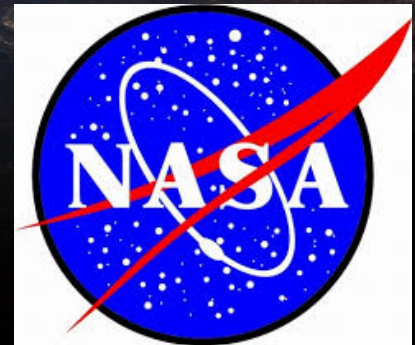


Maintaining Balance in Microgravity

Murray Perl



Sponsored by the National Space
Biomedical Research Institute
with additional support from
Mount Sinai School of Medicine and NASA



How do we maintain our balance?



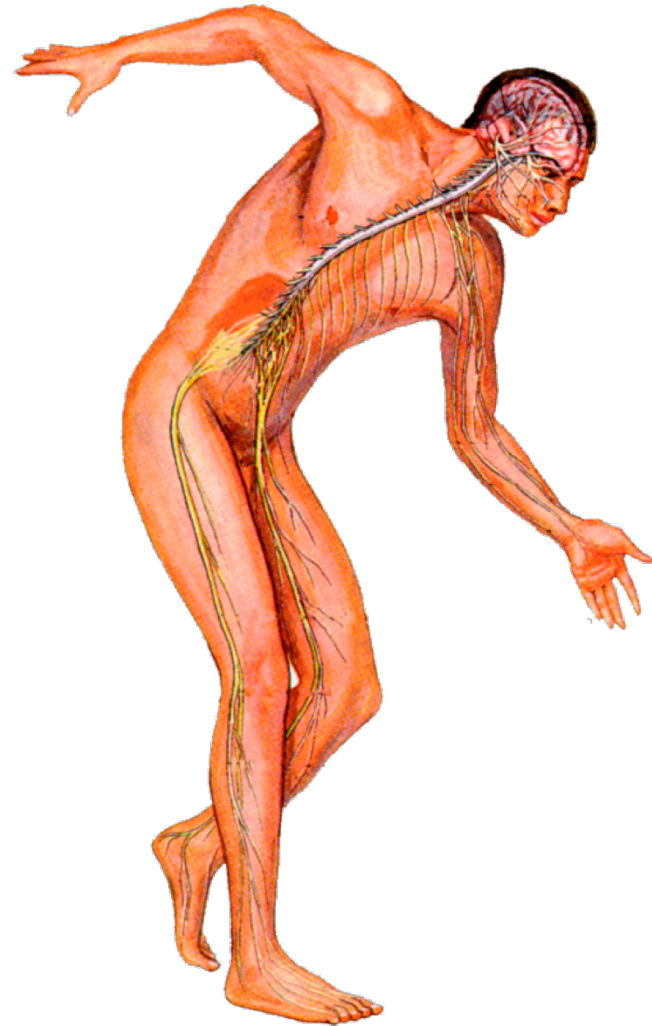
Stand on one leg and focus on what your body is doing to maintain balance.

What are you doing to stay upright?



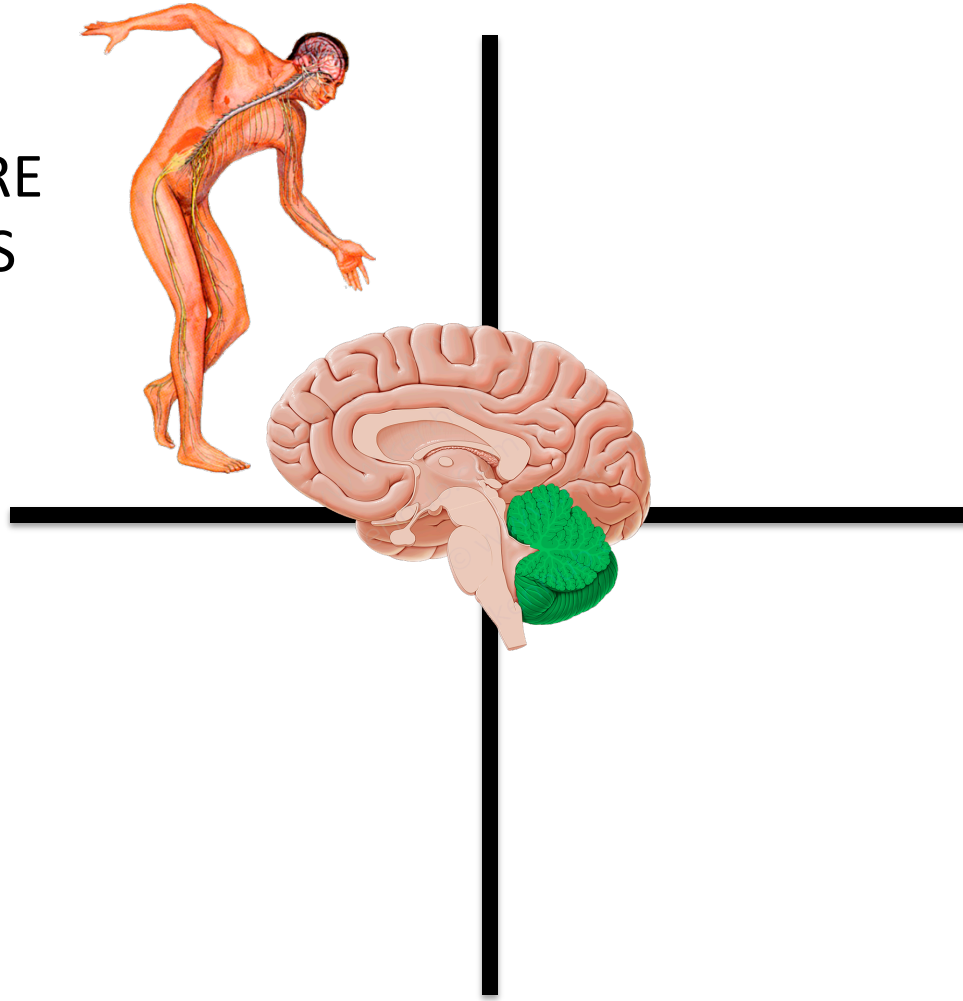
Stress receptors
(Proprioceptors) in muscles,
tendons and joints sense
pressure and body position.

They transmit the information
to the cerebellum in the brain
and adjust muscle tension to
maintain equilibrium.



Maintaining Balance

PRESSURE
SENSORS



Now stand on one leg and close your eyes.

Why is it harder to stay upright?



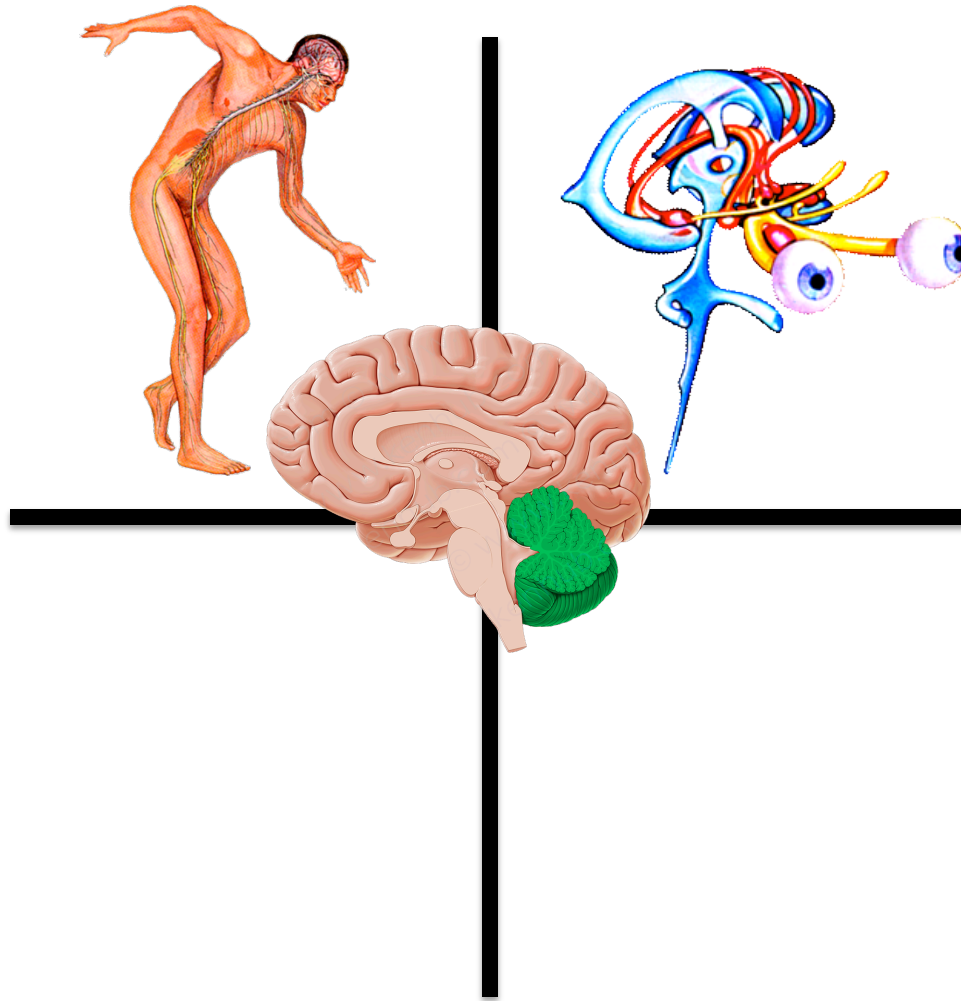
The eyes transmit visual information to the visual cortex in our brain about our orientation relative to the horizon.

