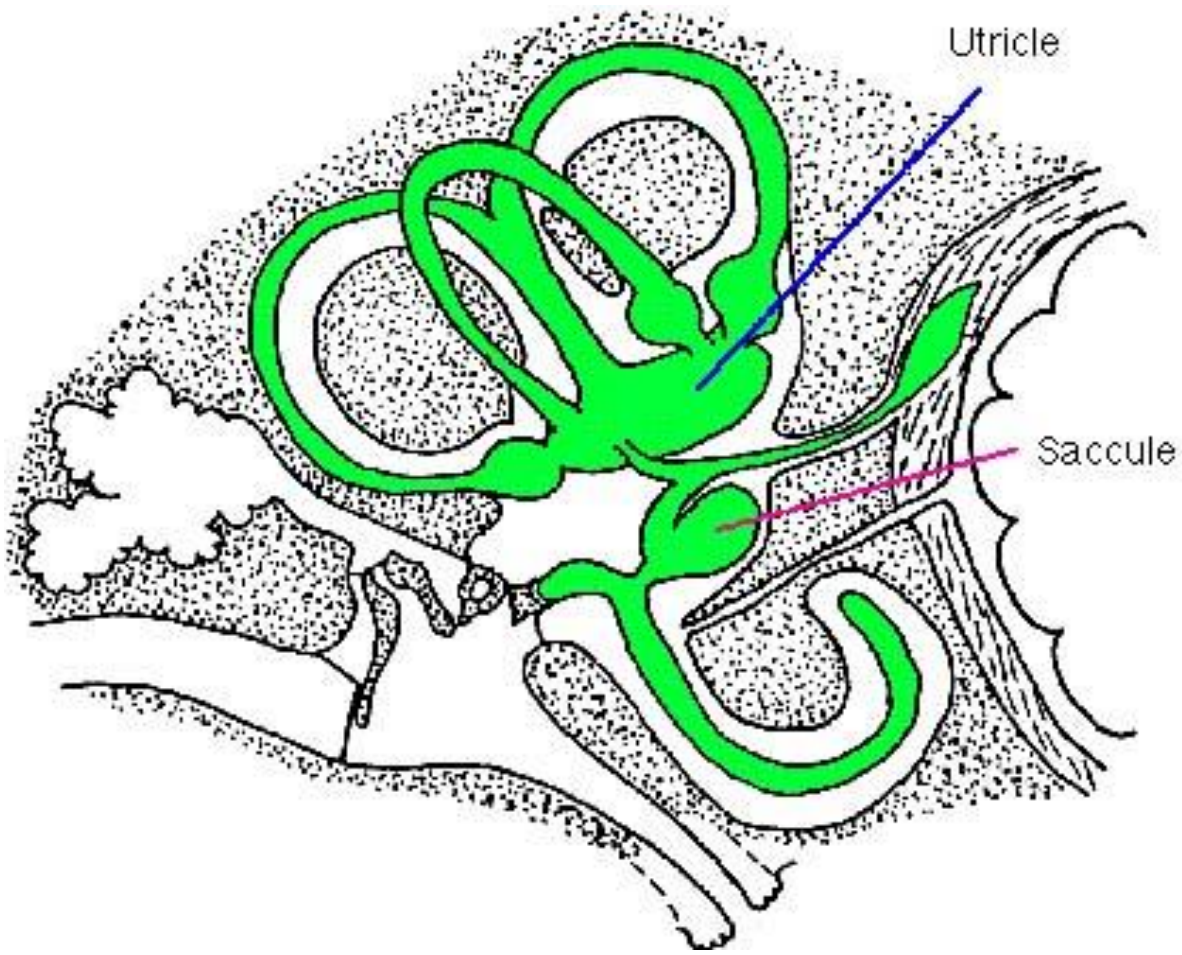

Cochlea
Semicircular canal
Semicircular duct
Vestibule
Cupula
Type I, type II hair cells
Supporting cells
Endolymph
Transitional epithelium

Responses of the Cristae

- All kinocilia are oriented in the same direction
- Crista in each pair of canals respond inversely to each other

