

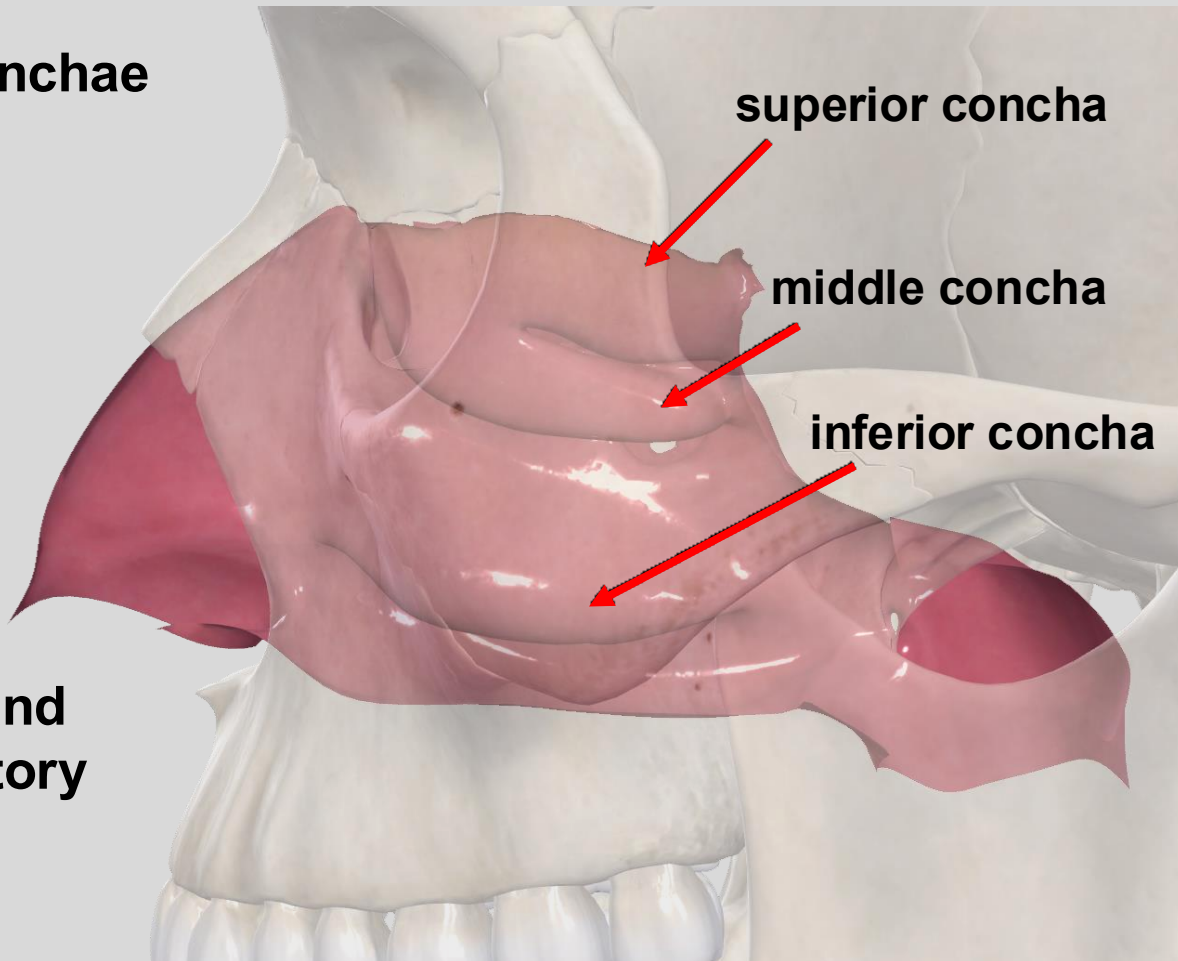
# Olfactory

5

## **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

12

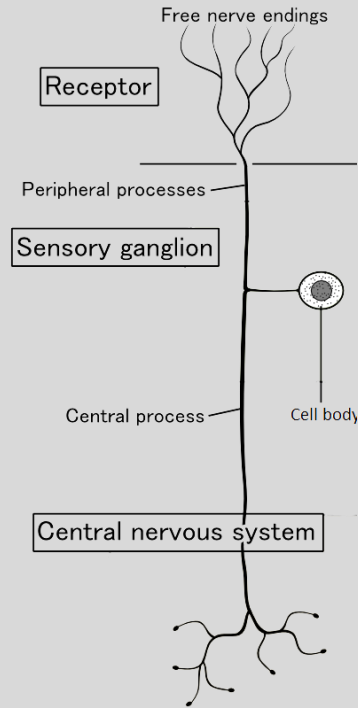
**Spicy is not a true taste but more of a neurological phenomenon**

**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

18

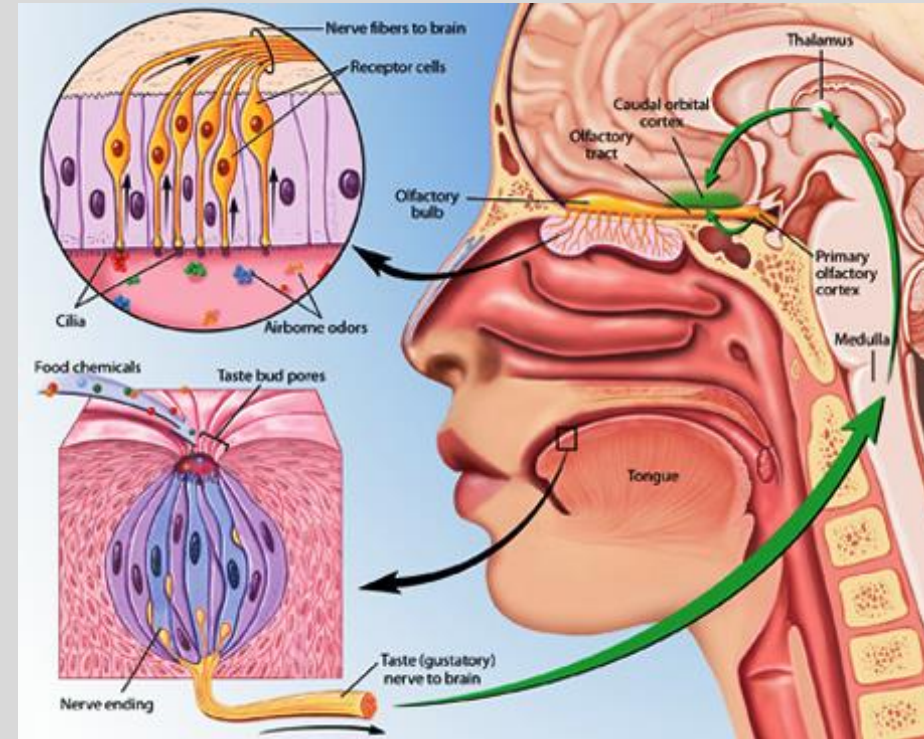
**Coupled senses = 2 or more senses that work together to perform a new function**

