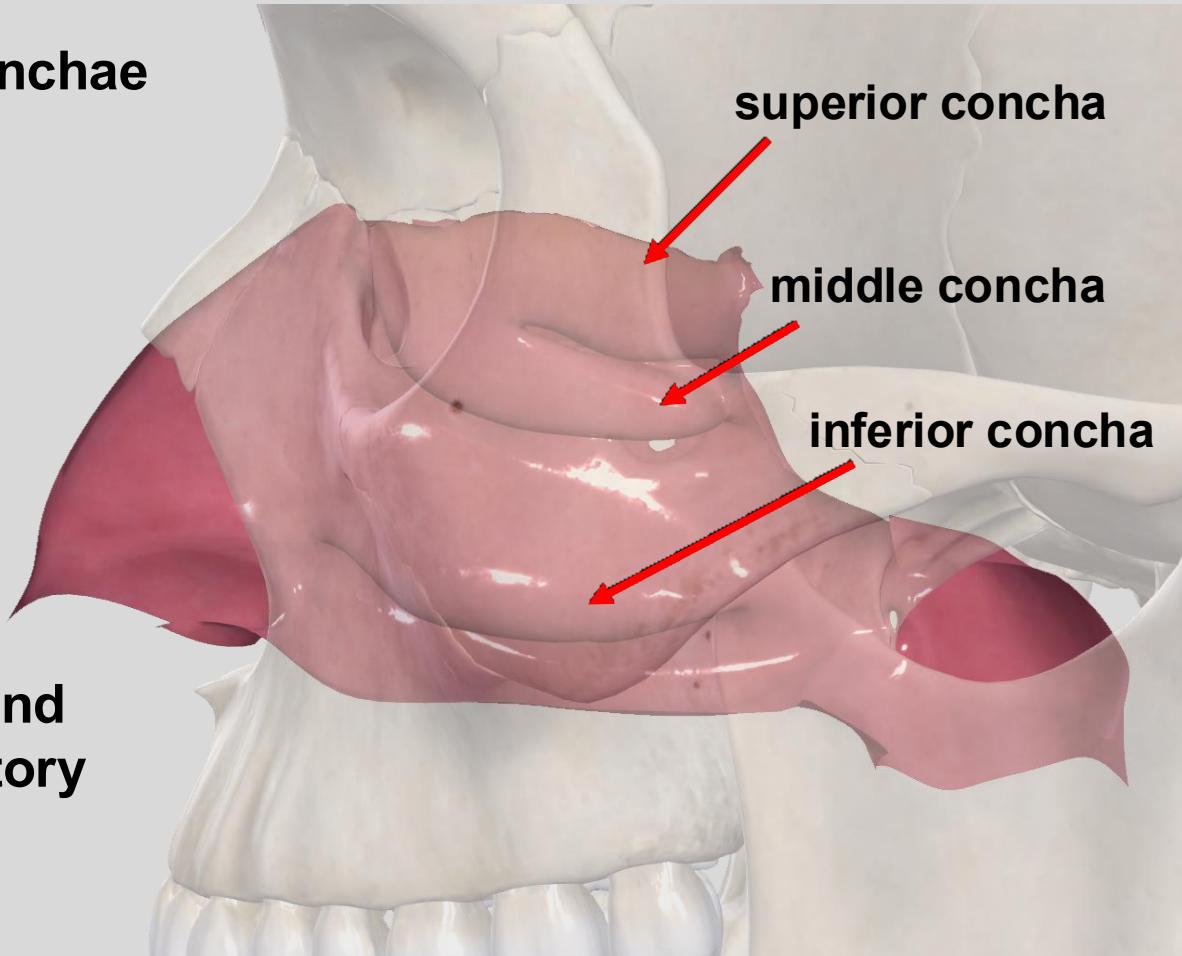


# Olfactory

Nasal passage houses 3 conchae

1. superior concha
2. middle concha
3. inferior concha



Only the superior concha and adjacent walls house olfactory epithelia

# Olfactory Clinical Correlates

## Anosmia

Smell “blindness”

Causes can be

Chemical (damage to epithelium)

Mechanical (damage to cribriform plate)

Congenital (failure of proper CN I development)

Viral — originally a CoViD-19 symptom



## Anosmia affects quality of life

Affects taste and appetite

Inability to detect spoiled food and dangerous situations (e.g., gas leaks)

# Taste

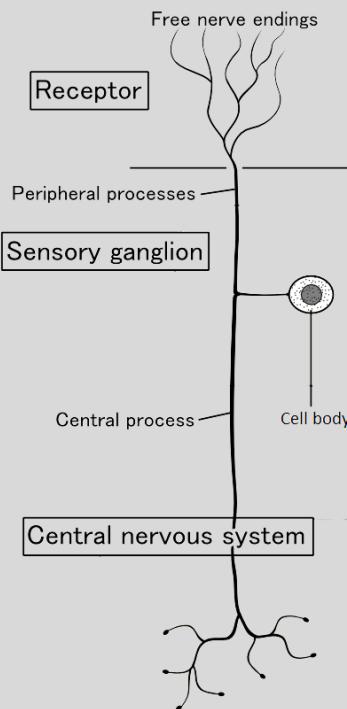
**Spicy is not a true taste but more of a neurological phenomenon**

**Nociception (pain) from spices like capsaicin are treated by the brain as a taste rather than normal pain**

**Any mucosal lining can “taste” spicy food**

**Spice tolerance = pain tolerance**

We can't all be as cool as Lorde



# Taste

## Clinical Correlate

### Ageusia

#### Taste loss

Often coupled (and confused) with  
anosmia

#### Caused by:

Toxic chemical exposure

Head trauma

Viral — originally a CoViD-19 symptom

#### Largely affects quality of life

Can lead to inadvertent food poisoning

Can also lead to poor nutrition

adding more sugar and salt to foods in an attempt to regain taste



# Coupled Senses: Flavour

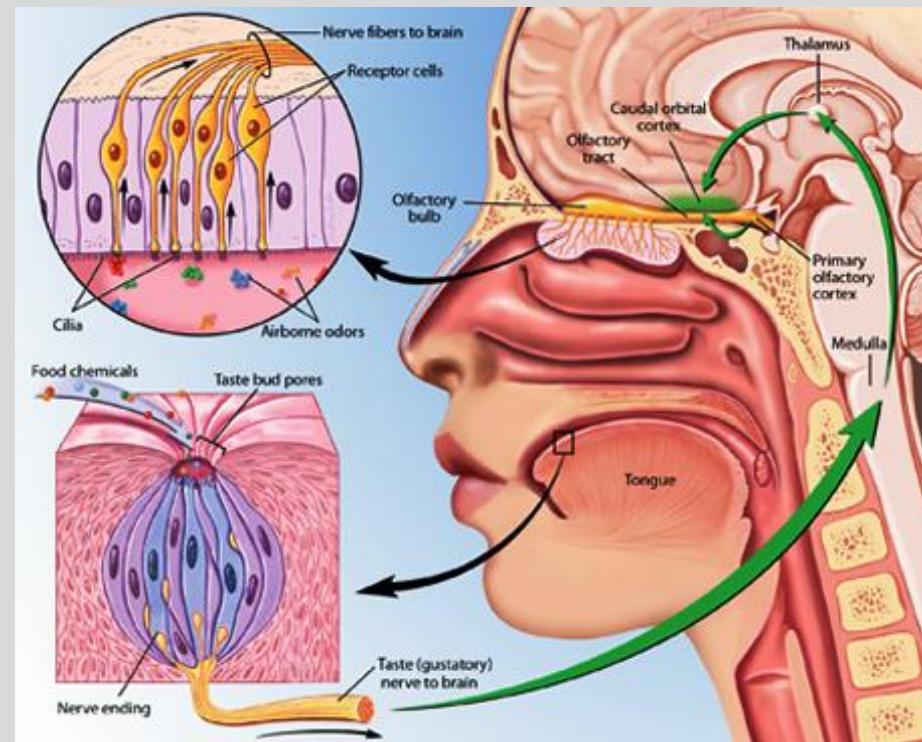
**Coupled senses = 2 or more senses that work together to perform a new function**

**Smell and taste are deeply intertwined**

**Taste requires smell to bring out flavour**

**80% of flavour is smell (allegedly)**

**Olfaction and gustation information is combined in the thalamus and orbitofrontal cortex**



**Lower air density in planes means these taste sweeter on the ground than in the air**



## Vision (CN II)

NEW YORK INSTITUTE  
OF TECHNOLOGY

College of Osteopathic  
Medicine

# Special Afferents of the Head and Neck

Jason Bourke, Ph.D.

Department of Biomedical and Anatomical Sciences

[jbourke@nyit.edu](mailto:jbourke@nyit.edu)

Do.  
Make.  
Heal.  
Innovate.  
Reinvent the Future.