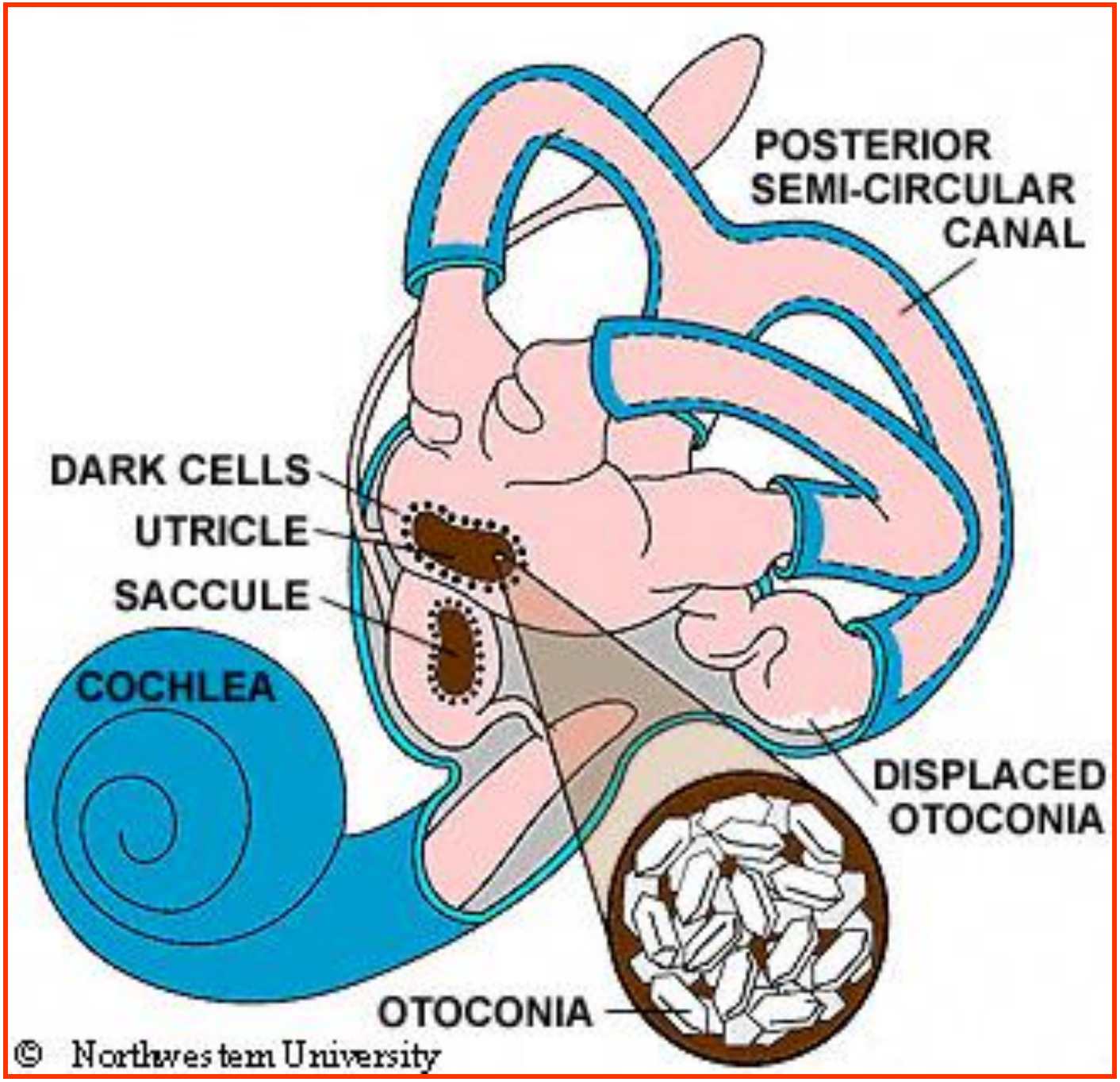


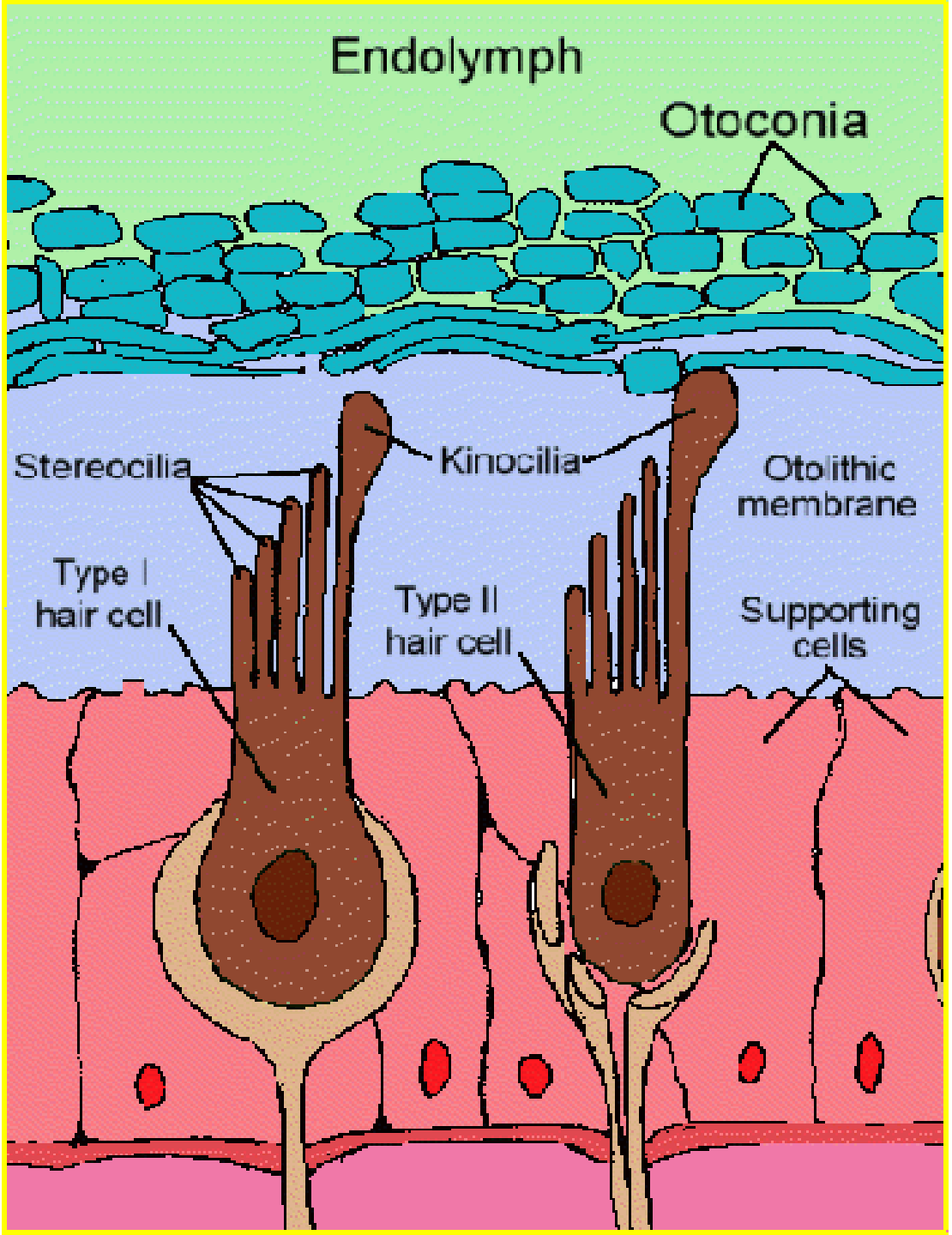
The Otolithic Organs