**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.  
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# Vision

2

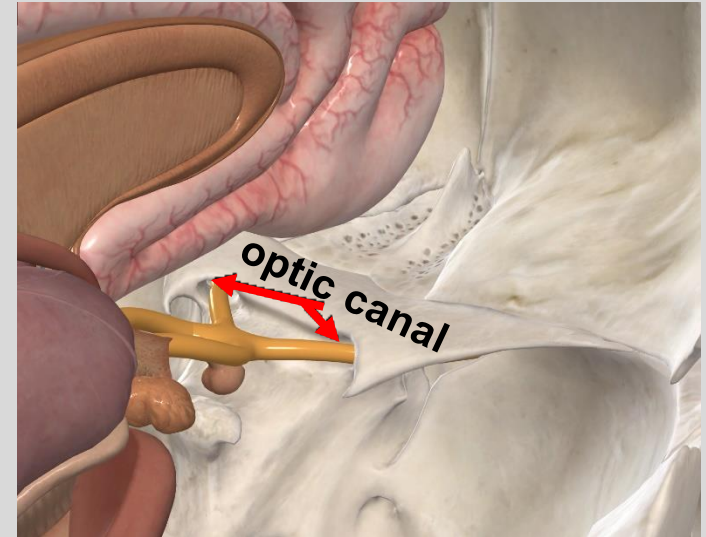
**The most important special afferent  
in our body**

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

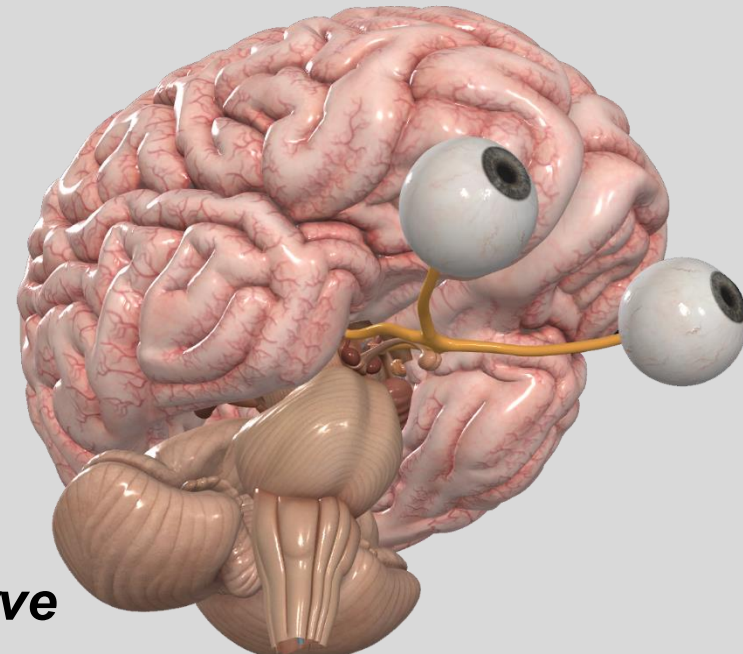
**Optic nerve is an anterior extension  
of the forebrain**