**VISUAL
CORTEX**



Maintaining Balance

PRESSURE
SENSORS



VISUAL
CORTEX

HOW DO WE KNOW WHICH WAY IS UP?

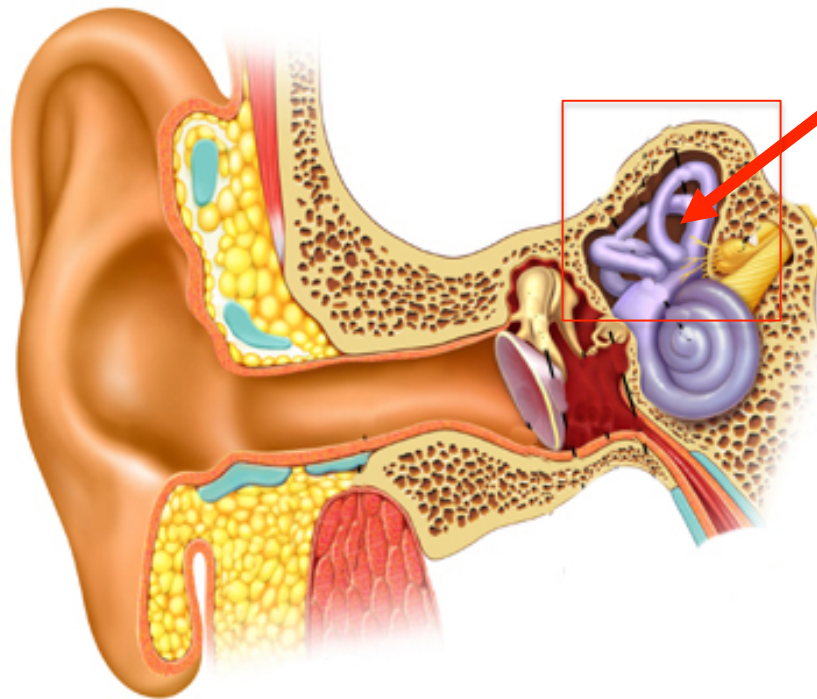


EAR ANATOMY

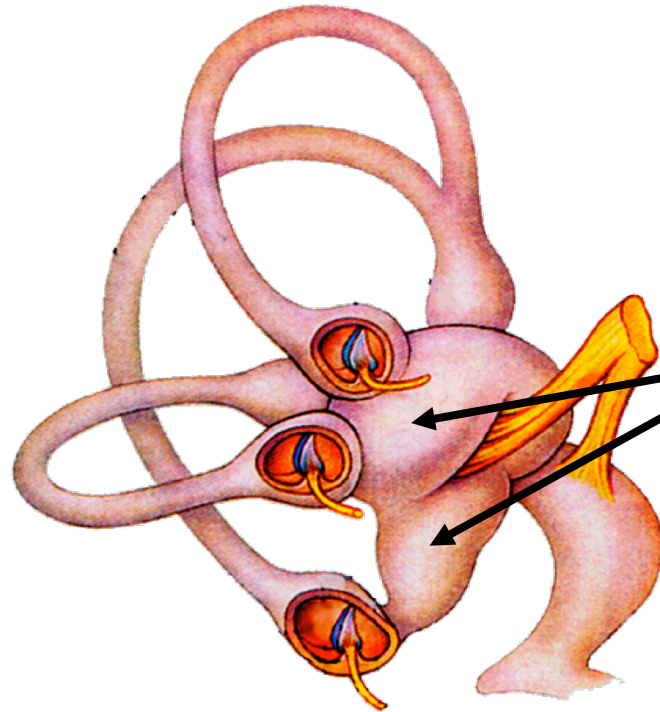
**OUTER
EAR**

MIDDLE EAR **INNER EAR**

**VESTIBULAR
SYSTEM**

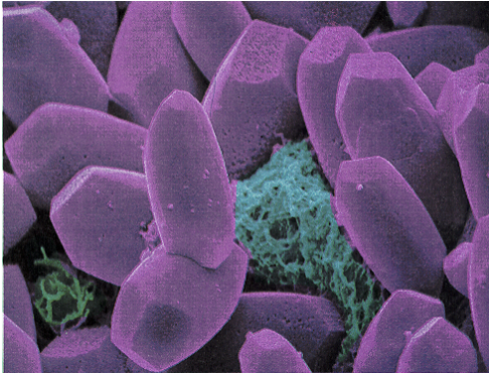


OTOLITH ORGAIN IN THE VESTIBULAR SYSTEM



Saccule
containing
Otolith
organs

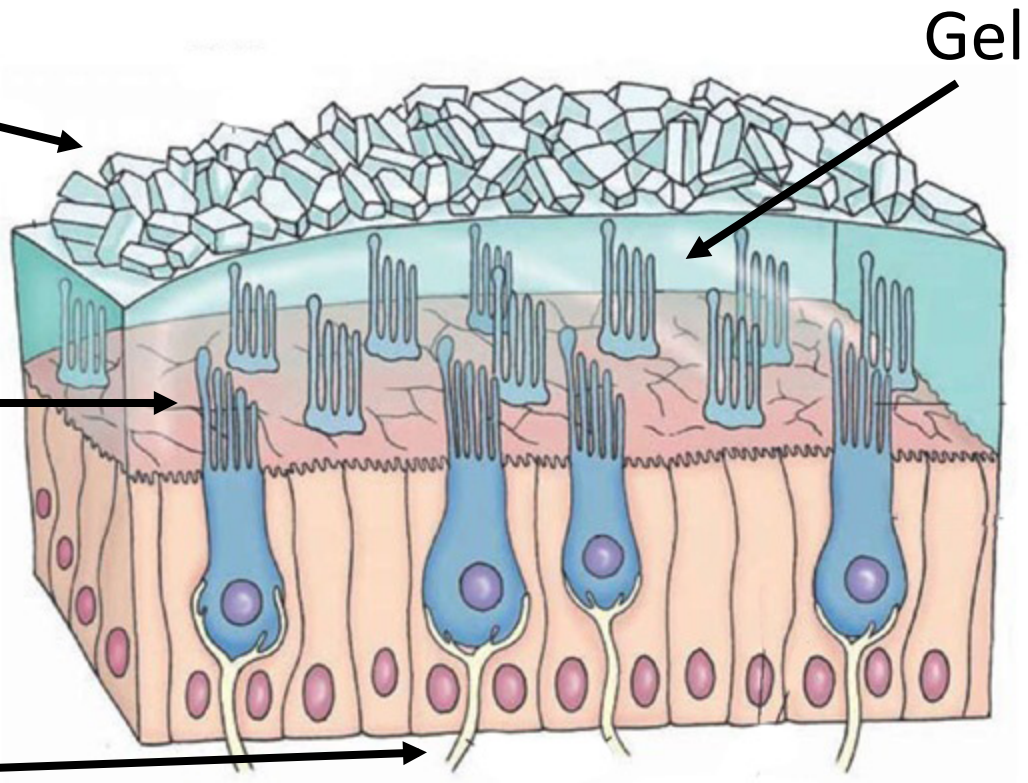
OTOLITH ORGAN



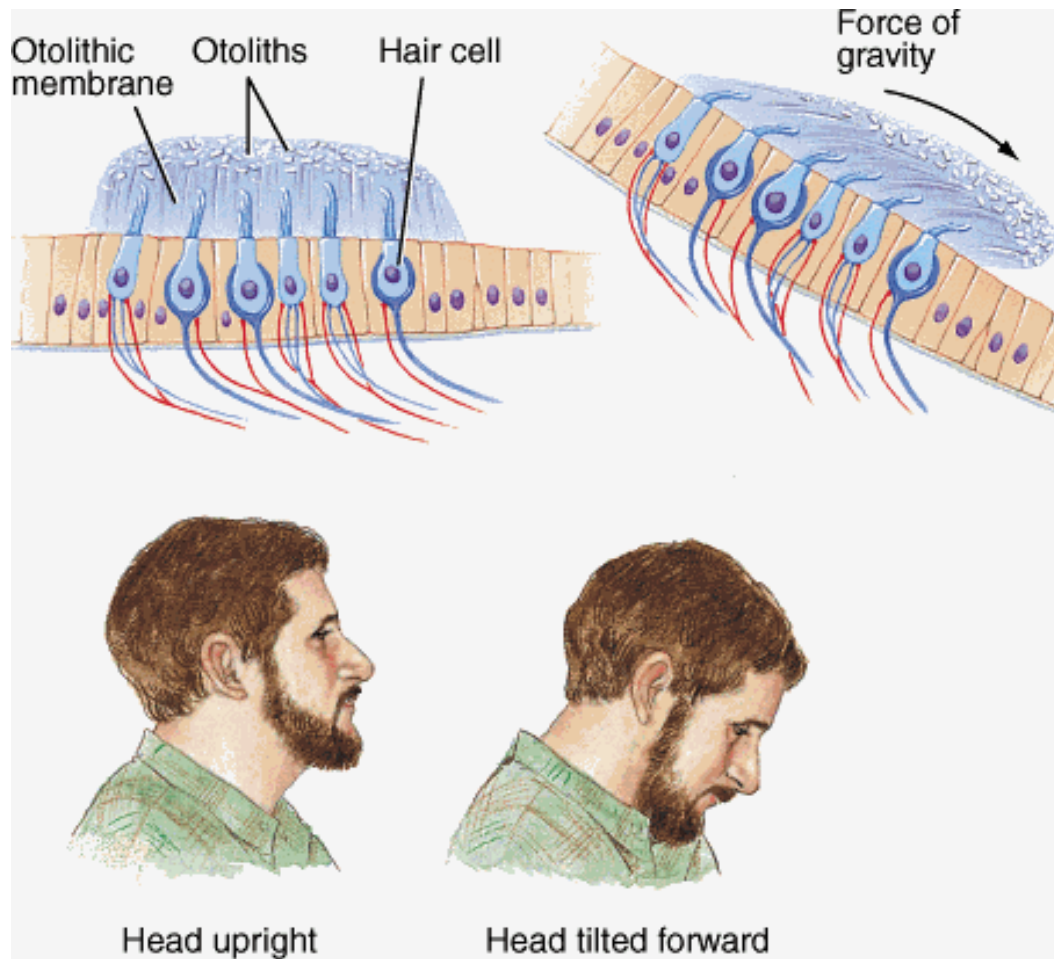