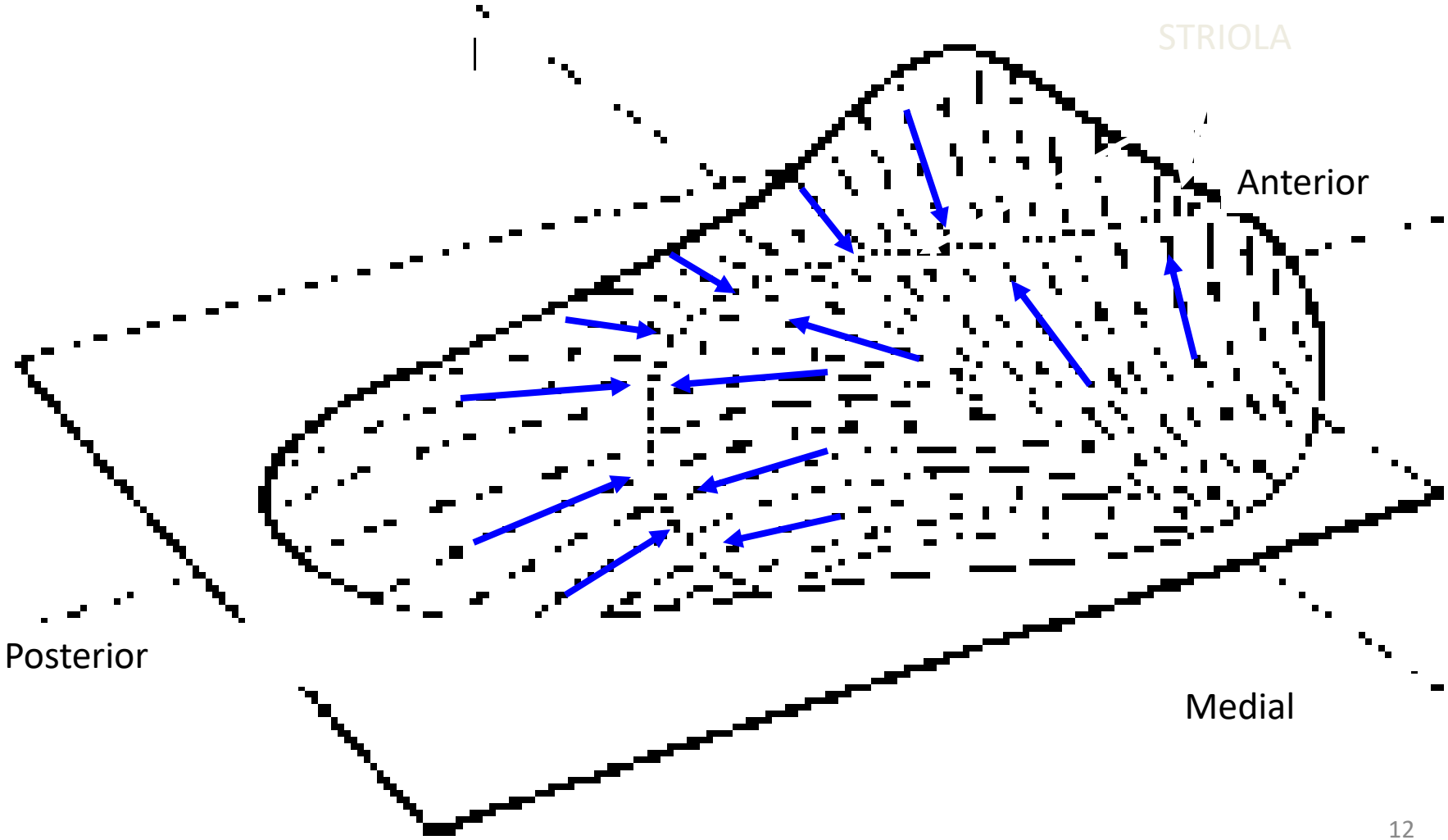
Saccule: roughly vertical orientation, responds to acceleration components within saggital plane