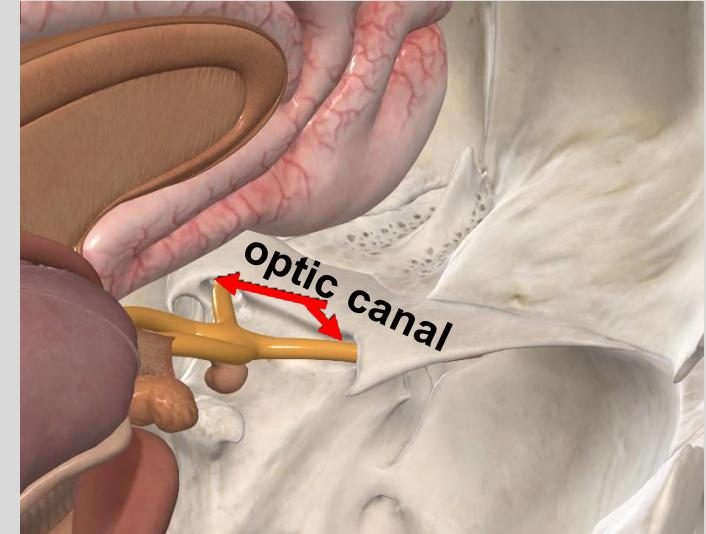
# Vision

The most important special afferent  
in our body

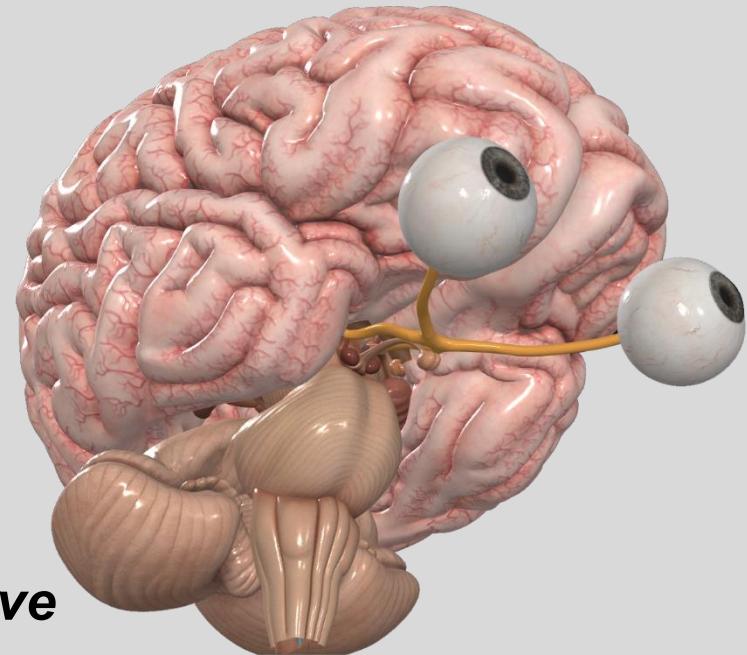
30–60% of our brain is  
dedicated to visual processing

Optic nerve is an anterior extension  
of the forebrain

Optic nerve exits *the endocranum*  
through the optic canal



superolateral view



*The eye is the terminal nerve of the optic nerve*

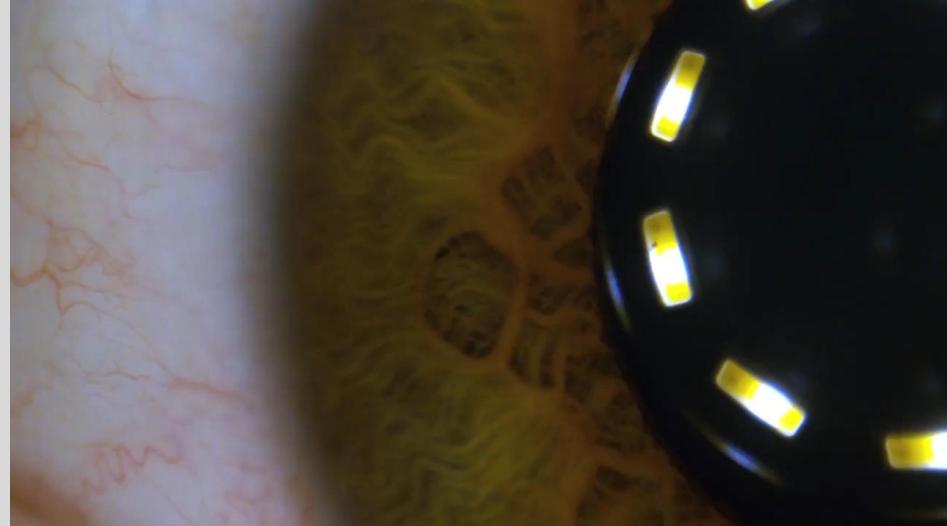
# Vision

## Vascular Layer

## Movies

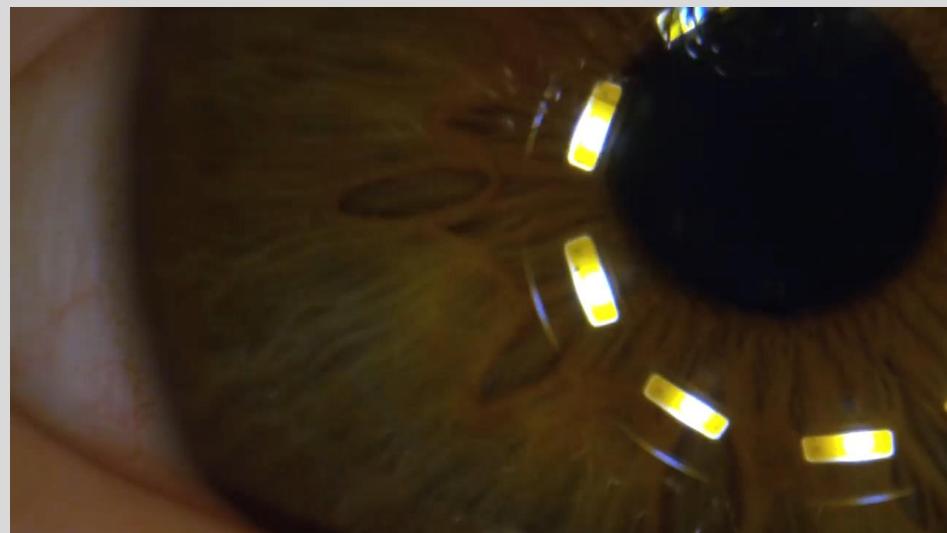
### sphincter pupillae

circular fibres  
parasympathetic  
fast contraction



### dilator pupillae

radial fibres  
sympathetic  
“slow” contraction



# Vision

9

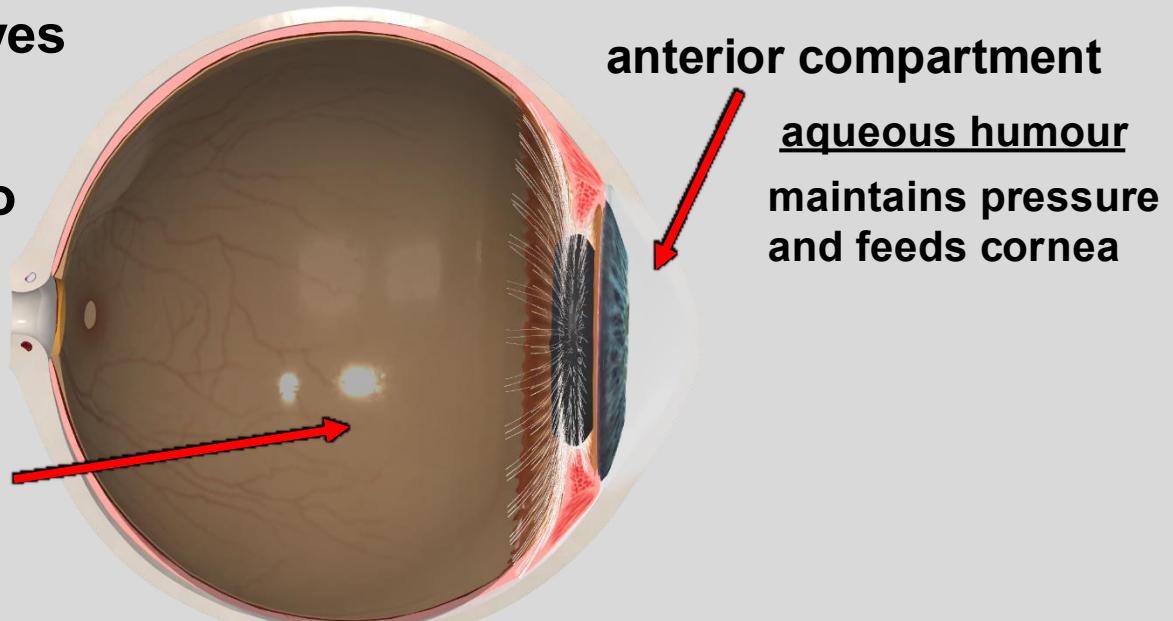
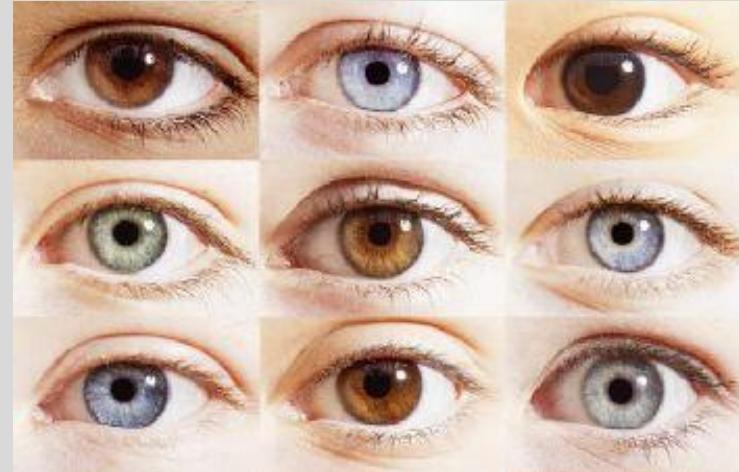
## Vascular Layer: Iris