Otoliths
(Ear stones)

Hair cells

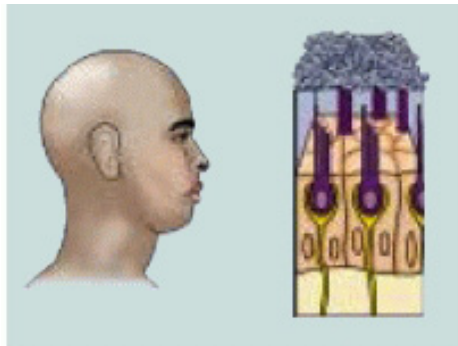
Neuron



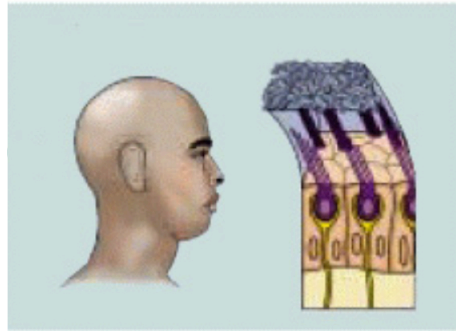
HOW THE OTOLITH ORGAN DETECTS TILTING OF THE BODY



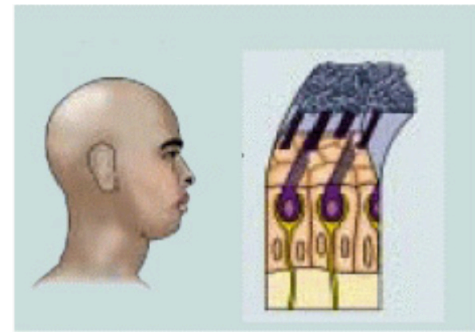
HOW THE OTOLITH ORGAN SENSES ACCELERATION



Stationary



Accelerate



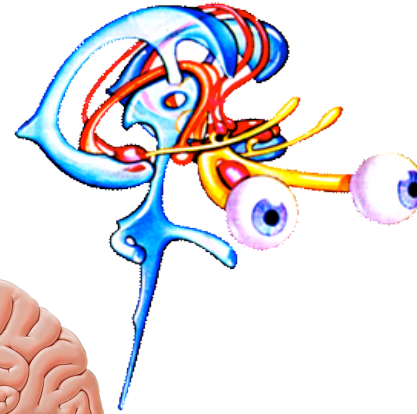
Decelerate

Maintaining Balance

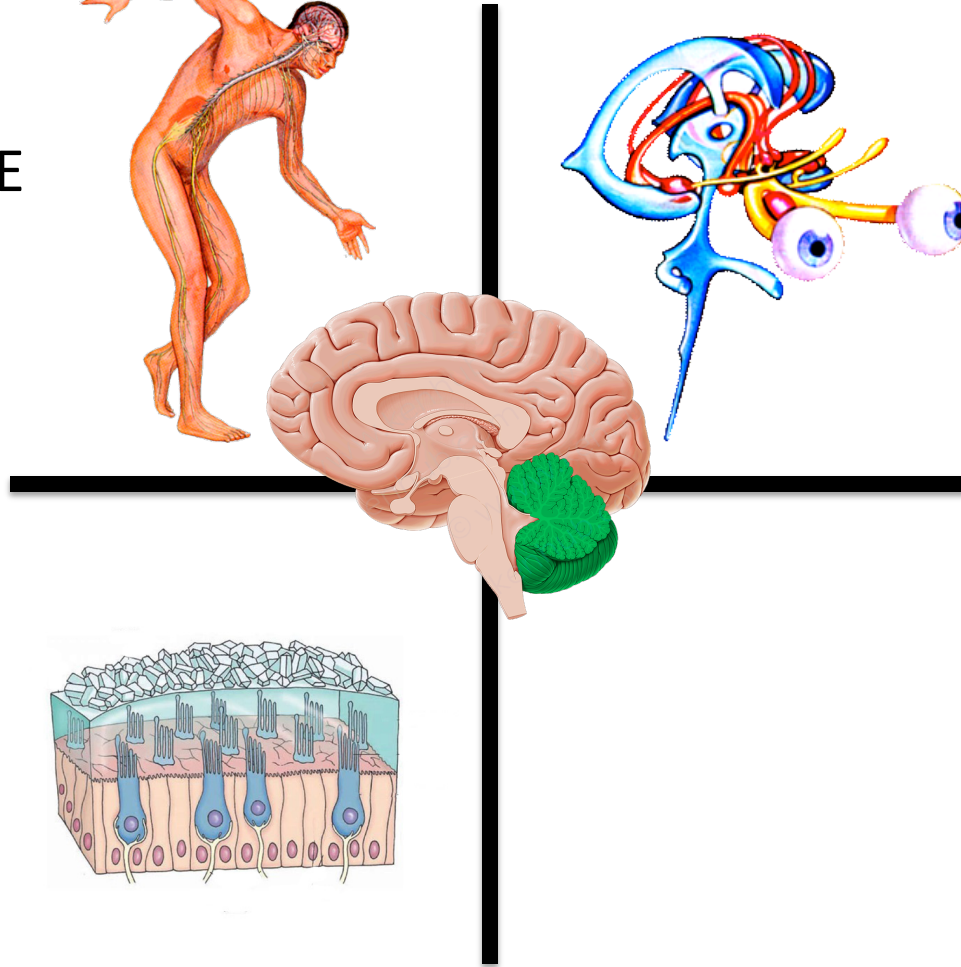
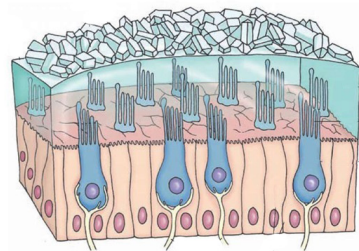
PRESSURE
SENSORS