**Optic nerve *exits the endocranium*  
through the optic canal**

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



**superolateral view**

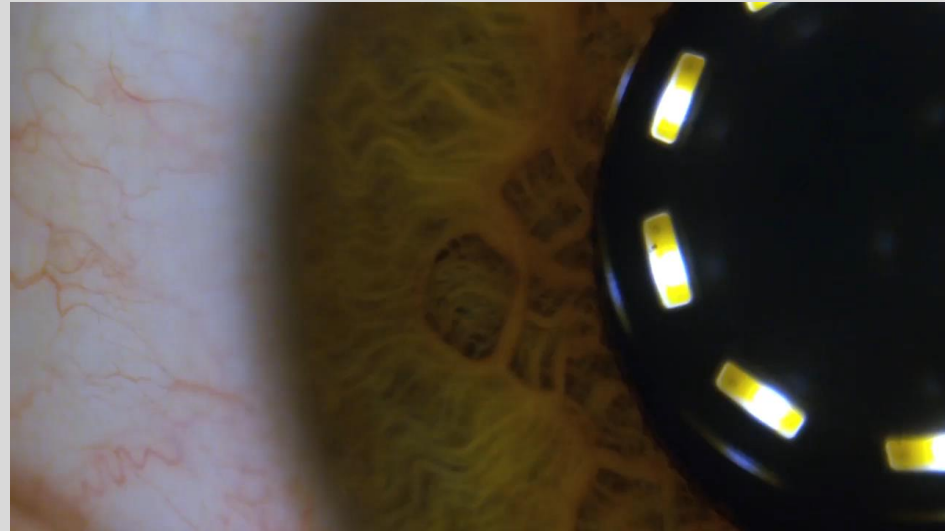


## Vascular Layer

## Movies

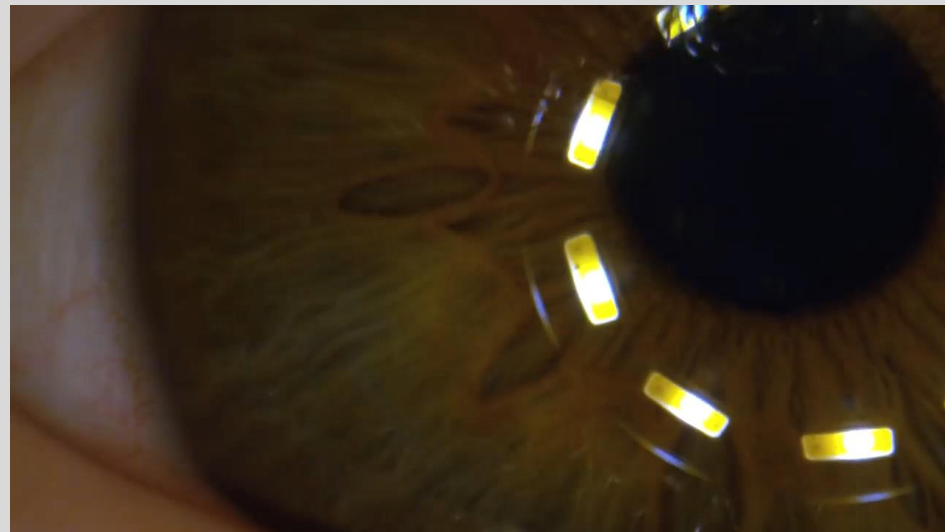
### **sphincter pupillae**

circular fibres  
parasympathetic  
fast contraction



### **dilator pupillae**

radial fibres  
sympathetic  
“slow” contraction



Slow Mo Guys

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

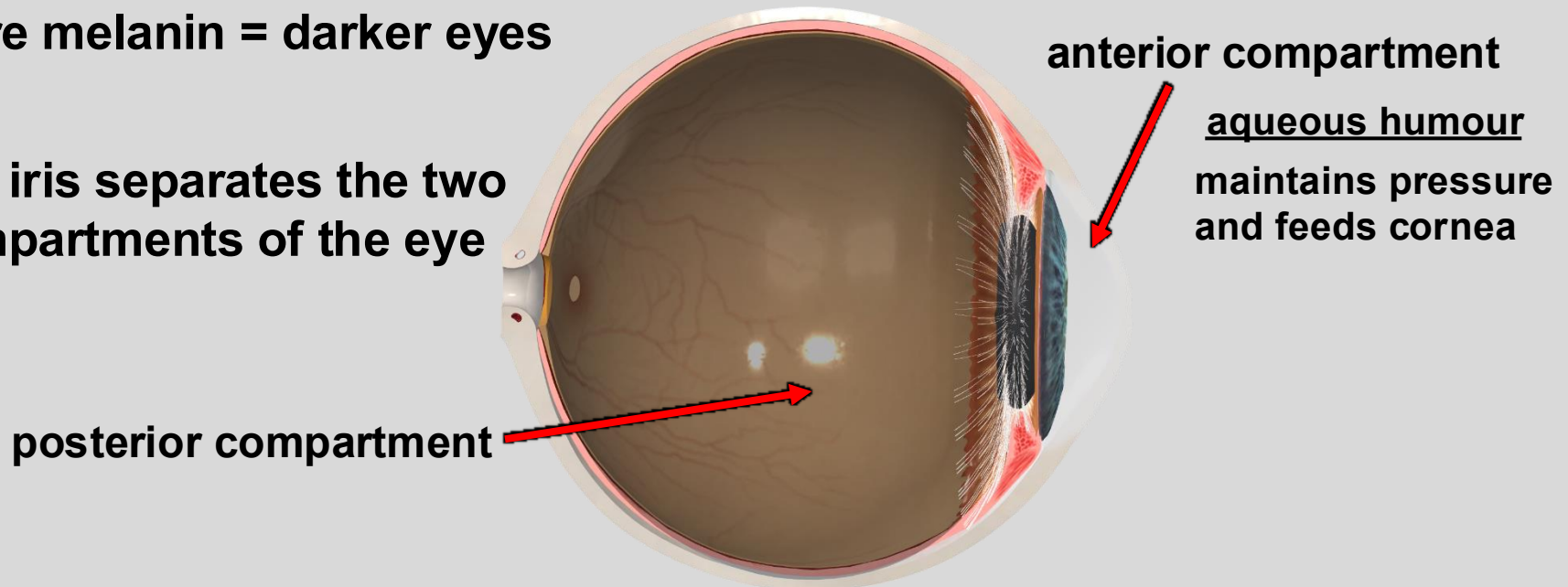
## Vascular Layer: Iris

**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

fovea centralis

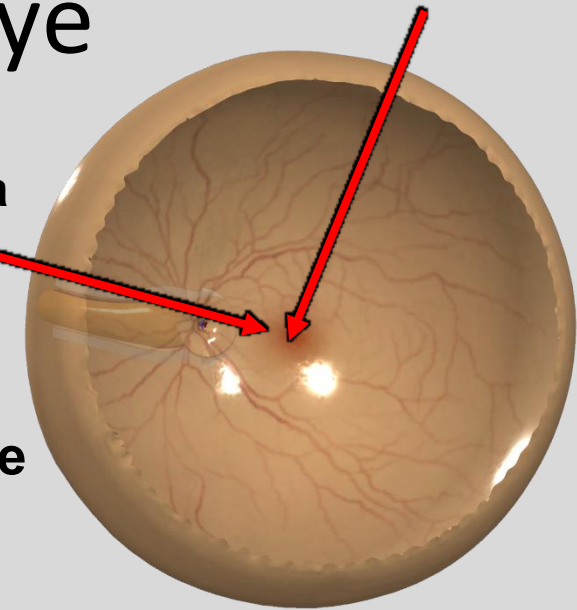
15

## 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)



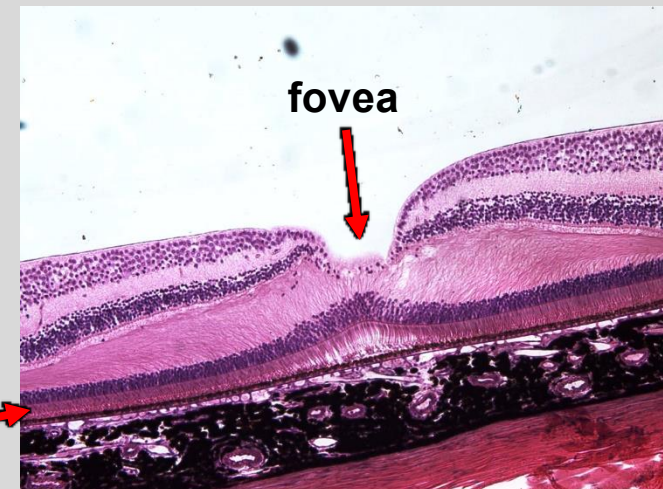
anterior view  
(retina only)