Melanocytes in pigmented layer produce melanin

Trapped melanin granules produce eye colour

More melanin = darker eyes

The iris separates the two compartments of the eye



# Vision: The Eye

15

## Neural Layer: Retina

### 2. Macula lutea

“Pit” in retina formed from non-photoreceptive cells angling away from incoming light

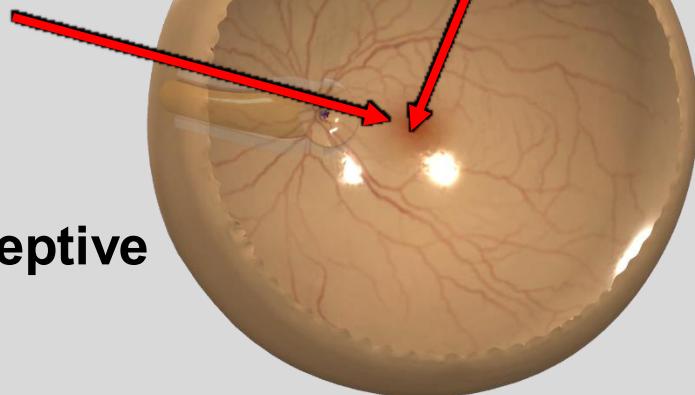
The area of clearest vision is at the center of the macula lutea (= fovea)

### Foveation

Focusing on an object by moving the image onto the fovea

macula lutea

fovea centralis

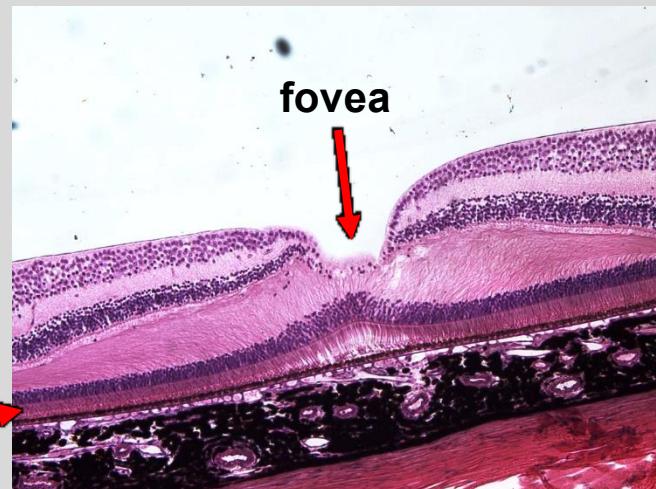


anterior view  
(retina only)

non-photoreceptive  
cells

photoreceptors

fovea



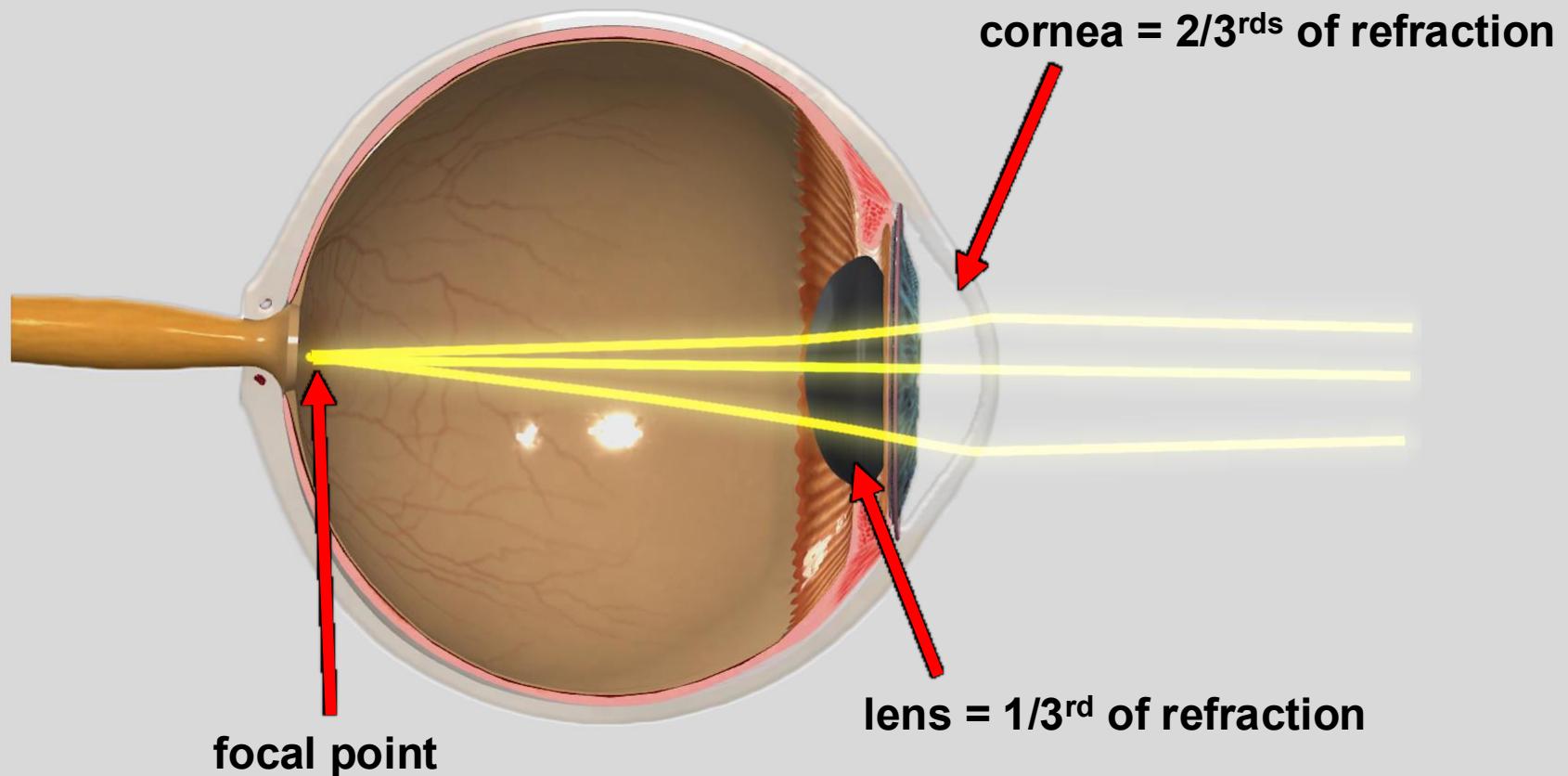
Latin: *macula* = spot / stain + *lutea* = yellow

Latin: *fovea* = small pit + *centralis* = center

# Vision: The Eye

## Accommodation

This is the ability to adjust the focal point in the eye



# Vision: The Eye



dissected lens  
(cow)

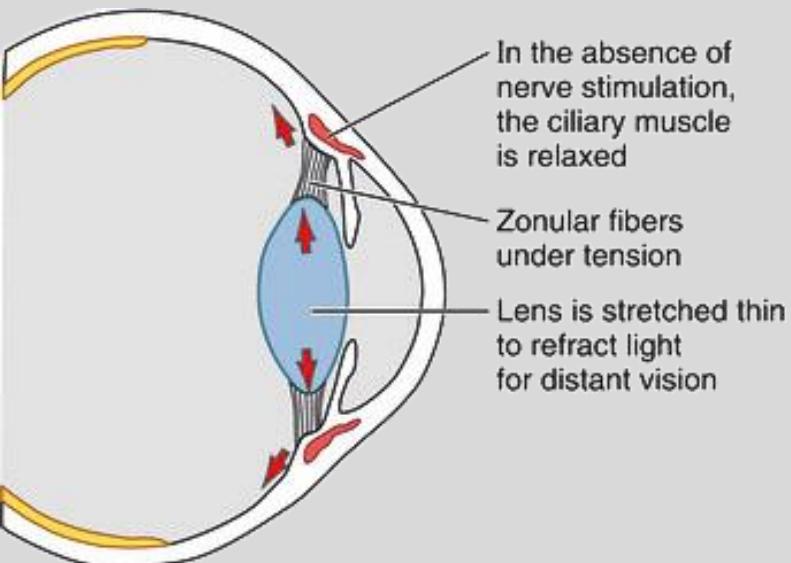
## Accommodation

The lens is spherical and elastic

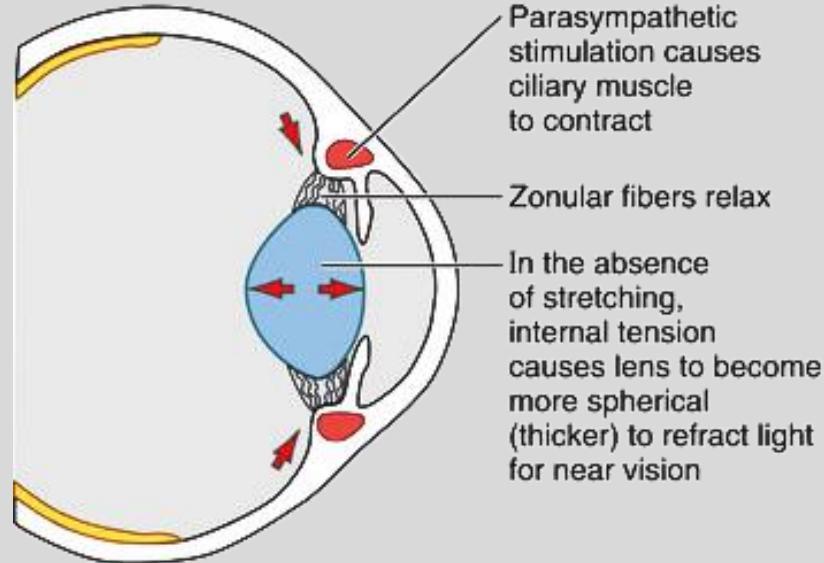
Deforming the lens changes the focal point