Utricle: horizontal (+ 30 deg.) orientation

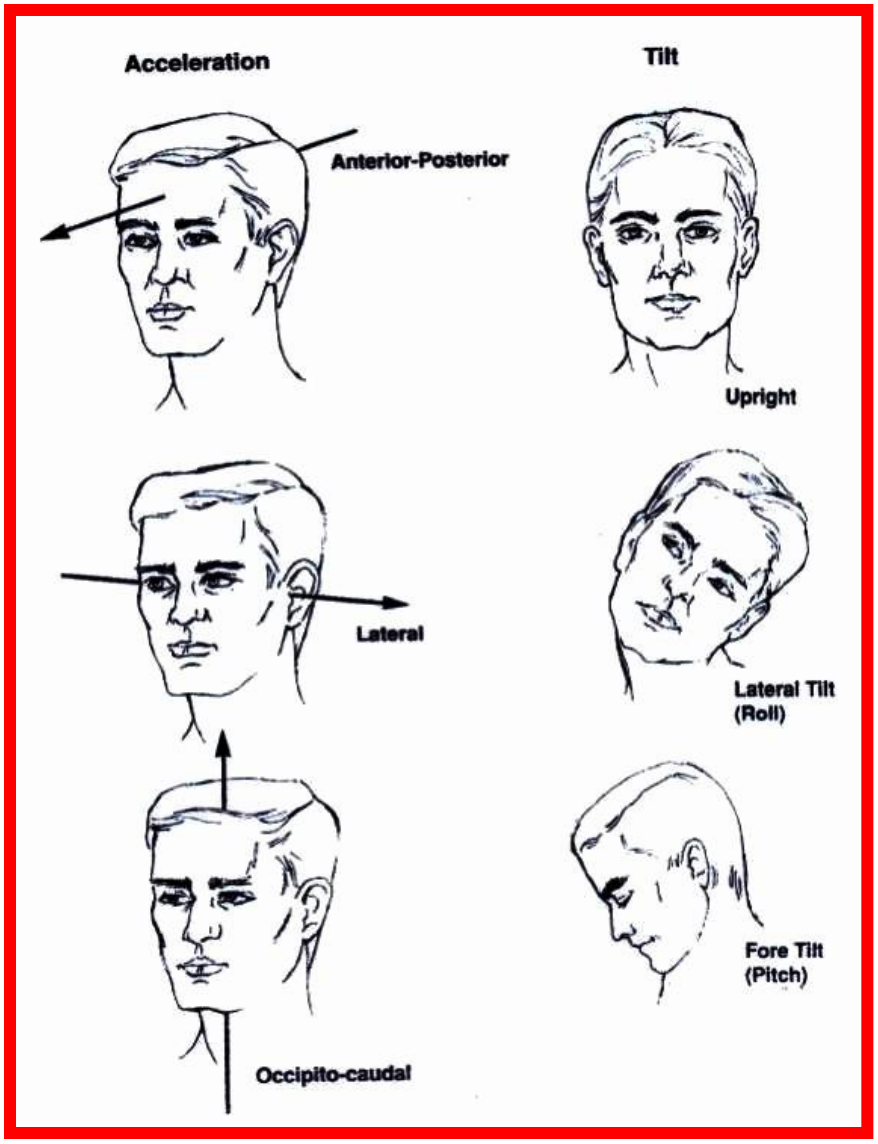

POSTERIOR
SEMI-CIRCULAR
CANAL
DARK CELLS
UTRICLE
SACCULE
COCHLEA
DISPLACED
OTOCONIA
OTOCONIA
© Northwestern University


Endolymph
Otoconia
Stereocilia
Kinocilia
Otolithic membrane
Type I hair cell
Type II hair cell
Supporting cells