VISUAL
CORTEX



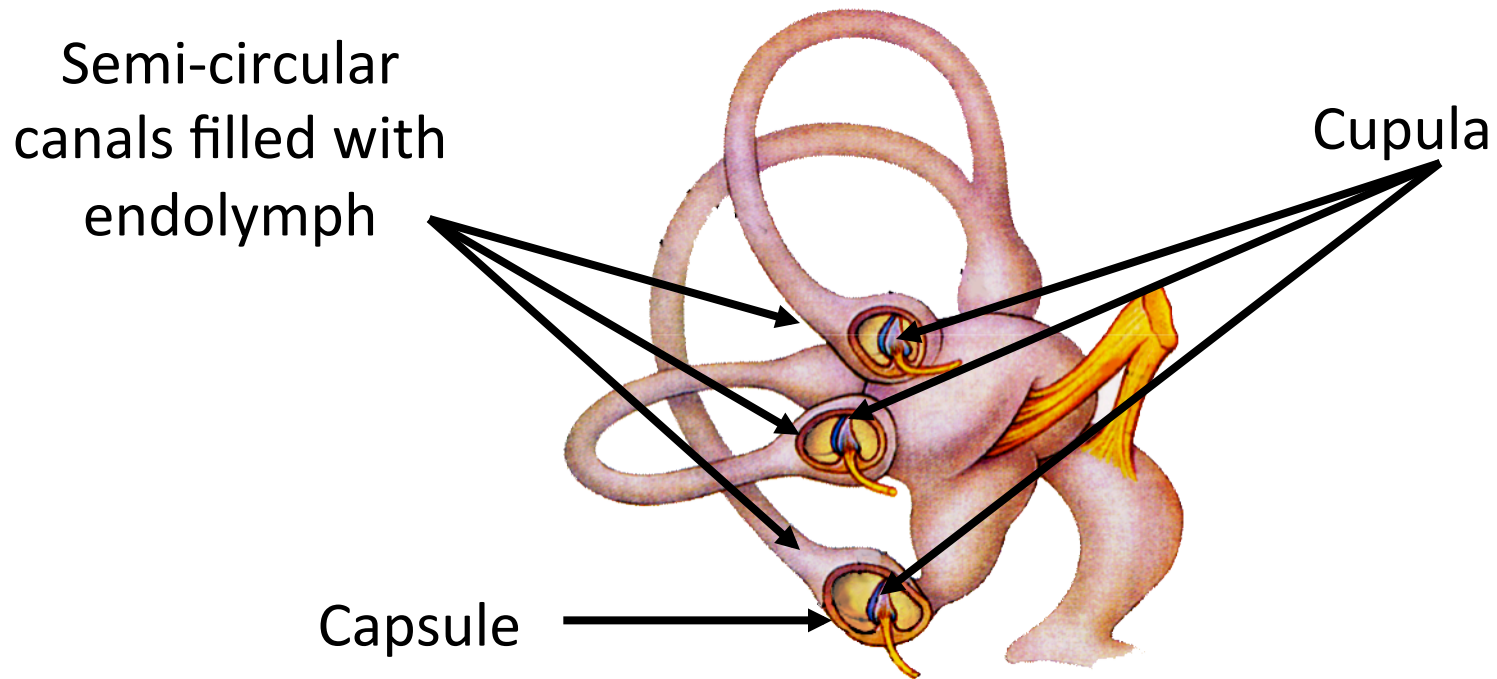
OTOLITH
ORGAN



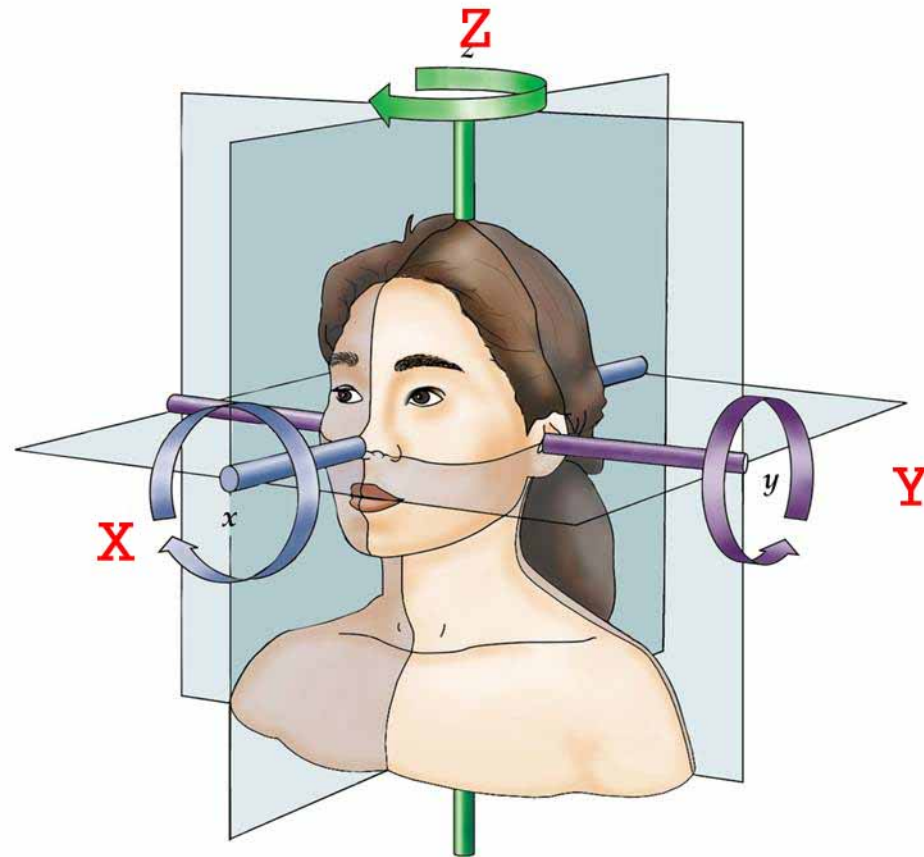
HOW DO WE SENSE ROTATIONAL MOTION?