Distance focus stretches the lens

Near point focus = rounder lens



Stretching is a **passive** act



**Active contraction of ciliary body**

# Vision: The Eye

## Accommodation

Accommodation is counterintuitive

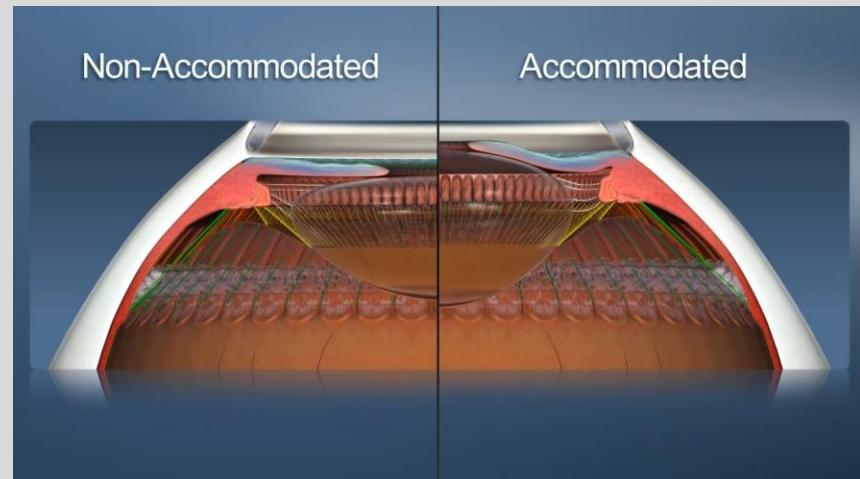
Changing lens shape (stretching) is a passive process

Distance focus *does not require* nerve stimulation

Relaxing the lens requires *active contraction* of the ciliary muscle

Eye strain is the result of an exhausted ciliary muscle

## Movie



Goldberg 2011. Computer-animated model of accommodation and theory of reciprocal zonular action

<https://www.youtube.com/watch?v=1ylpyitm6eE>

# Vision: The Eye

## Clinical Correlates

### Presbyopia

Lens loses elasticity with age

Stretched lens has trouble “bouncing back” to its original shape

Near-point focusing ability is reduced

Treatment includes corrective lenses or multifocal / presbyLASIK



# Vision: The Eye

## Clinical Correlates

### Cataracts

**Protein breakdown exceeds repair rate as we age**

**Denatured proteins build up in the lens thickening and clouding it**

**Hypertension, poor nutrition & smoking may increase rates of cataract formation**

**Down and Turner's syndrome may increase chance of cataracts**

**68% of U.S. pop over 80, have / had cataracts**

**Requires surgical intervention**

**Partial / total lens replacement**



**Cataract in 55-year old male**



**Healthy lens next to two lenses with various degrees of cataracts**

# Vision: The Eye

## Clinical Correlates

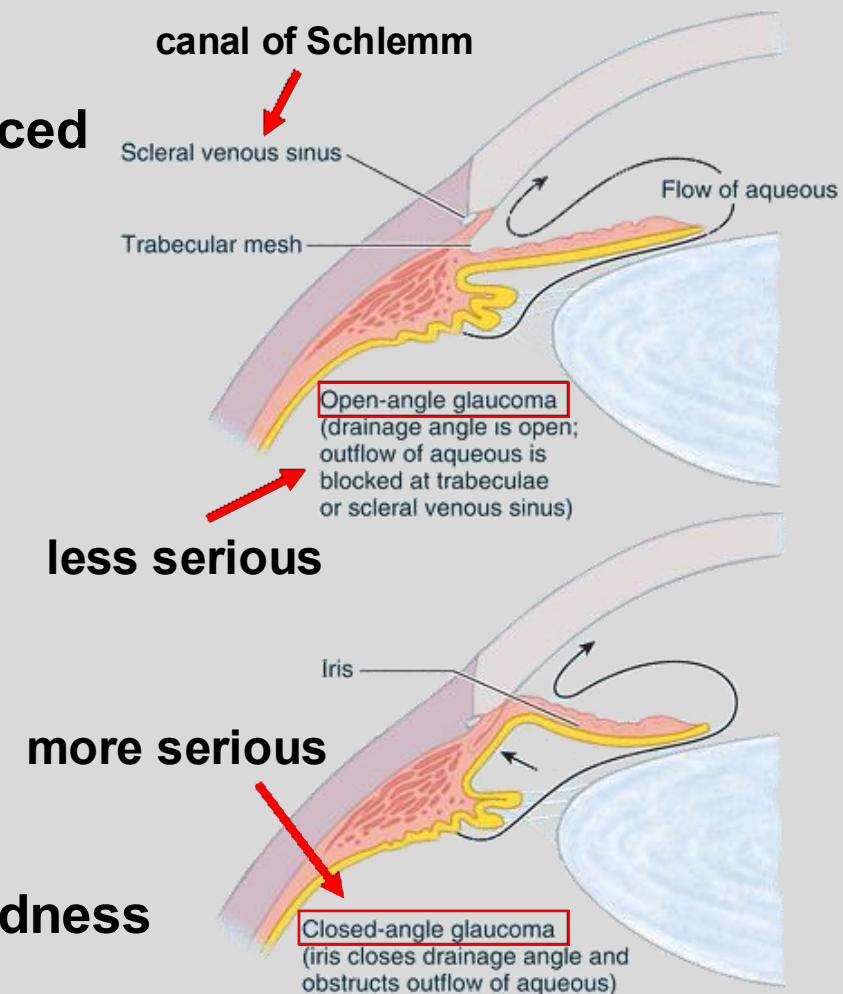
### Glaucoma

Aqueous humour is continuously produced by the ciliary body

The humour is continuously drained through the scleral venous sinus (canal of Schlemm)

Blockage of this flow causes stagnation and cloudiness

Left untreated, glaucoma will cause blindness due to optic nerve compression



# Vision: The Eye

## Clinical Correlates

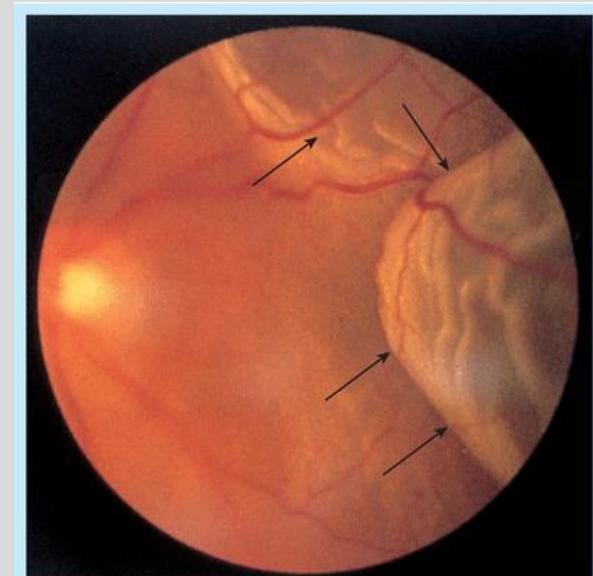
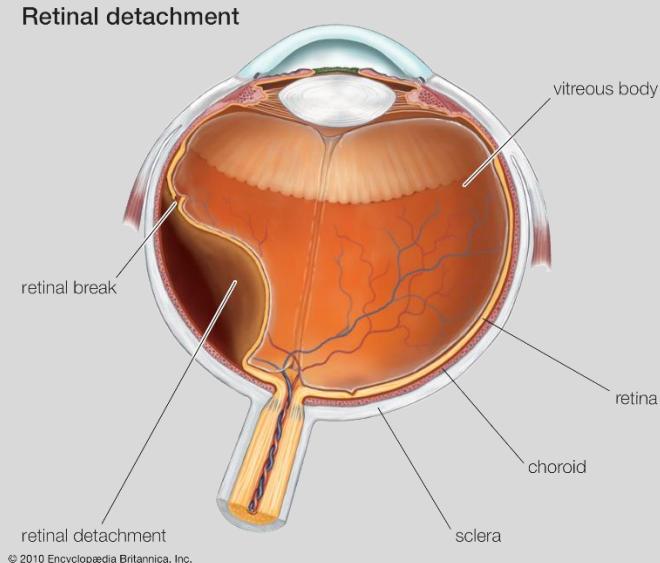
### Retinal detachment

**Neural layer of retina requires ocular pressure to maintain attachment to choroid**

**Injuries that reduce intraocular pressure put the retina at risk of detachment**

**Patients complain of flashes and specs of light**

**Retinal detachments are immediate medical emergencies**



Ophthalmoscopic view (arrows, wrinkles in detached retina)

## Hearing and Balance (CN VIII)

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine

# Special Afferents of the Head and Neck

Jason Bourke, Ph.D.