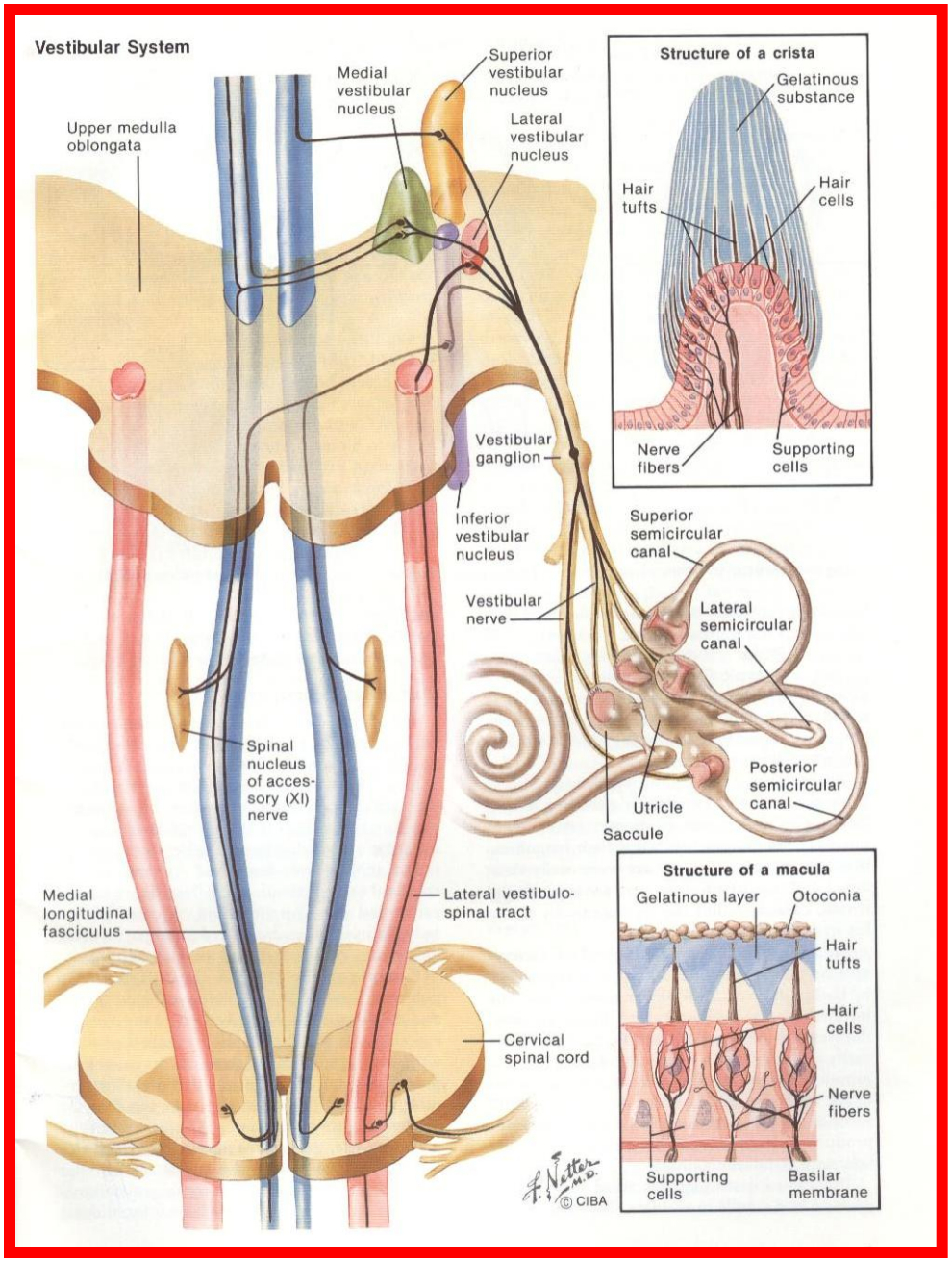
Excitation Patterns in the Utricle

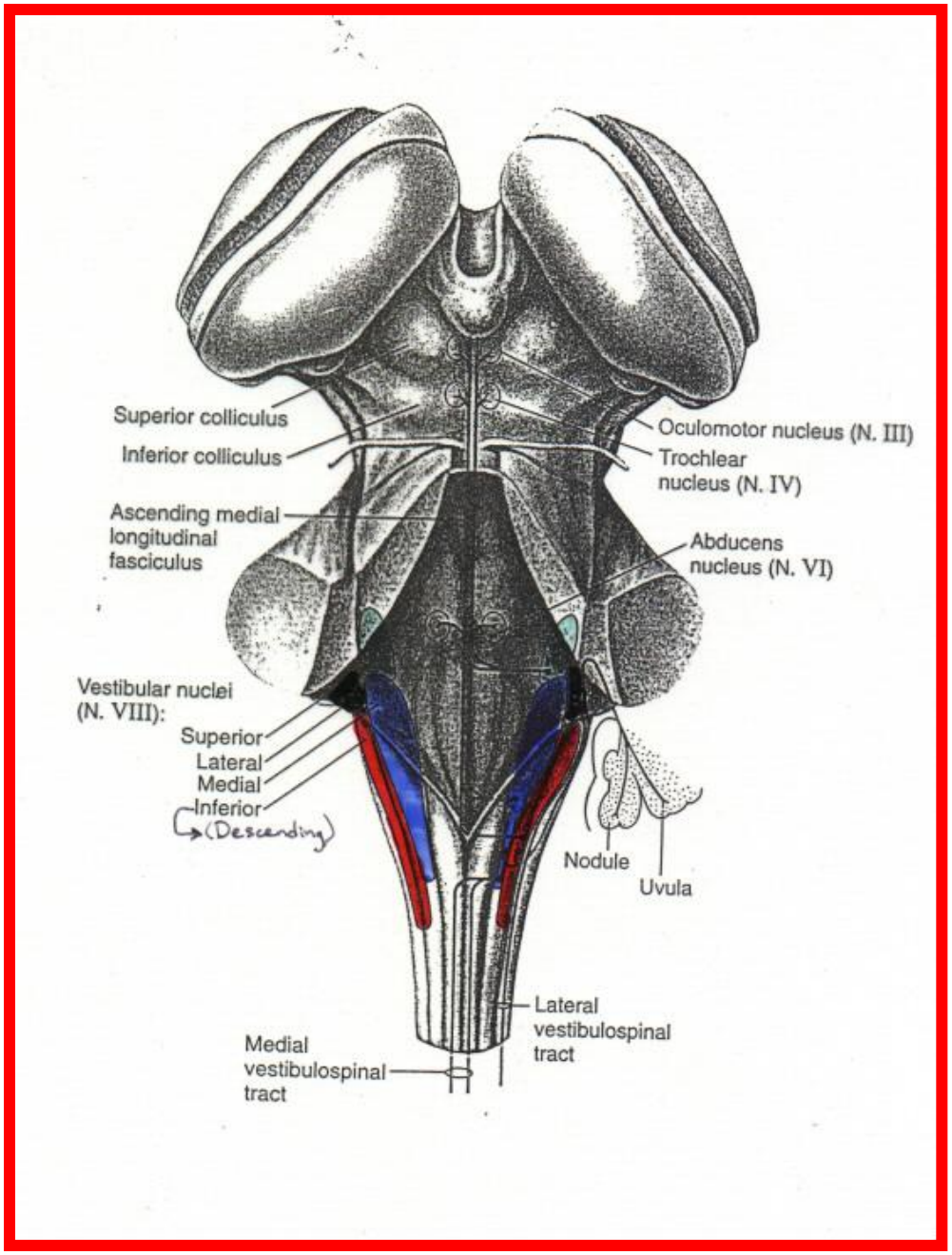


The otoliths register linear acceleration and static tilt

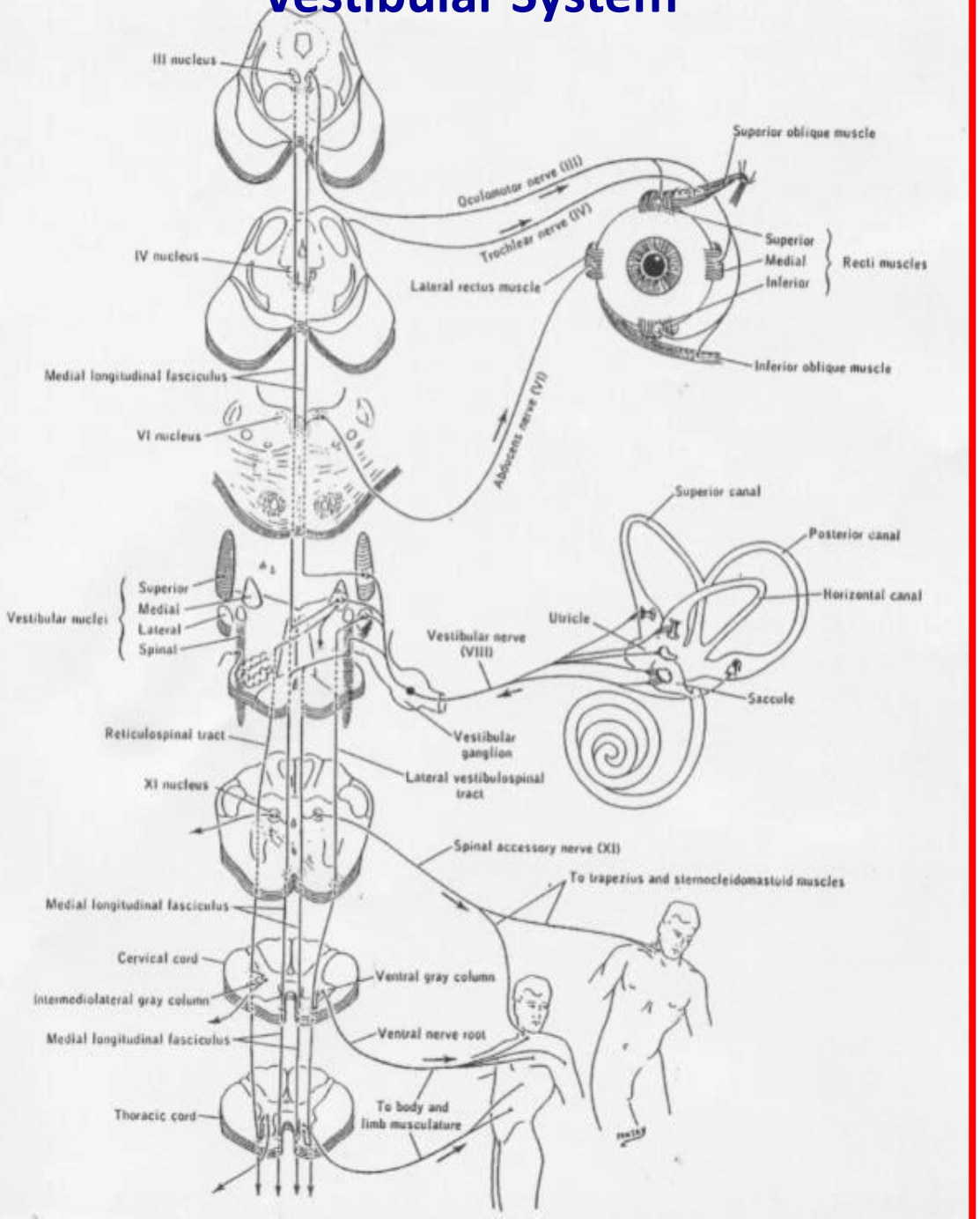


Vestibular system




Superior colliculus
Inferior colliculus
Ascending medial longitudinal fasciculus
Vestibular nuclei (N. VIII):
Superior
Lateral
Medial
Inferior
(Descending)
Oculomotor nucleus (N. III)
Trochlear nucleus (N. IV)
Abducens nucleus (N. VI)
Nodule
Uvula
Lateral vestibulospinal tract
Medial vestibulospinal tract