## Foveation

Focusing on an object by moving the image onto the fovea

non-photoreceptive cells

photoreceptors



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

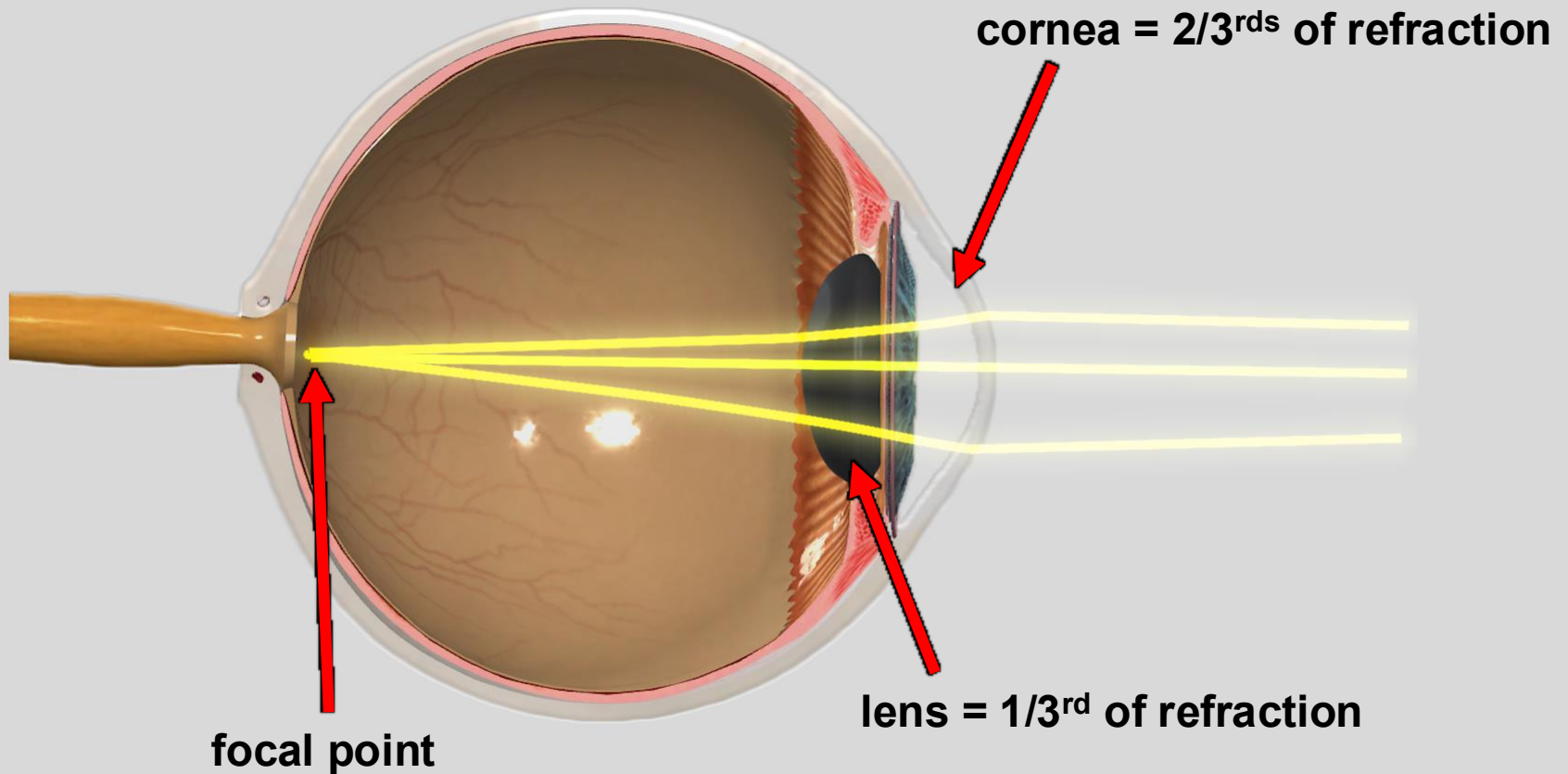
Latin: *fovea* = small pit + *centralis* = center

# Vision: The Eye

17

## Accommodation

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



# Vision: The Eye

18



**dissected lens  
(cow)**

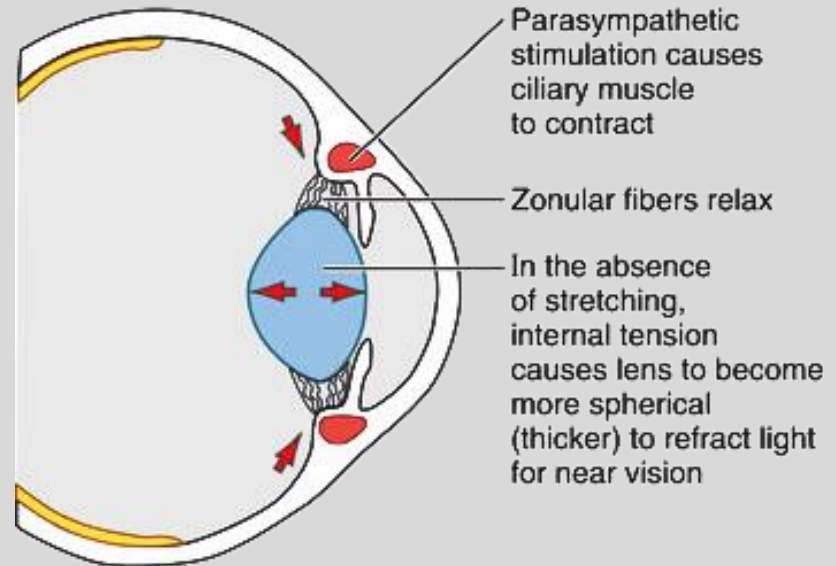
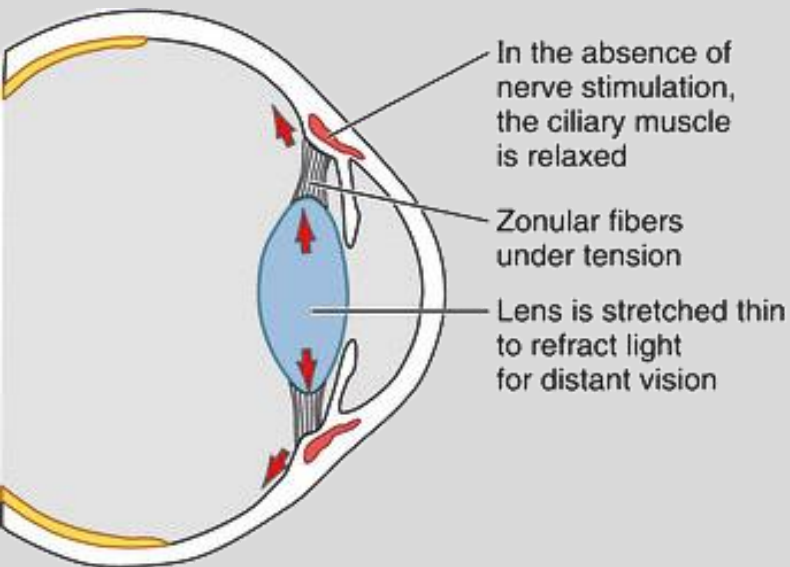
## Accommodation

**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**

## Accommodation

Accommodation is counterintuitive

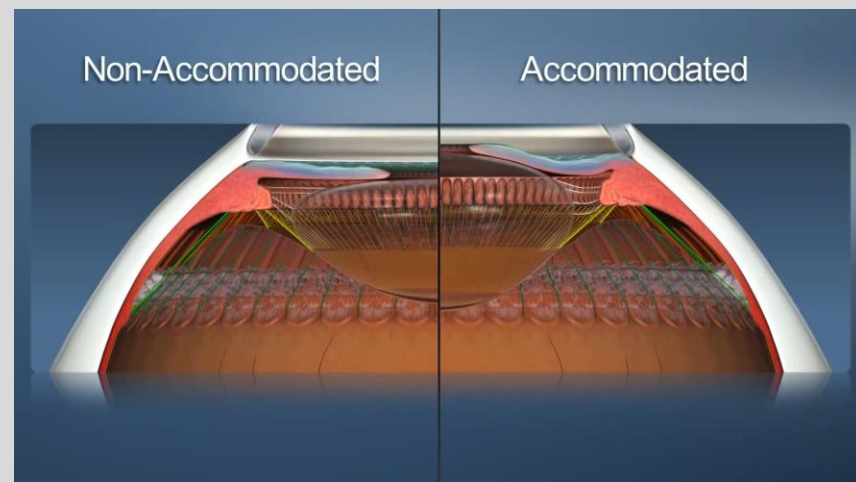
Changing lens shape (stretching) is a passive process