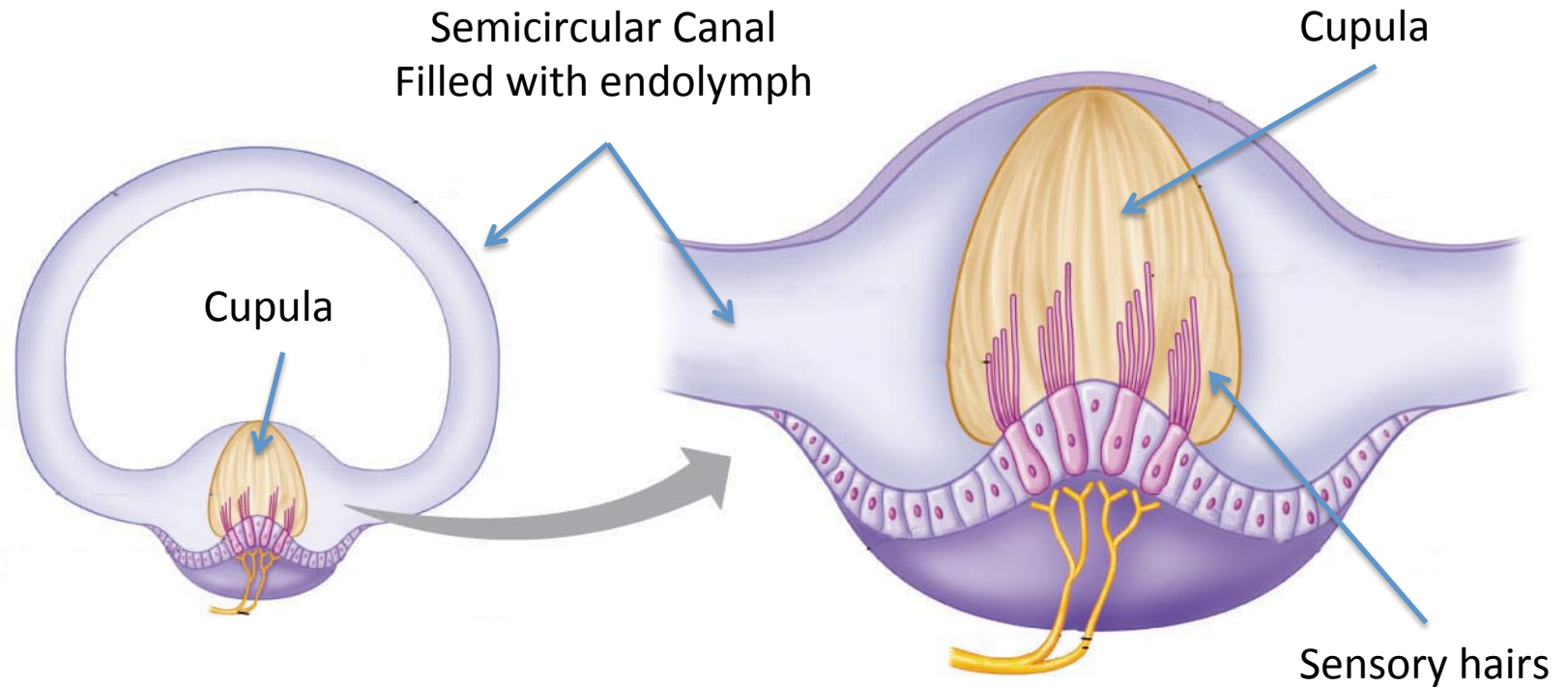
CUPULA/SEMICIRCULAR CANALS



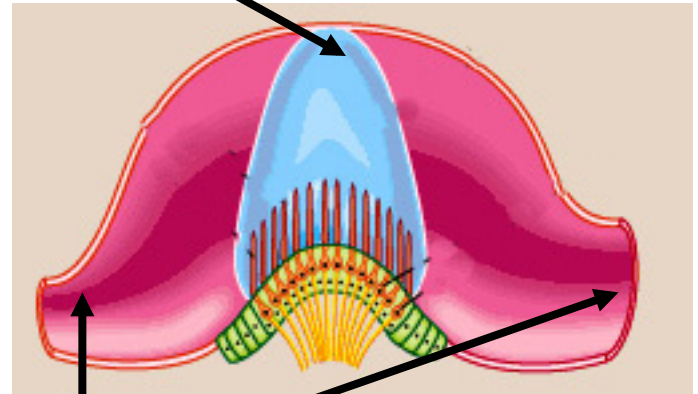
WHY ARE THERE 3 SEMICIRCULAR CANALS?



CUPULA/SEMICIRCULAR CANALS

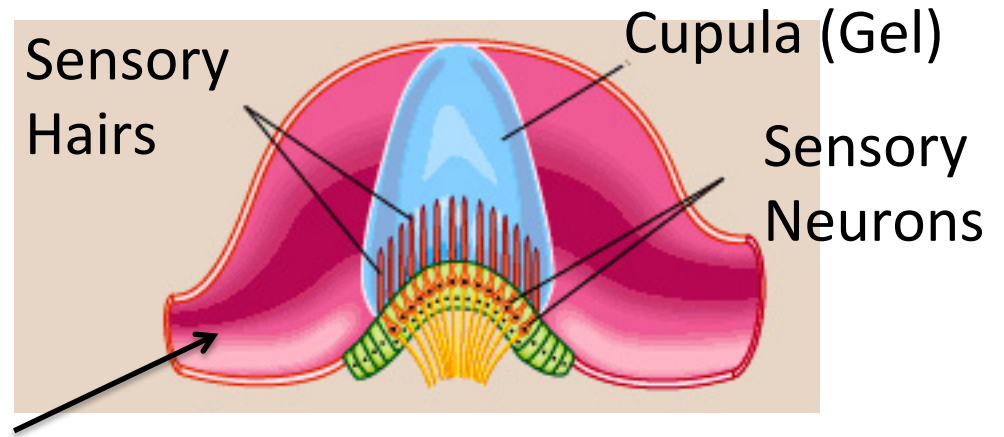
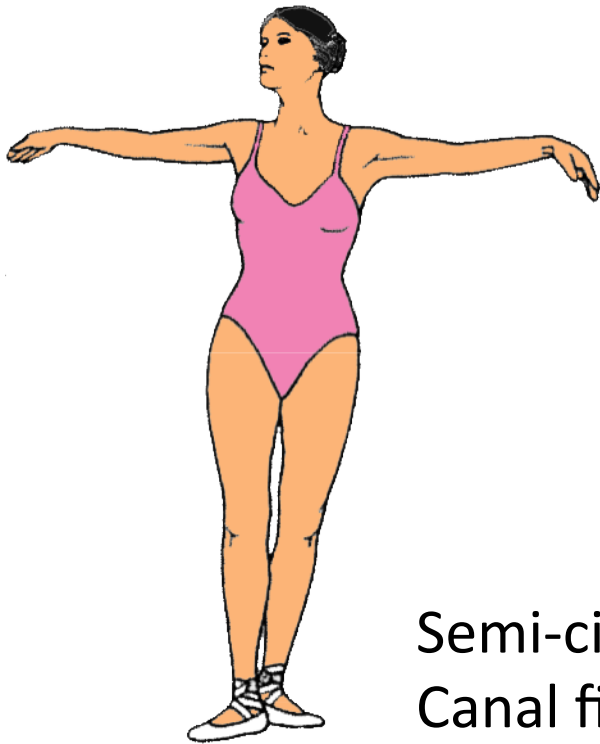


CUPULA



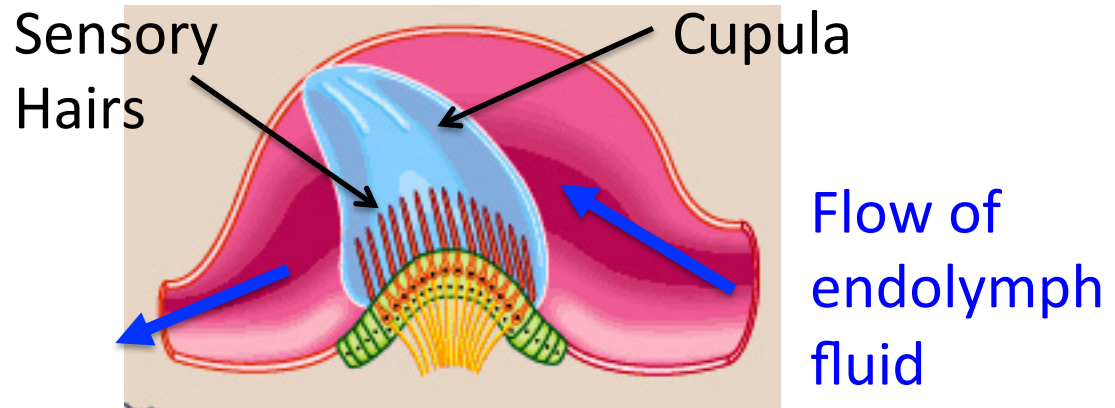
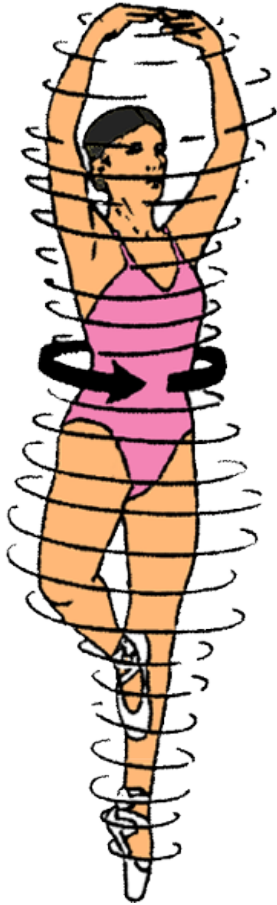
Semi-circular canals