Vestibular System



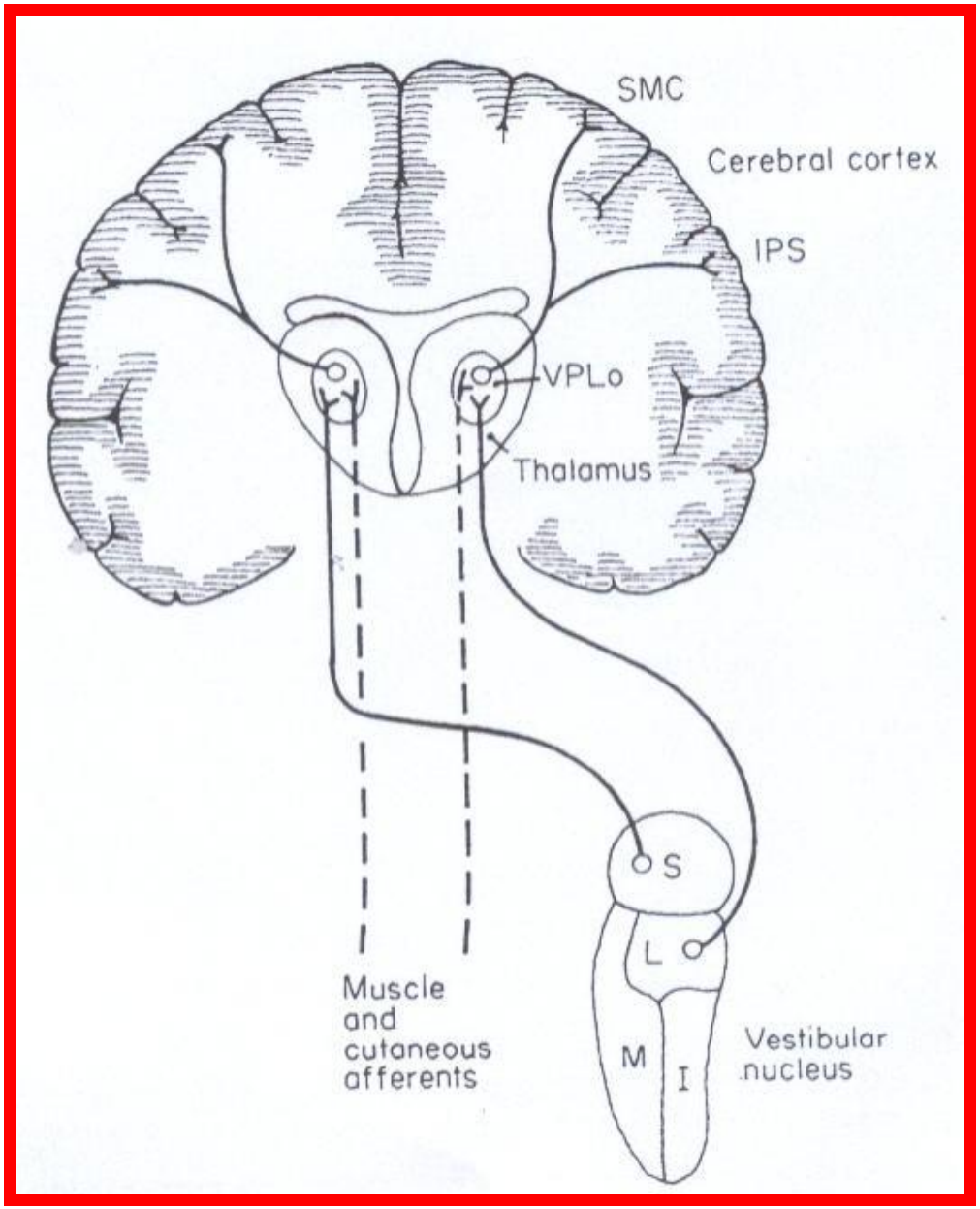
Vestibular Nuclei (VN)

Vestibular signals originating in the two labyrinths first interact with signals from other sensory systems in the VN.

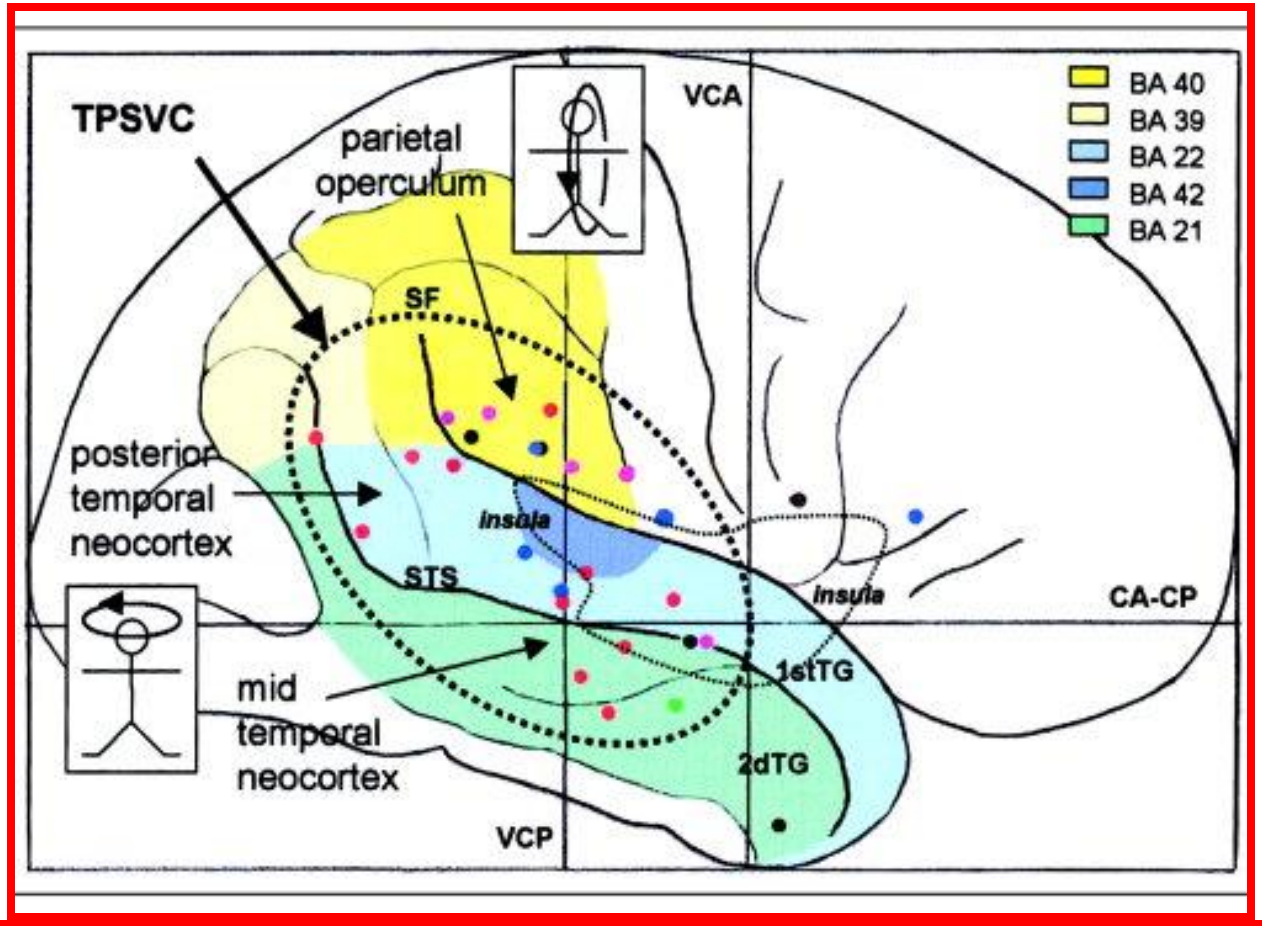
Only one fraction of the neurons in the VN receive direct vestibular input, and most neurons receive afferent input from other sensory systems (visual or proprioceptive) or regions of the CNS (cerebellum, reticular formation, spinal cord and contralateral VN).