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=1yIpyitm6eE>

# Vision: The Eye

## Clinical Correlates

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### **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

23

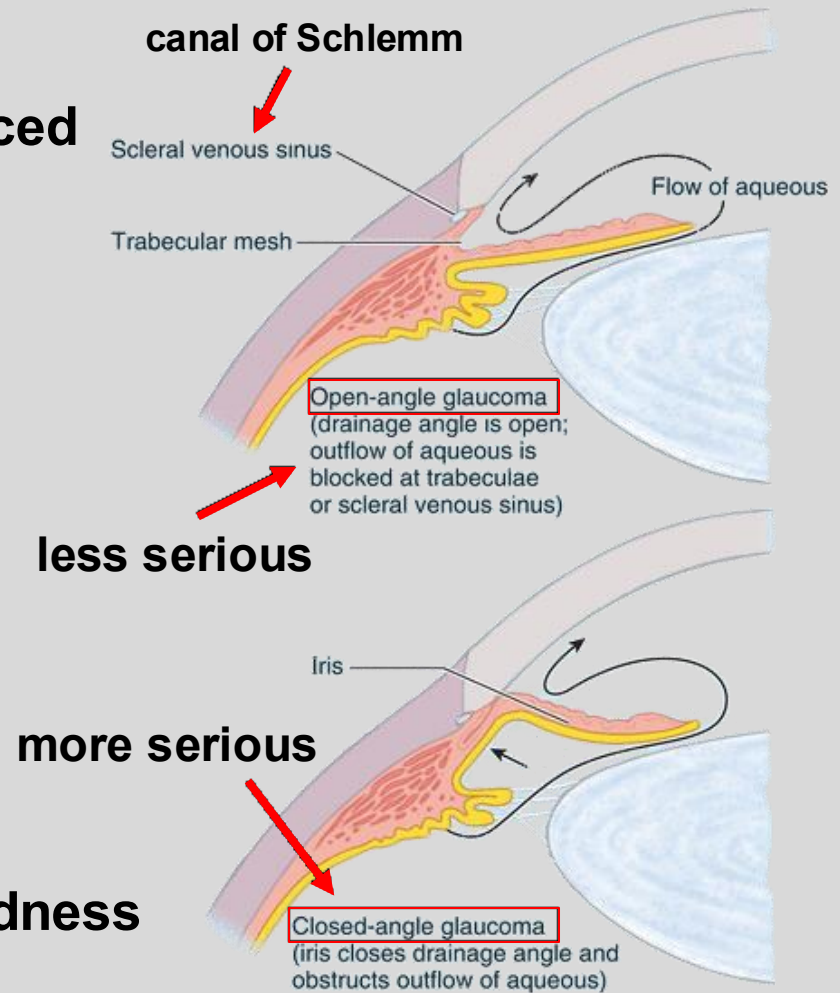
### **Glaucoma**

**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

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### Retinal detachment

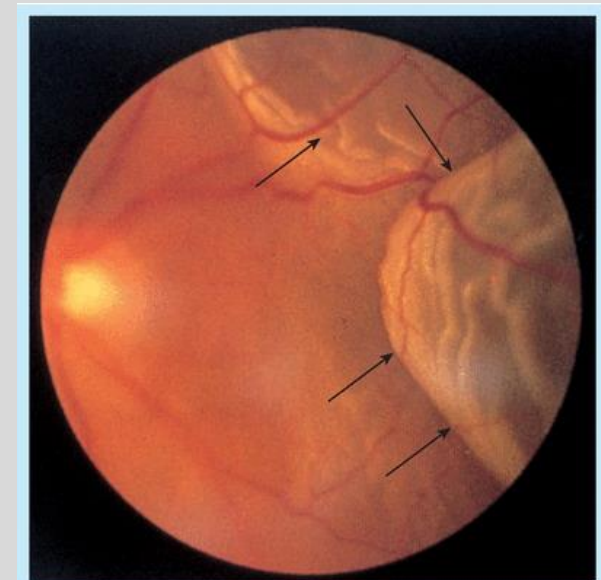
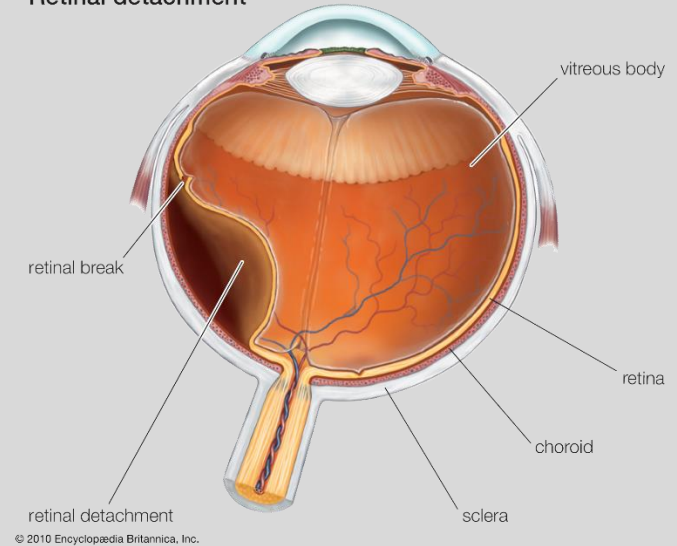
**Neural layer of retina requires ocular pressure to maintain attachment to choroid**

**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**

Retinal detachment



Ophthalmoscopic view (arrows, wrinkles in detached retina)

## Hearing and Balance (CN VIII)

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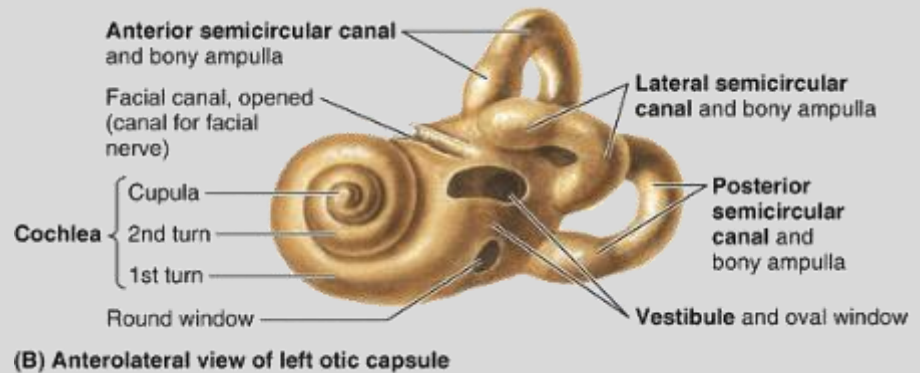
# Otic Capsule