Department of Biomedical and Anatomical Sciences

[jbourke@nyit.edu](mailto:jbourke@nyit.edu)

Do.  
Make.  
Heal.  
Innovate.  
Reinvent the Future.

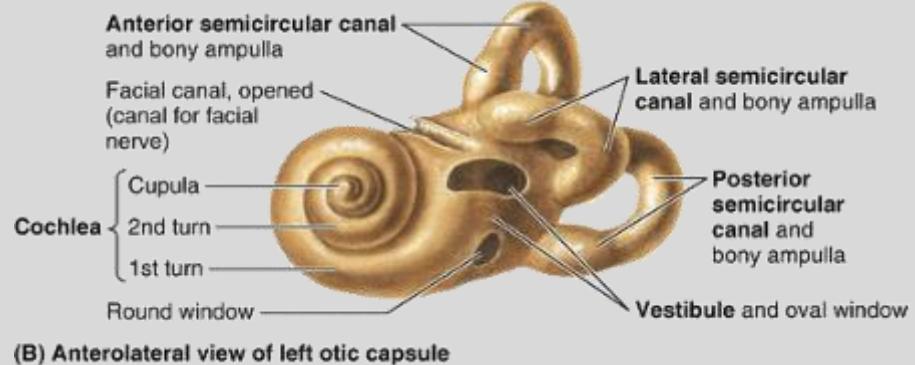
# Otic Capsule

Comprised of an **endosseous (bony) labyrinth**

## endosseous (bony) labyrinth

Filled with **perilymph**

Same constituency as  
extracellular fluid



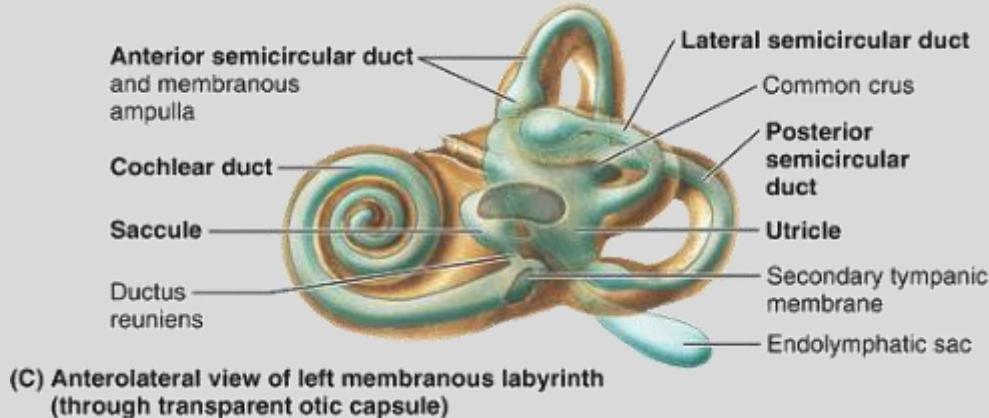
Deep to the bony labyrinth is the **membranous labyrinth**

## membranous labyrinth

This is the physiologically active part of the inner ear

Filled with **endolymph**

Same constituency as  
intracellular fluid

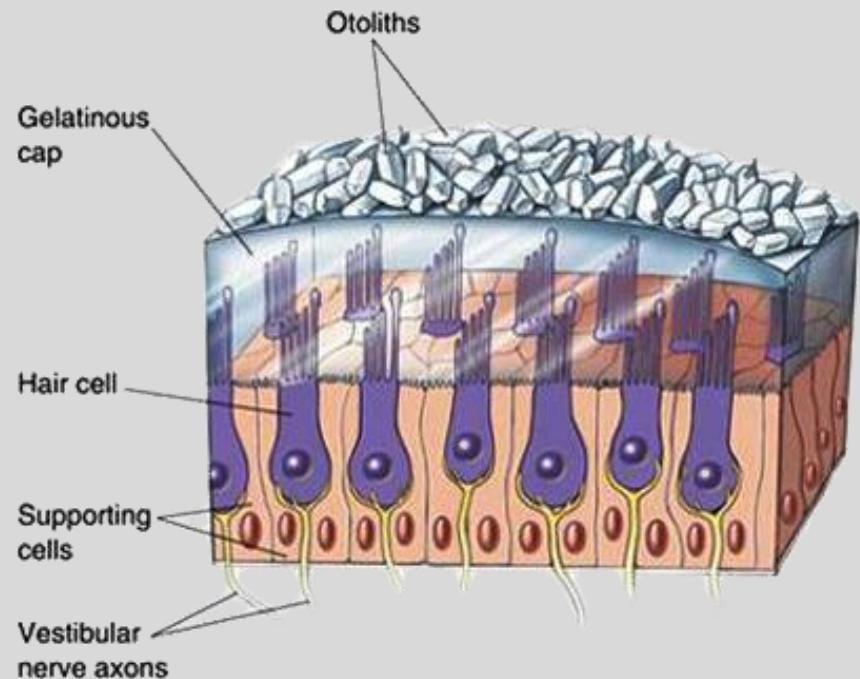


# Vestibular Organ

## Otolith organs

Greek: *oūs* = ear + *lithos* = stone

Otoliths are small calcifications



They give weight to the utricle and saccule

# Vestibular Organ

## Otolith organs

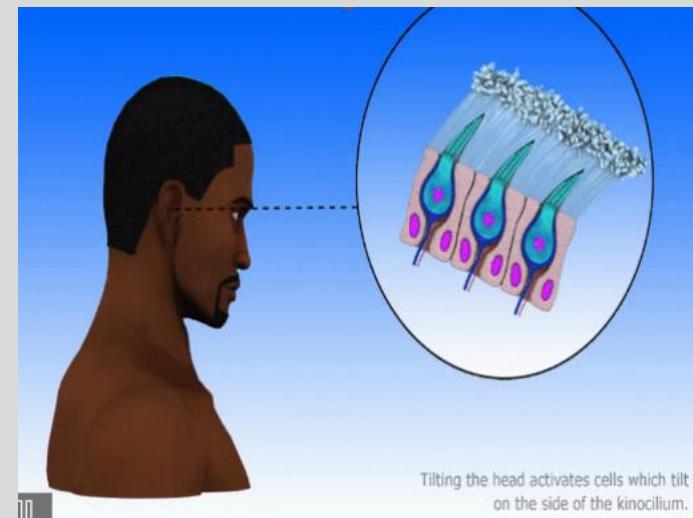
### Utricle

Horizontally aligned in the inner ear

Sensory neurons lie on the floor of the utricle (macula)

Senses horizontal acceleration

Works in tandem with the semicircular canals to determine head position in space



Adapted from 3D Anatomy Lyon  
<https://www.youtube.com/watch?v=ZiFyIfBWYoO>

# Vestibular Organ

## Otolith Organs

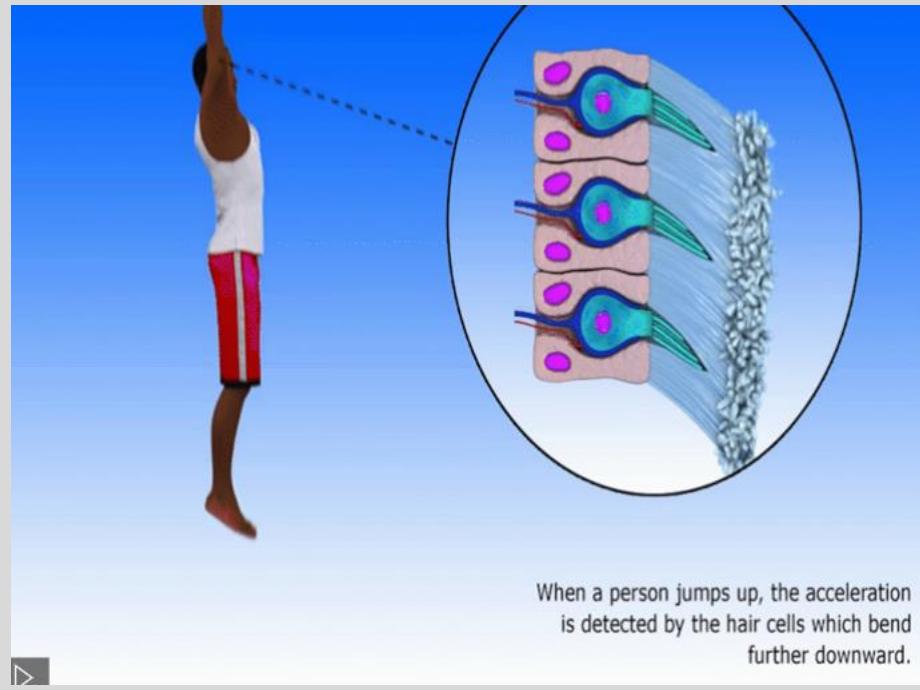
### Otolith organs

#### Saccule

Neurons lie on the medial wall of the saccule (macula)

Senses vertical acceleration

Functions as our gravity sensor



When a person jumps up, the acceleration is detected by the hair cells which bend further downward.