CUPULA AT REST



Semi-circular
Canal filled with
endolymph fluid

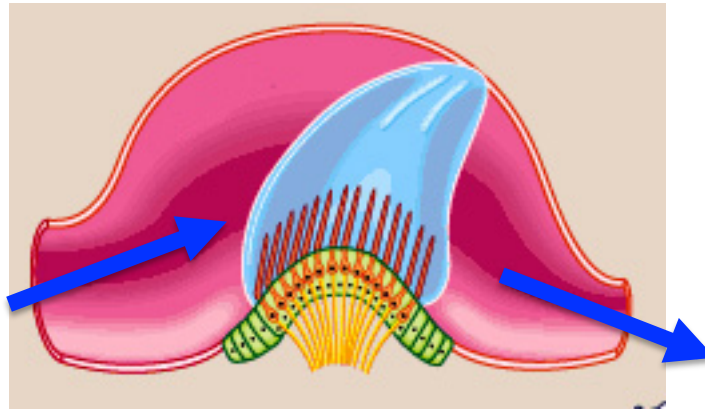
THE EFFECT OF ROTATION ON THE CUPULA



Sensation of spinning as moving fluid deflects hairs

WHY DO YOU STILL FEEL LIKE YOU ARE SPINNING AFTER YOU GET OFF THE CAROUSEL?

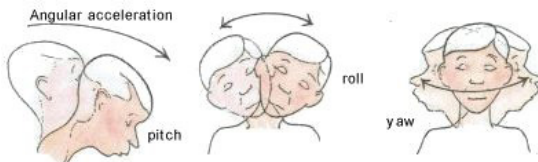
Endolymph Flow



The sensation of spinning continues as fluid continues to move through semi-circular canals which deflects hairs in the cupula