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

## endosseous (bony) labyrinth

**Filled with perilymph**

Same constituency as  
extracellular fluid



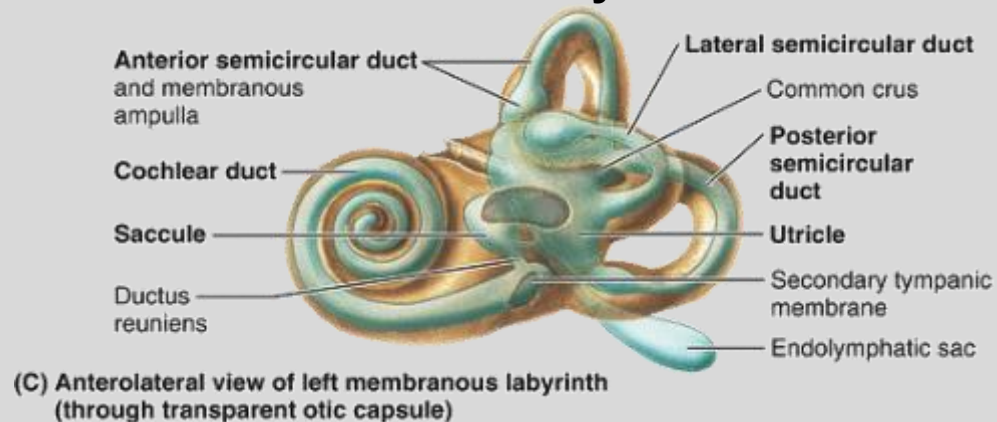
**Deep to the bony labyrinth is the membranous labyrinth**