Adapted from 3D Anatomy Lyon  
<https://www.youtube.com/watch?v=ZiFyIfBWYo>

# Vestibular Organ

Semicircular canals (SCC)

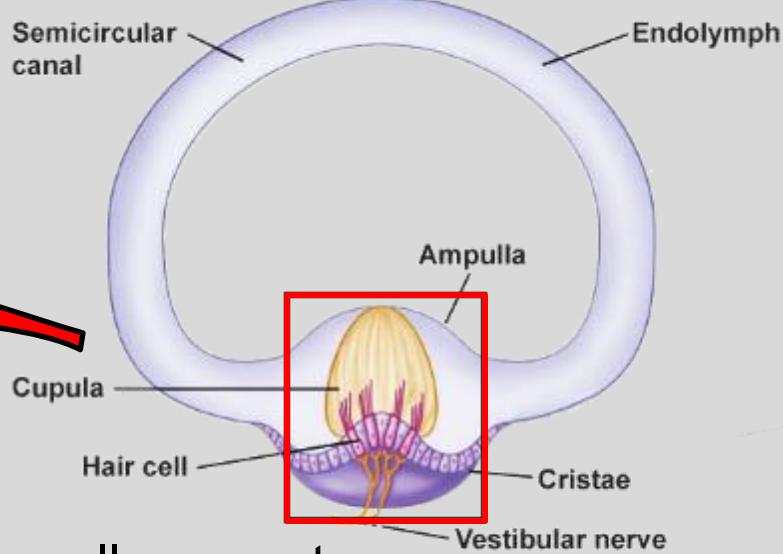
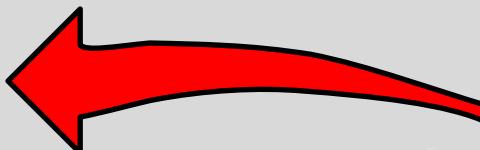
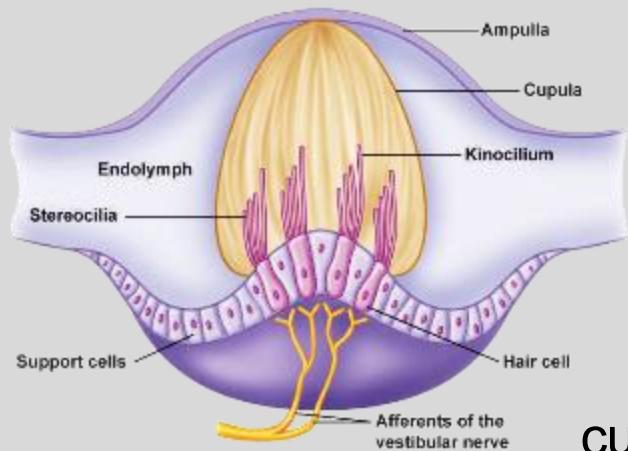
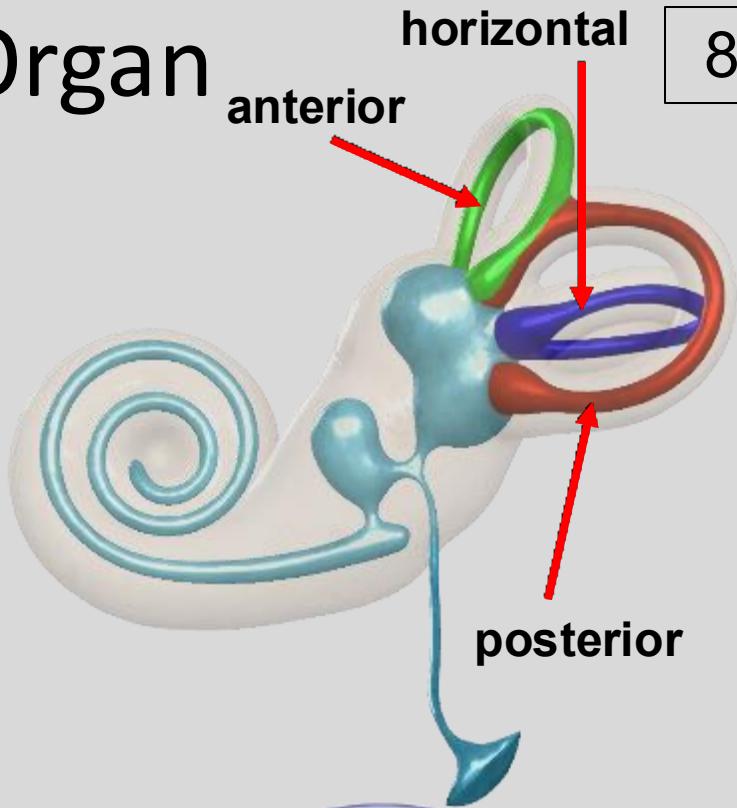
Provide head orientation information

3 semicircular canals

- 1) Anterior
- 2) Posterior
- 3) Horizontal

Canals are filled with endolymph

Each canal expands into an ampulla



cupula + cristae = ampullary crest

# Vestibular Organ

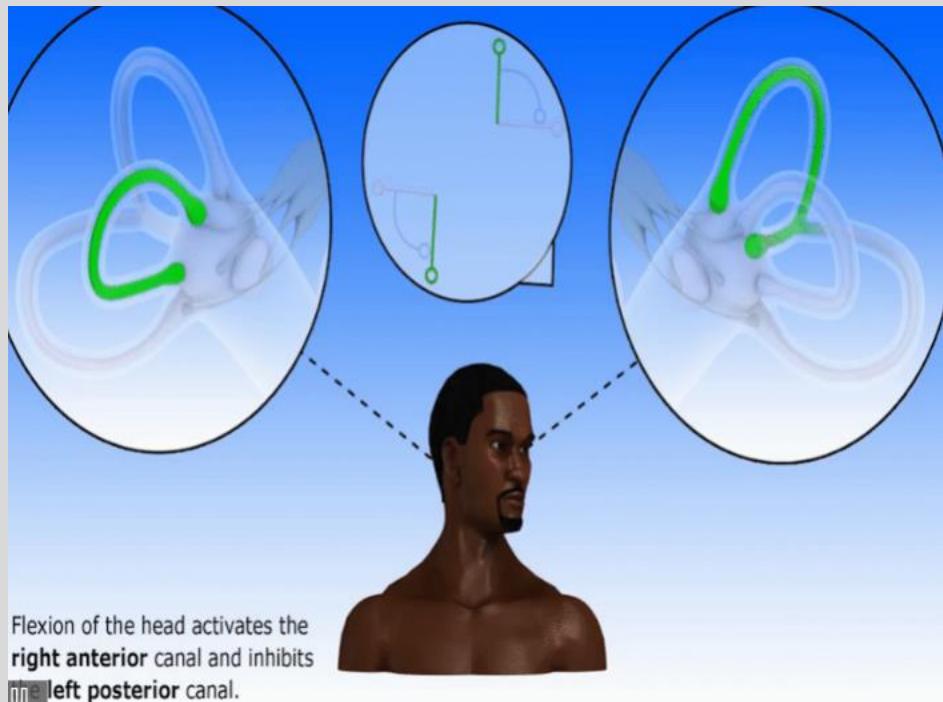
## Semicircular canals (SCC)

SCCs works as pairs with a contralateral SCC

Info from each pair determines head position in space

3 pairs of SCCs

1. right & left horizontal
2. right anterior & left posterior
3. left anterior & right posterior



Adapted from 3D Anatomy Lyon  
<https://www.youtube.com/watch?v=ZiFylfBWYoO>

# Vestibular Organ

## Semicircular canals (SCC)

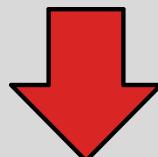
Head rotation moves endolymph in SCCs

Places uneven pressure on cupula, bending it

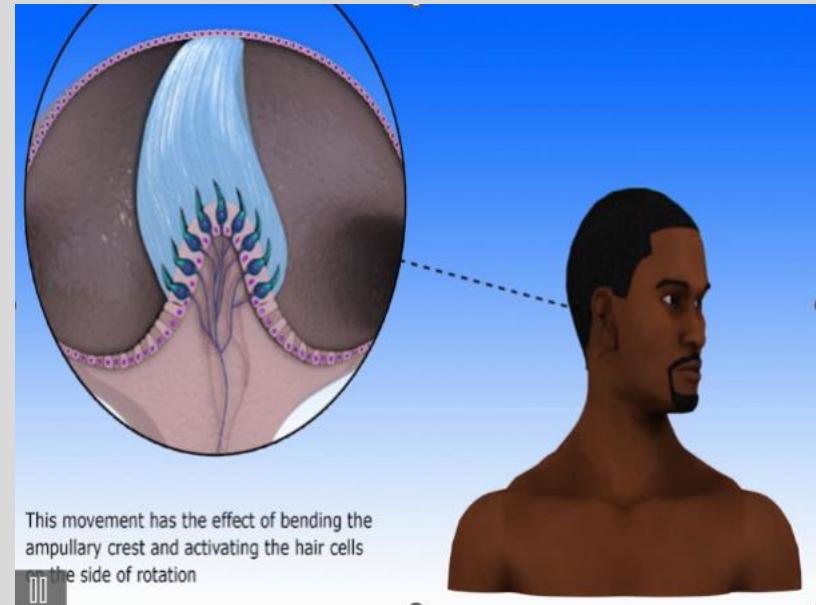
Bending of cupula results in:



Depolarizing afferent neurons on **turning** side



Hyperpolarizing afferent neurons on **opposite** side



Adapted from 3D Anatomy Lyon

<https://www.youtube.com/watch?v=ZiFyIfBWY0o>

Asymmetry of firing pattern determines which way the head is turning

# Cochlea

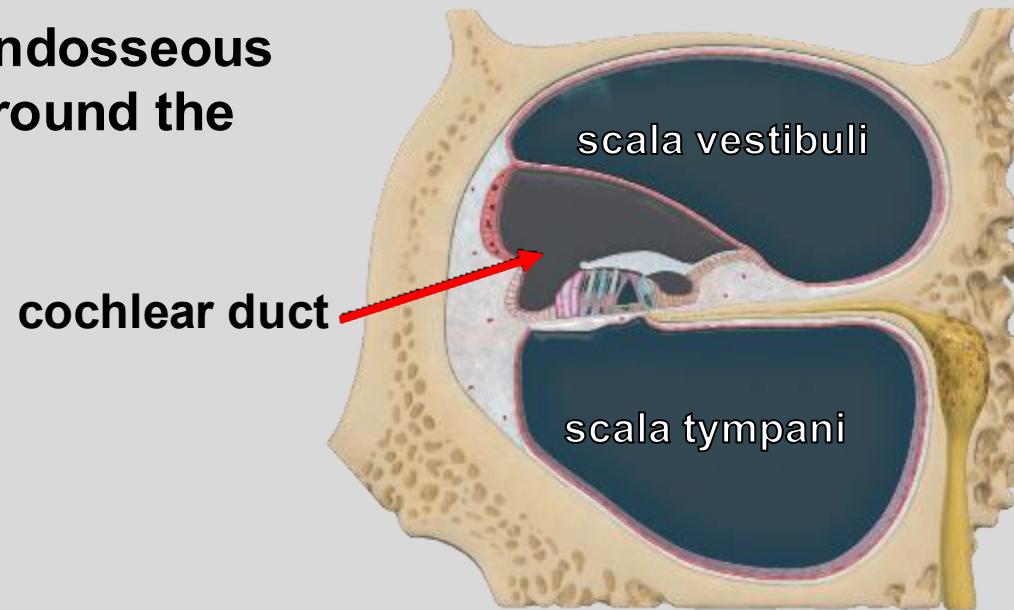
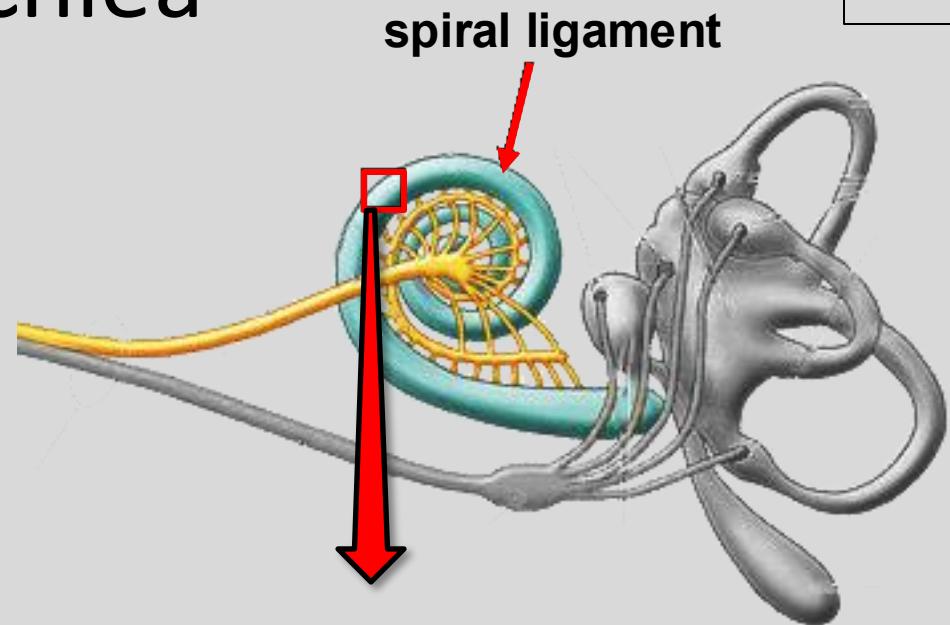
Cochlea is our spiral hearing organ

Hearing information is sent back on the cochlear nerve

The spiral ligament houses the cochlear duct

Spiral ligament splits the endosseous labyrinth into 2 channels around the cochlear duct

1. scala vestibuli
2. scala tympani



# Cochlea

## Organ of Corti

**Sensory unit of the cochlea**

**Stereocilia and endolymph composition are similar to rest of inner ear**

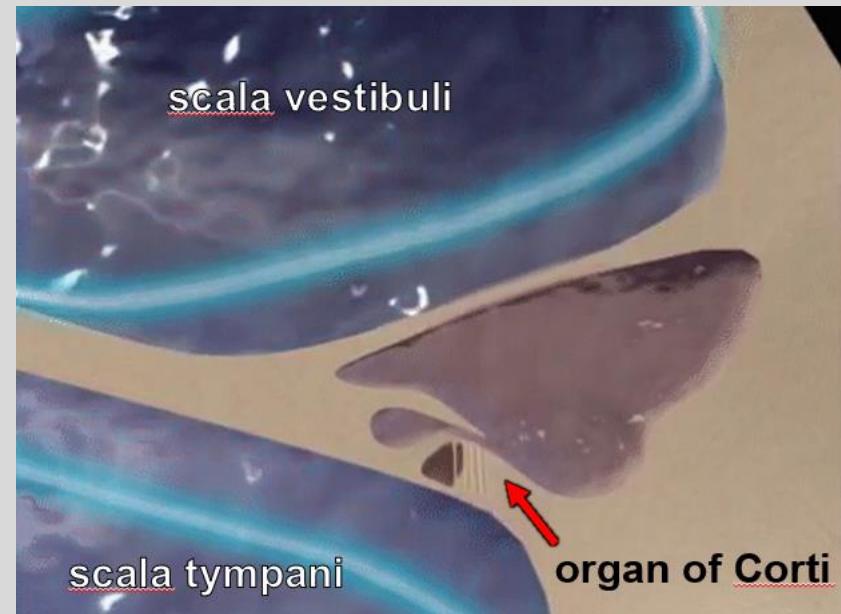
**Depolarization occurs at specific frequencies**

**Pressure wave is transferred from scala vestibuli to scala tympani**

**The remaining energy is released at the round window**

**Neuron activation occurs at different frequencies along the cochlea**

**Lower frequencies travel further up the spiral**



Brandon Pletsch

<https://www.youtube.com/watch?v=PeTriGTENoC>

# Hearing

## Clinical Correlates

### Hearing Loss

Can be congenital or acquired

#### Conductive hearing loss

Affects the *middle ear*

Result of damage to:

Tympanum — perforation / tear

Ear ossicles — scarring from prolonged  
inflammation

People speak softly thinking they are loud

Can be treated surgically or with a hearing aid



# Hearing

## Clinical Correlates

### Hearing Loss

Can be congenital or acquired

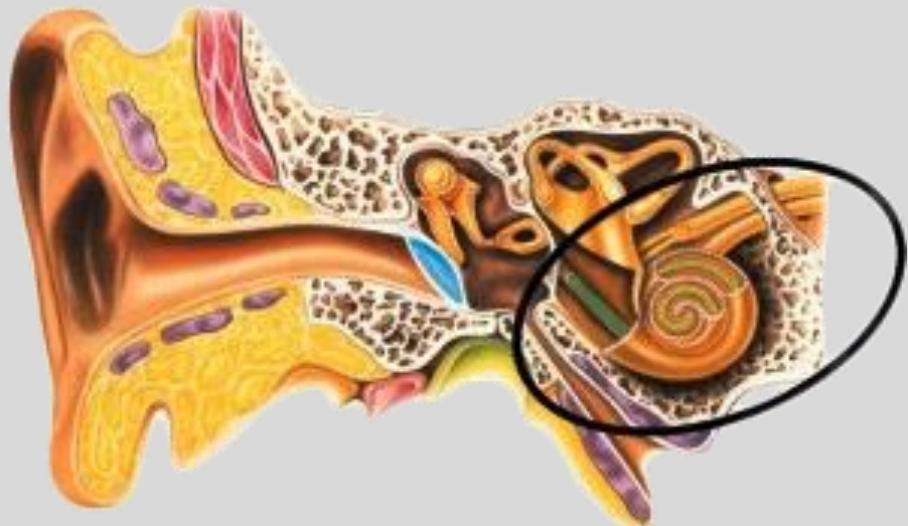
### Sensorineural hearing loss

Affects the *inner ear*

Result of damage to:

stereocilia ("hair" cells)

cochlear nerve or associated brain relays



Cochlear implants used, but reclaimed sound is still crude

# Hearing

## Clinical Correlates

### Tinnitus

Affects 15–20 % of U.S. population

Age-related loss of “hair” cells along cochlea

Loss is often at higher frequencies

Ringing sensation whenever brain “checks” those frequencies



Symptom of some other causes such as:

excessive noise (construction sites, concerts)

side-effect of some drugs

Ringing is constant and often without a stimulus

# Hearing

## Clinical Correlates

Sensorineural hearing loss has increased 30% in the past 20 years

Ear buds are likely to blame as they don't form a tight seal around the ear

Sound leakage is countered by increasing volume to deceptively dangerous levels

The screenshot shows the homepage of the American Osteopathic Association (AOA) website. The top navigation bar includes links for "Members", "Academic Physicians", "Practicing Physicians", "Liai + Cancer", "CME", "About AOA", and "Home". The main banner features a young girl wearing headphones and looking at a tablet, with the text "Headphones & Hearing Loss". Below the banner, there is a sidebar with links to "What is Osteopathic Medicine?", "What is a DO?", "Osteopathic Manipulative Treatment", "The Benefits of Yoga", "Right Benefits", "Headphones & Hearing Loss", and "Ingestion". The main content area contains an article titled "Is anyone listening? Monitoring your teen's headphone volume can help avoid hearing loss". The article discusses how parents might find themselves asking their children to remove their headphones, and it highlights that today's teenagers are exposed to louder sounds from headphones than those from 20 years ago. It also notes that the increase in hearing loss is due to increased use of headphones.