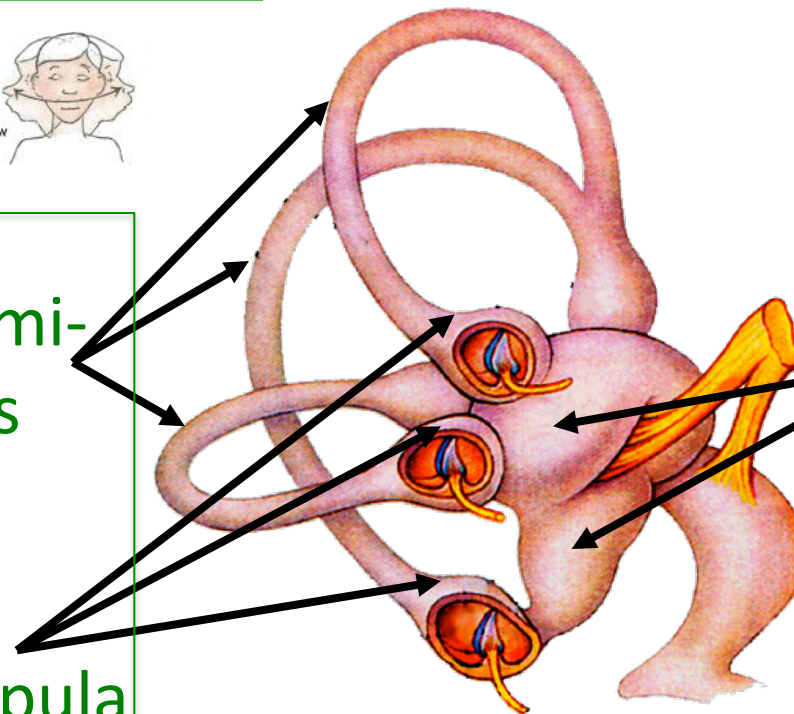
VESTIBULAR SYSTEM

ROTATIONAL MOTION & ANGULAR ACCELERATION

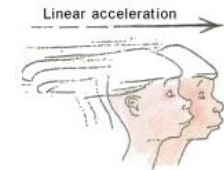


Fluid filled semi-circular canals

Capsule containing cupula



LINEAR MOTION & GRAVITY



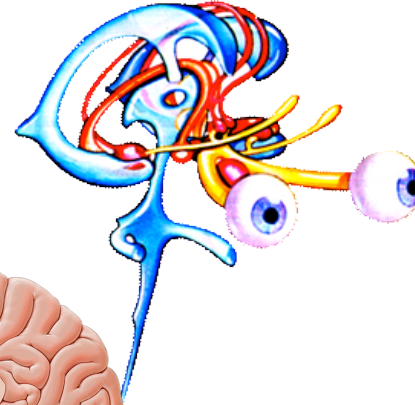
Saccule containing Otolith organs

Maintaining Balance

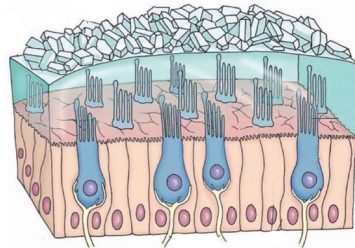
PRESSURE
SENSORS



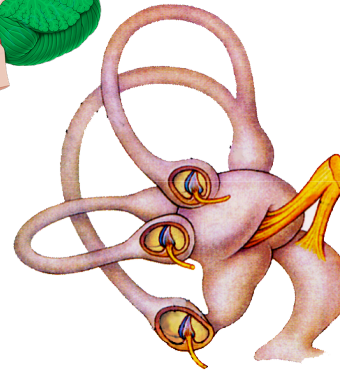
VISUAL
CORTEX



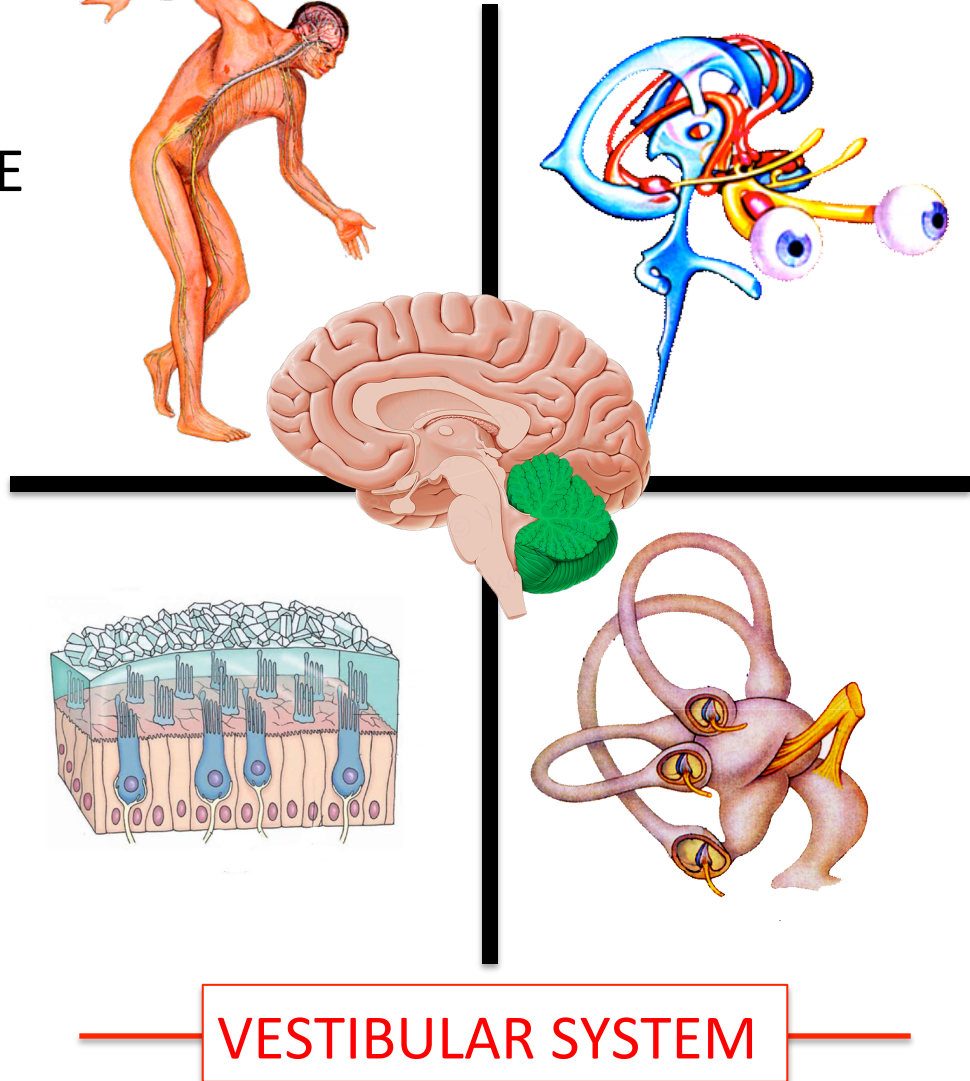
OTOLITH
ORGAN



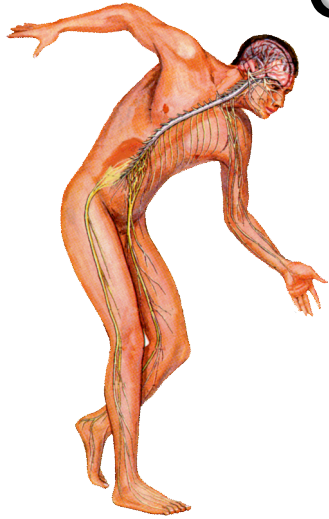
CUPULA/
SEMICIRCULAR
CANALS



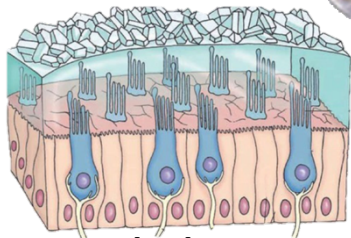
VESTIBULAR SYSTEM



WHICH SENSORY INPUTS CAN OPERATE IN SPACE?



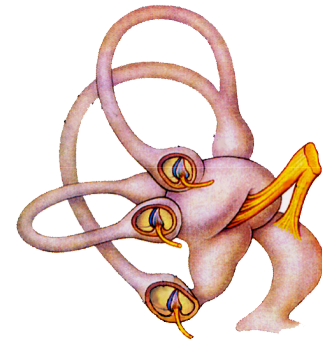
Pressure sensors
(Proprioceptors)



Otolith Organ

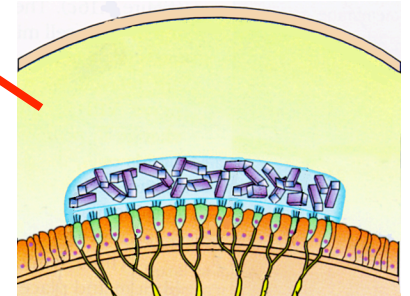
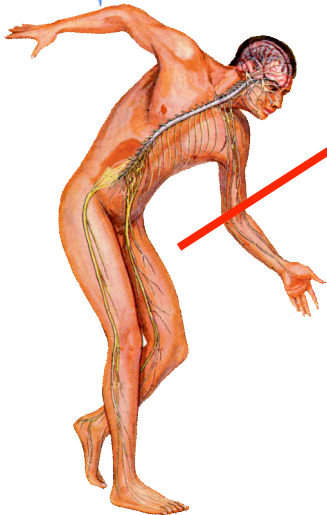
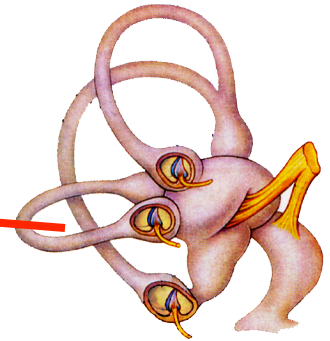


Visual cortex



Cupula

WHEN THE BRAIN RECEIVES CONFLICTING INFORMATION FROM THE VARIOUS COMPONENTS OF THE VESTIBULAR SYSTEM WE SUFFER FROM VERTIGO



WHY DO SOME ASTRONAUTS GET SICK WHEN THEY ARE IN SPACE?



HABITUATION ON “VOMIT COMET”



NASA KC-135 “VOMIT COMET”



WHY DO SOME PEOPLE GET SEA SICK WHEN STAYING BELOW DECK?



WHY DO SOME PEOPLE GET QUEASY WHEN WATCHING IMAX MOVIES?



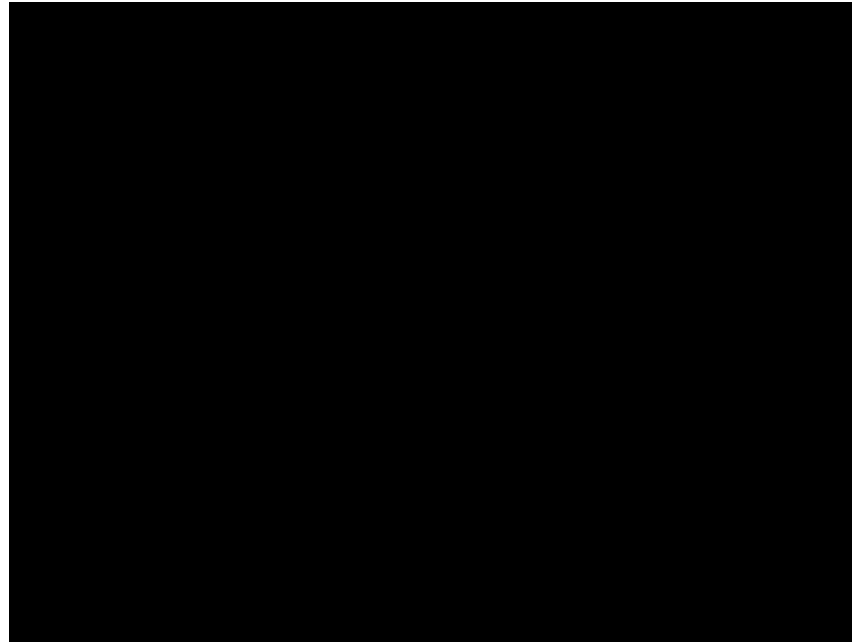
WHY DO SOME
PEOPLE SUFFER
FROM MOTION
SICKNESS WHEN
READING IN A CAR?



**NOTE THE MOTION OF THE HEAD AS A
PERSON WALKS**



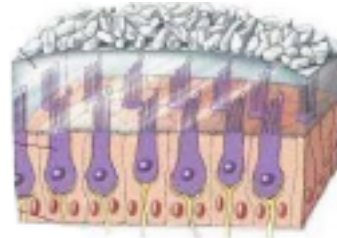
THE WORLD SHOULD LOOK LIKE THIS
WHEN WE WALK



VESTIBULO-OCULAR REFLEX (VOR)