## membranous labyrinth

**This is the physiologically active part of the inner ear**

**Filled with endolymph**

Same constituency as  
intracellular fluid



# Vestibular Organ

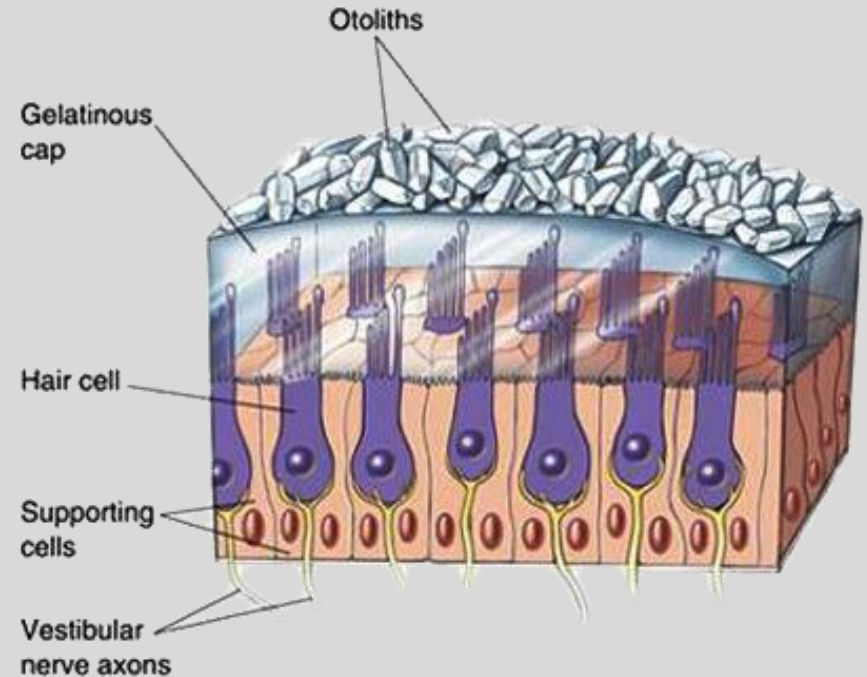
5

## Otolith organs

Greek: *oûs* = ear + *líthos* = stone

Otoliths are small calcifications

They give weight to the utricle and saccule



# Vestibular Organ

6

## Otolith organs

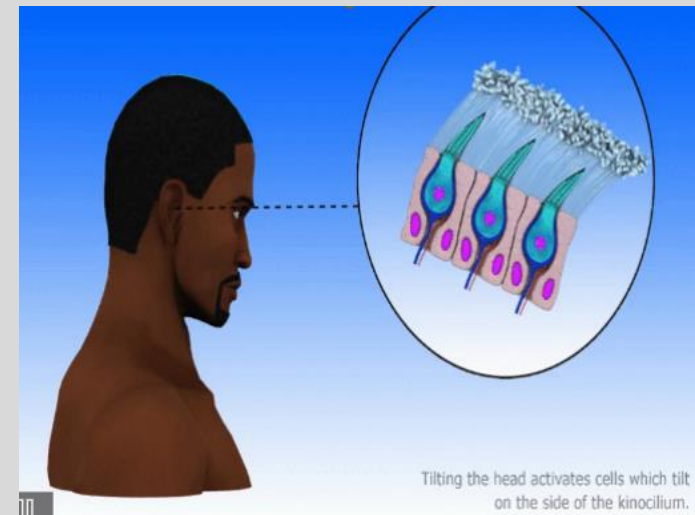
### Utricle

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=ZiFyIfBWY0o>

# Vestibular Organ

## Otolith Organs

7

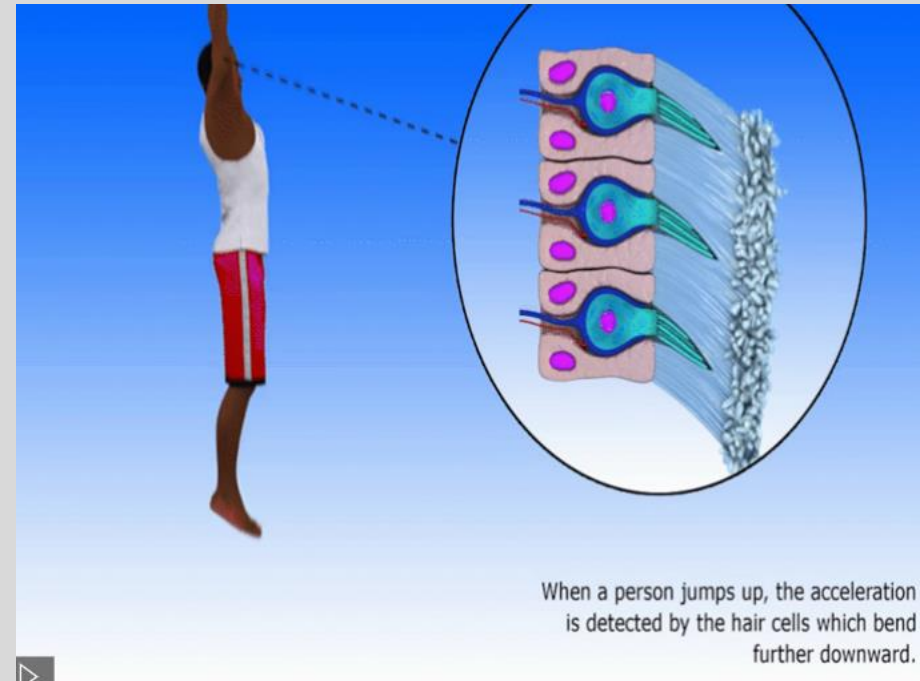
### Otolith organs

#### Saccule

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

Senses vertical acceleration

Functions as our gravity sensor



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

# Vestibular Organ

8

## Semicircular canals (SCC)

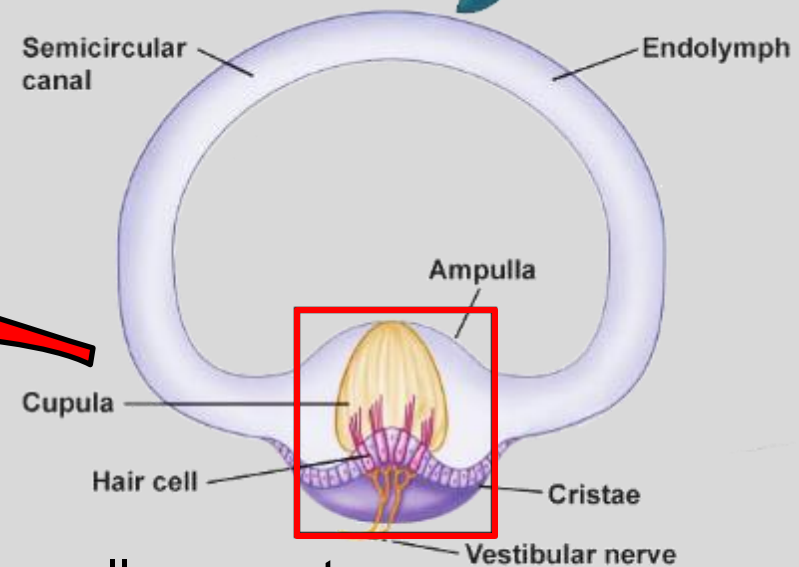
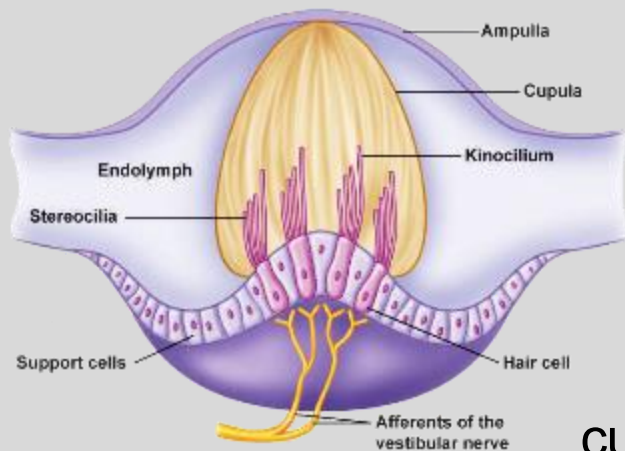
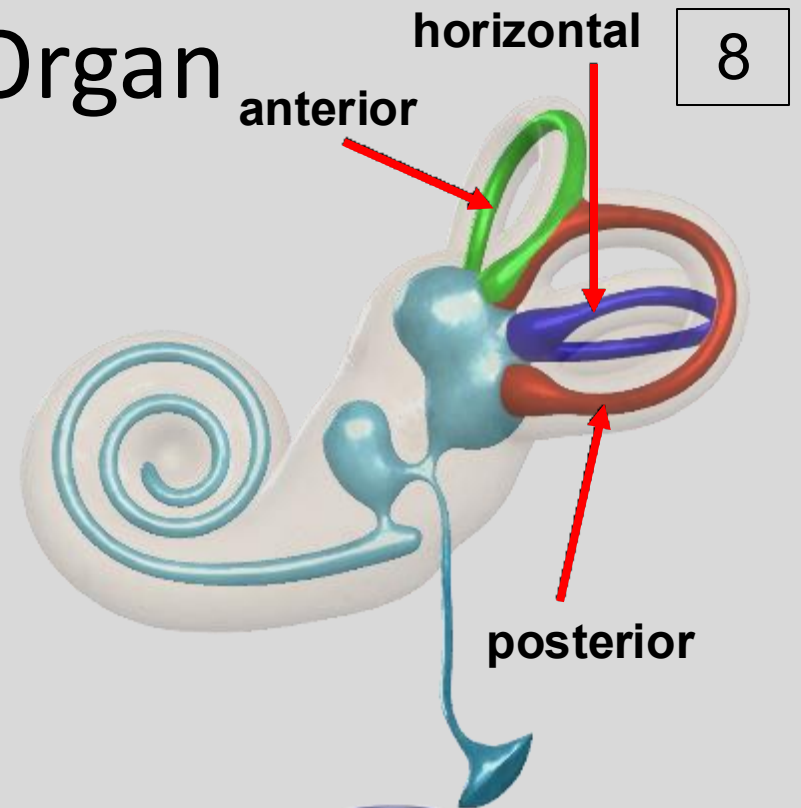
Provide head orientation information

## 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

9

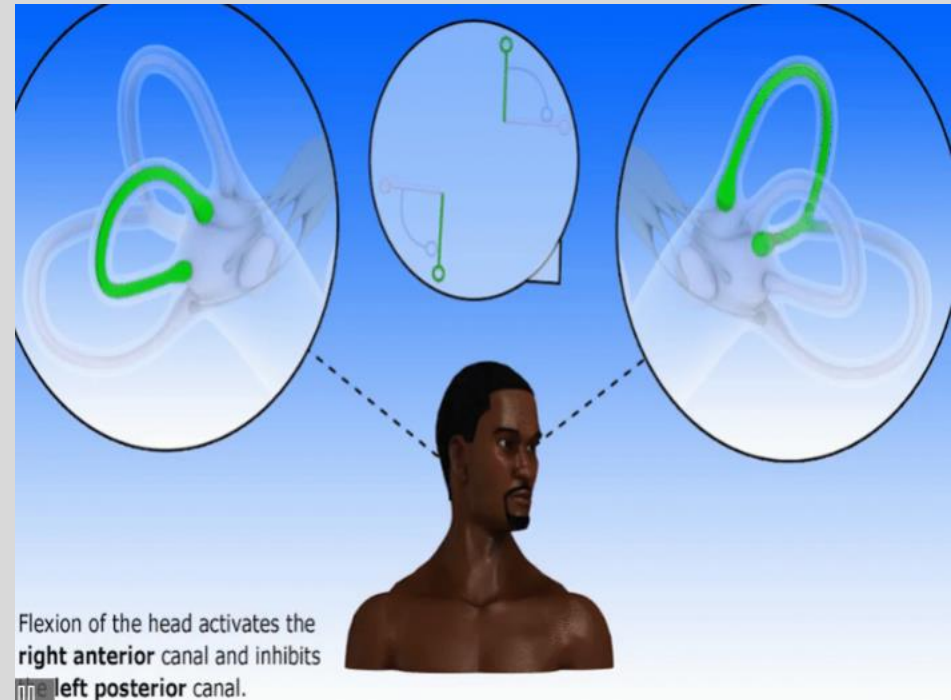
## Semicircular canals (SCC)