<https://osteopathic.org/what-is-osteopathic-medicine/headphones-hearing-loss/>

# Hearing

## Clinical Correlates

### Benign Paroxysmal Position Vertigo (BPPV)

Occurs when otoliths break free from utricle

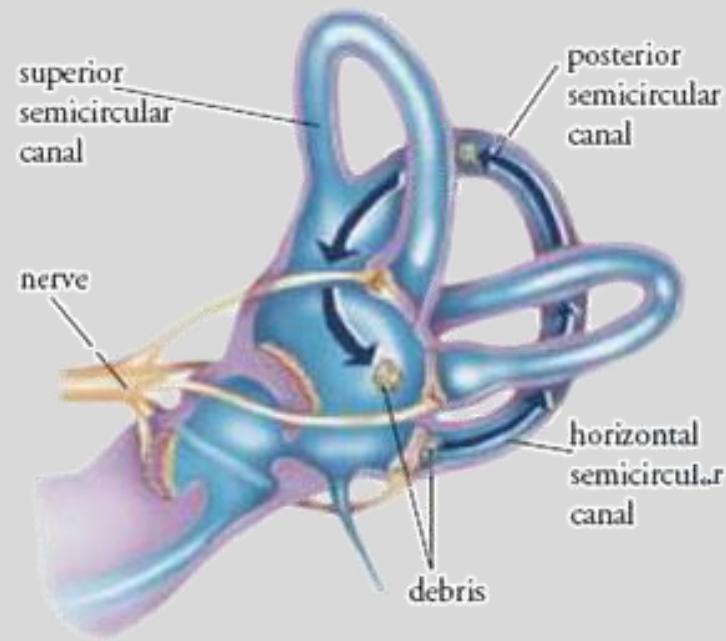
Free-floating otoliths enter SCC producing conflicting signals to the brain about head orientation

BPPV has multiple causes

blunt trauma to head

age-related weakening of tissue

idiopathic (most common)



# Hearing

## Clinical Correlates

### Benign Paroxysmal Position Vertigo (BPPV)

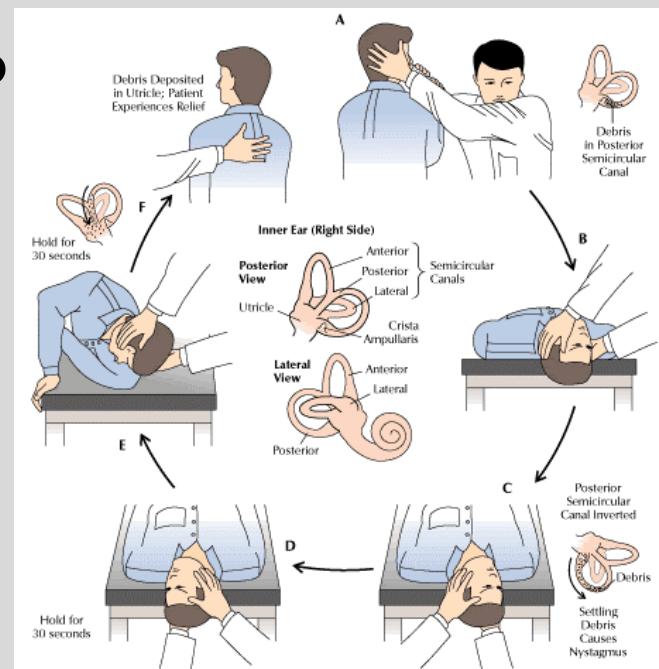
**Patients experience intense, debilitating vertigo**

**Vertigo lasts anywhere from minutes to months**

**BPPV usually resolves on its own via otolith resorption**

**Canalith repositioning (Epley Maneuver)**

**Surgery**



**Epley maneuver**

# Coupled Senses

**Coupled senses = 2 or more senses that work together to perform a new function**

## Vestibulo-ocular reflex

**Provides gaze stabilization**

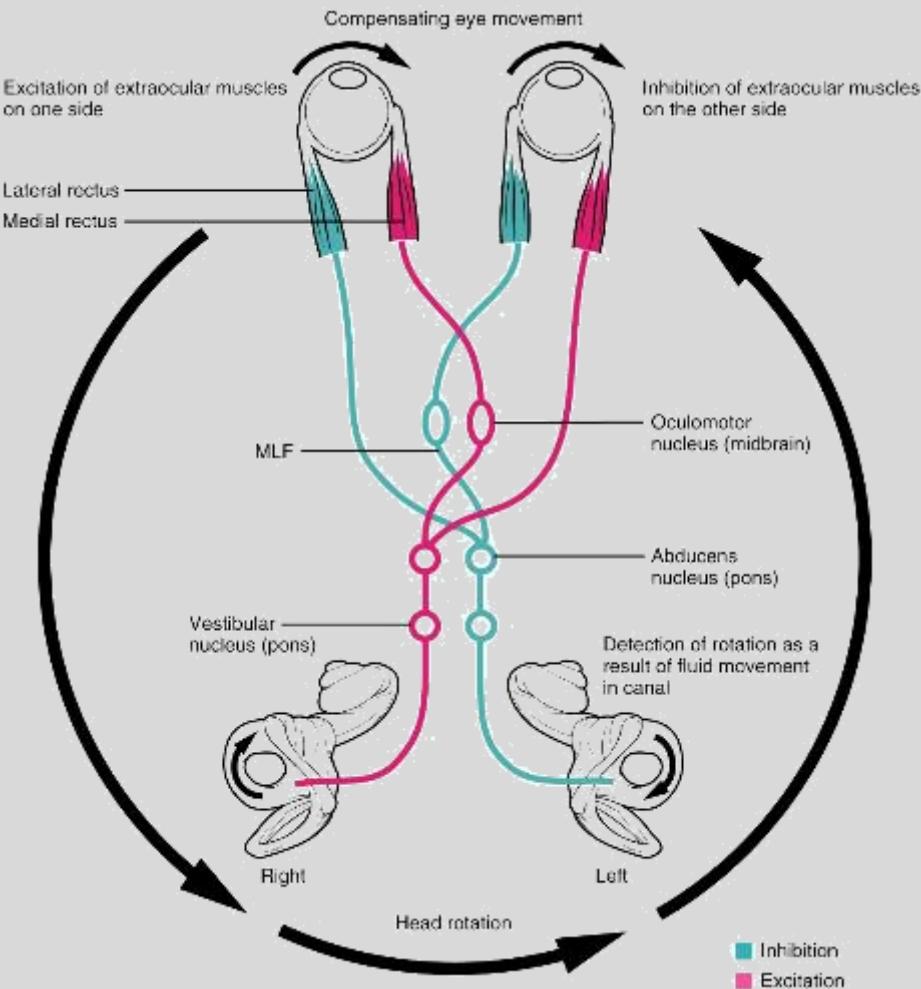
**Couples the vestibular system with the eyes**

**Afferent limb: vestibulocochlear**

sends balance information to specific nuclei in the brain

**Efferent limb: CNs III, IV, VI**

Extraocular muscles move eyes to compensate for head position



# Coupled Senses

## Vestibulo-ocular reflex

This reflex extends into the neck muscles of birds

Providing for this dramatic example of gaze stabilization



# Coupled Senses

## Clinical Correlate

### Nystagmus

**Result of a delay in the vestibulo-ocular reflex**

#### Acquired nystagmus

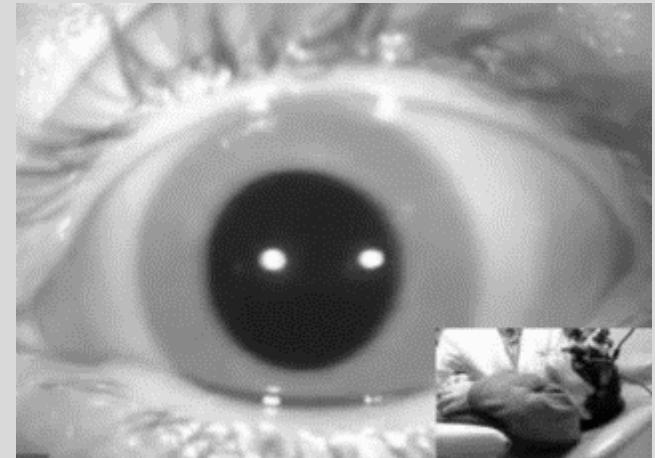
alcohol

drug use (opiates, barbiturates, marijuana)

#### Congenital nystagmus

heritable trait (recessive)

results in resting nystagmus



Michael Teixido MD

<https://www.youtube.com/watch?v=zeuYnPUv5YU>

**Often benign, but rare debilitating cases can be treated pharmacologically**