HEAD LEVEL

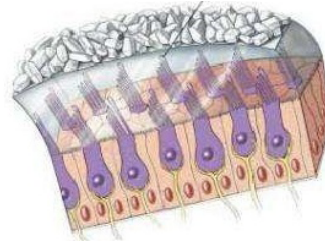


OTOLITH LEVEL

EYES LEVEL

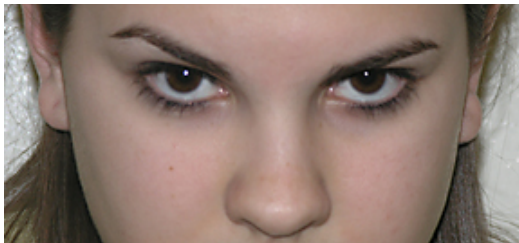


HEAD TILTS UP

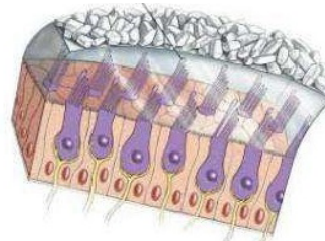


OTOLITH TILTS UP

EYES MOVE DOWN



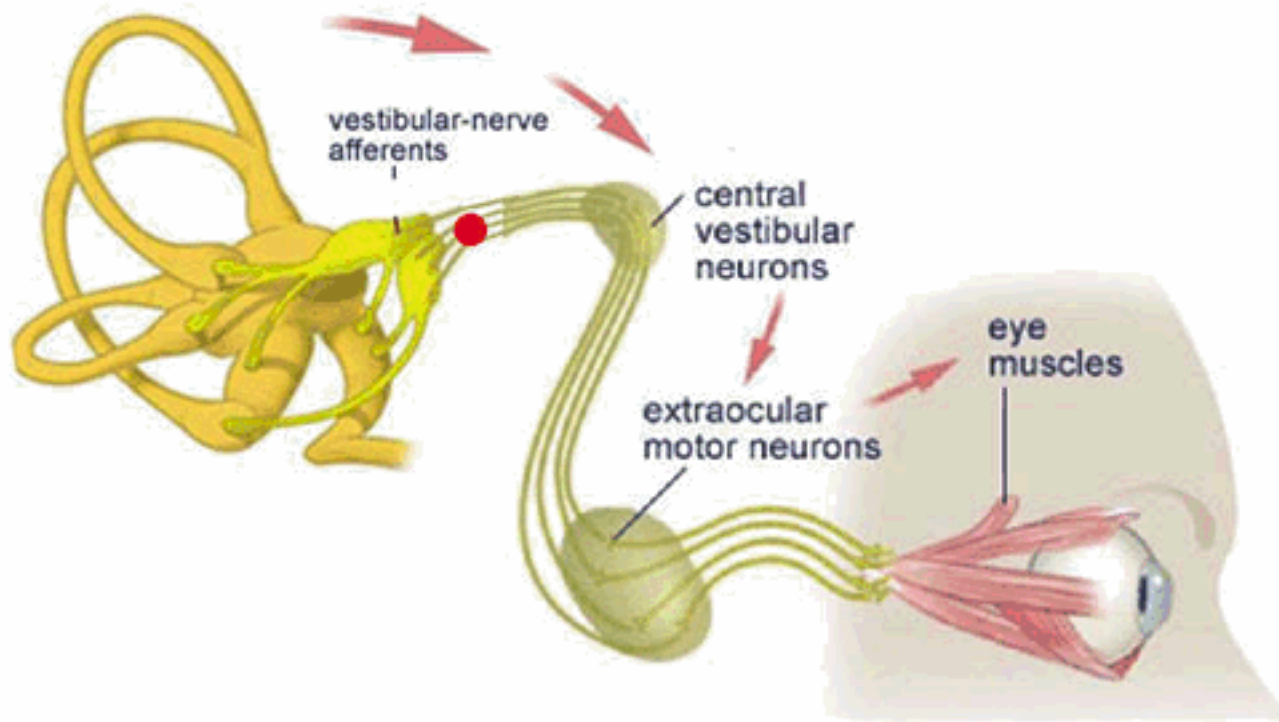
HEAD TILTS DOWN



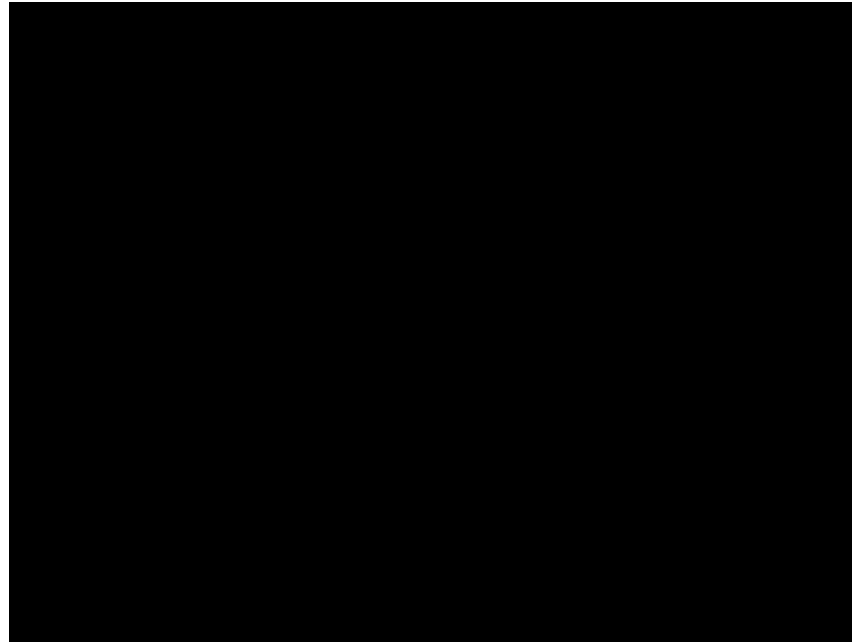
OTOLITH TILTS DOWN

EYES MOVE UP

VESTIBULO-OCULAR REFLEX



***THE VESTIBULO-OCULAR REFLEX
(VOR) STABILIZES OUR VIEW***

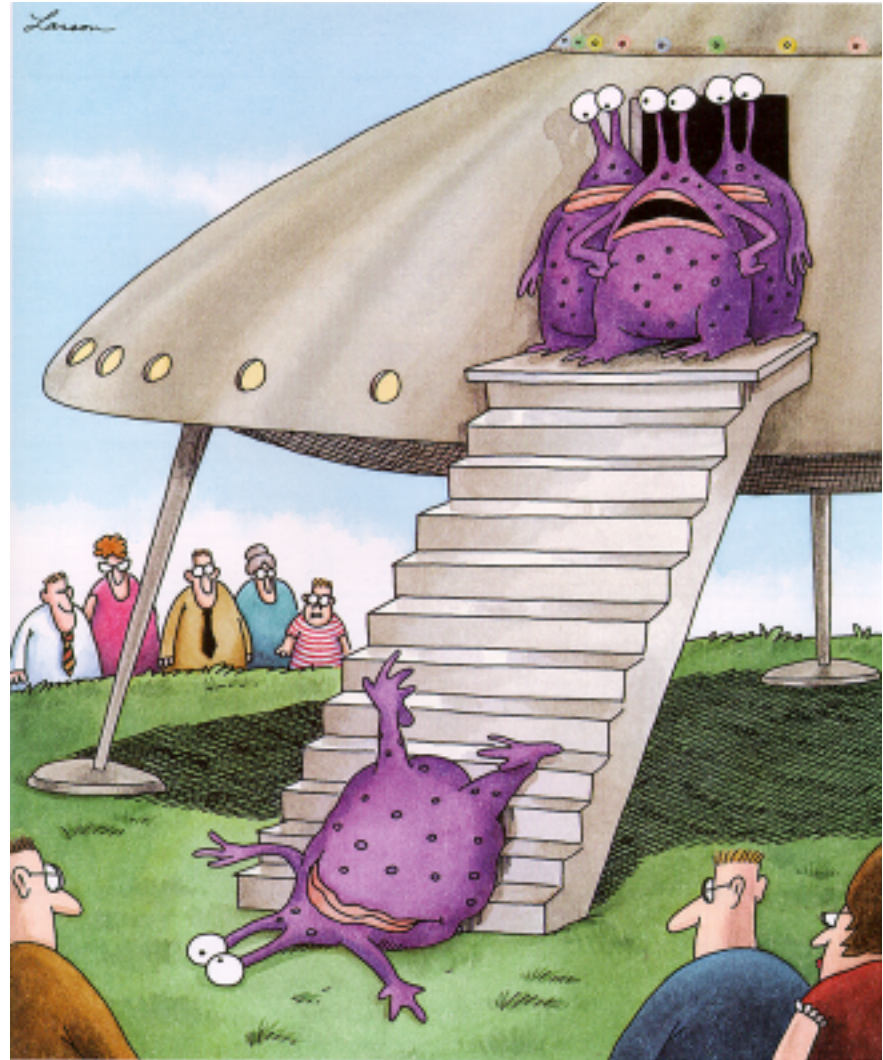


IN SPACE THE VOR CANNOT COMPENSATE FOR HEAD MOVEMENT LEADING SOME ASTRONAUTS TO SUFFER FROM VERTIGO AND DISORIENTATION



A MISSION TO MARS WOULD
KEEP THE ASTRONAUTS IN
SPACE FOR 22 MONTHS.

THE LONG TERM EFFECTS OF
MICROGRAVITY ON THE THE
VESTIBULAR SYSTEM REMAIN
UNKNOWN



“Wonderful! Just Wonderful!
...So much for instilling them with a sense of awe.”

A cinematic view of Earth from space, showing the curvature of the planet and the atmosphere. The sun is visible in the upper center, creating a bright lens flare. The text "THE END" is overlaid in white, centered horizontally. The image has a dark, atmospheric quality with some lens flare artifacts.

THE END