Consequently the output of neurons from the VN reflect the interaction of many systems.

Vestibular Cortex

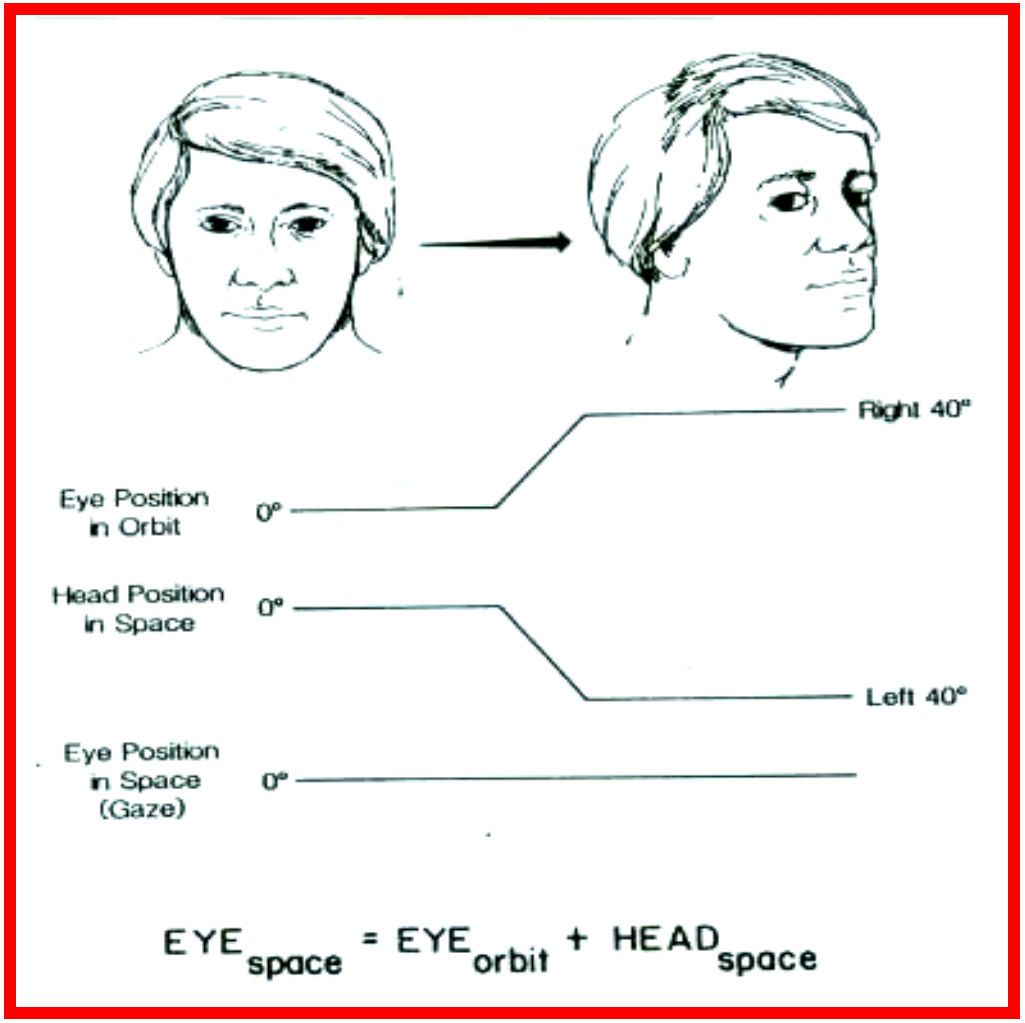


Vestibular Cortex



Schematic representation of the temporo-peri-Sylvian vestibular cortex (TPSVC). The vestibular sites located at the lateral aspect of the right or left hemispheres are projected on a lateral view of the right hemisphere normalized in the proportional stereotactic grid system of Talairach and Tournoux. BA = Brodmann area; CA-CP = anterior commissure-posterior commissure plane; VCA = vertical plane through CA; VCP = vertical plane through CP; SF = Sylvian fissure; STS = superior temporal sulcus; 1stTG = first (superior) temporal gyrus; 2dTG = second (mid) temporal gyrus. (*red dots*) Yaw plane illusions; (*pink dots*) pitch plane illusions; (*blue dots*) roll plane illusions; (*green dots*) translations; (*black dots*) indefinable sensations of body motion.

Vestibulo-Ocular Reflex (VOR)



To hold images of the seen world steady on the retina during brief head rotations

Dizziness – Vertigo - Disequilibrium