**SCCs work 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=ZiFylfBWY0o>

# Vestibular Organ

10

## 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

Asymmetry of firing pattern determines which way the head is turning



Adapted from 3D Anatomy Lyon  
<https://www.youtube.com/watch?v=ZiFylfBWY0o>

# Cochlea

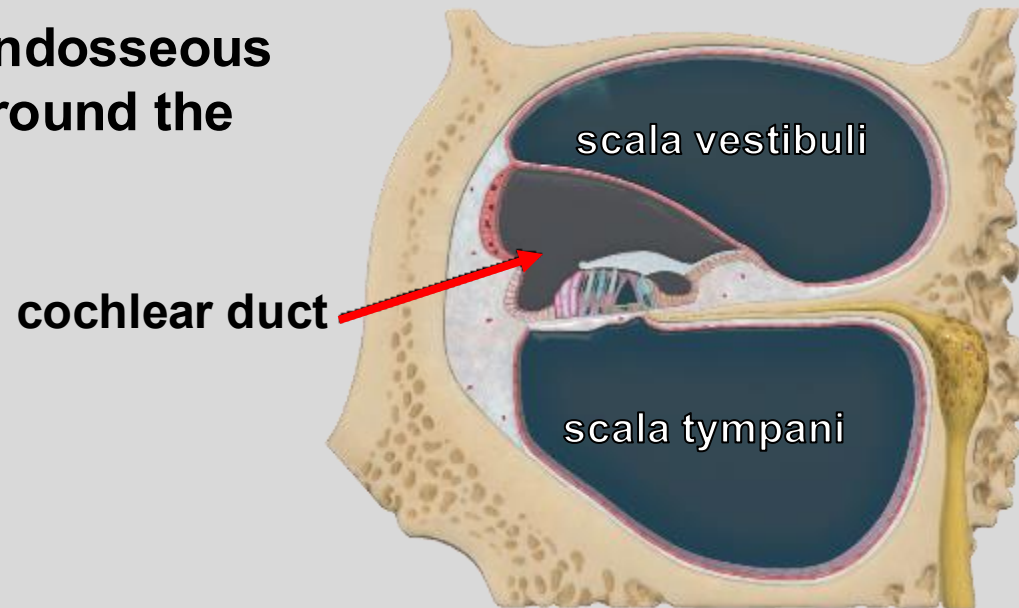
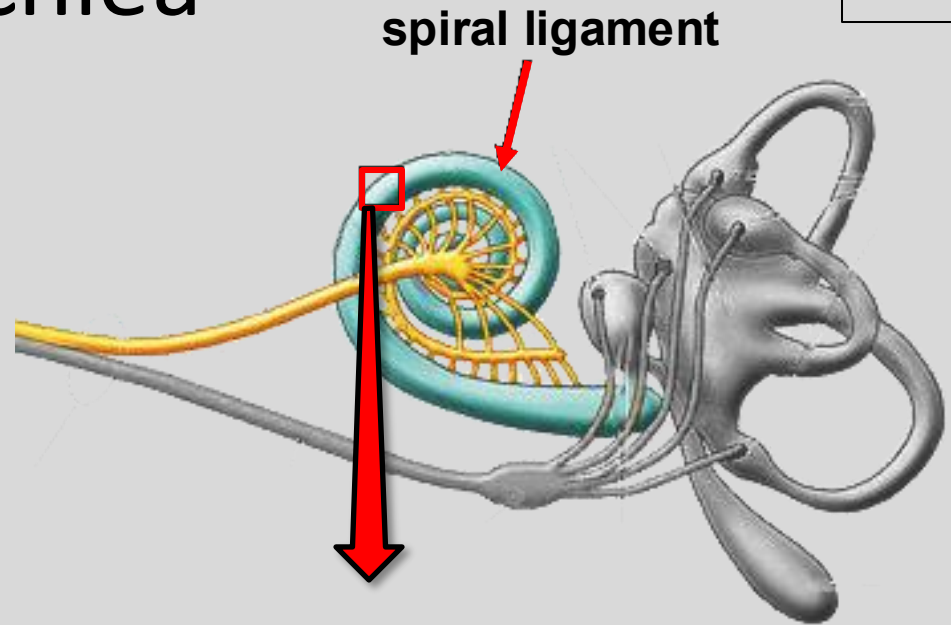
**Cochlea is our spiral hearing organ**

**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



## Organ of Corti

**Sensory unit of the cochlea**

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

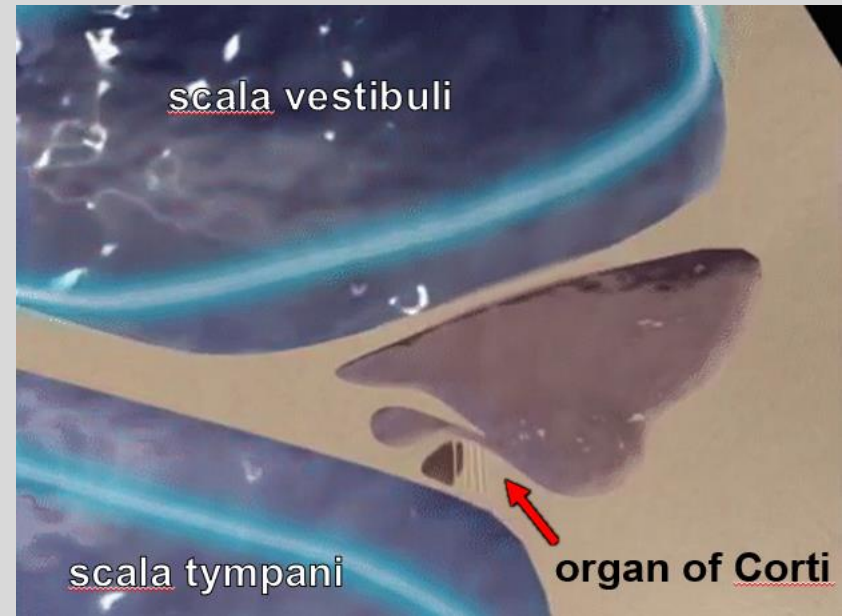
**Depolarization occurs at specific frequencies**

**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**

**Ringling sensation whenever brain “checks” those frequencies**



**Symptom of some other causes such as:**

excessive noise (construction sites, concerts)

side-effect of some drugs

**Ringling 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**



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

# Hearing

## Clinical Correlates

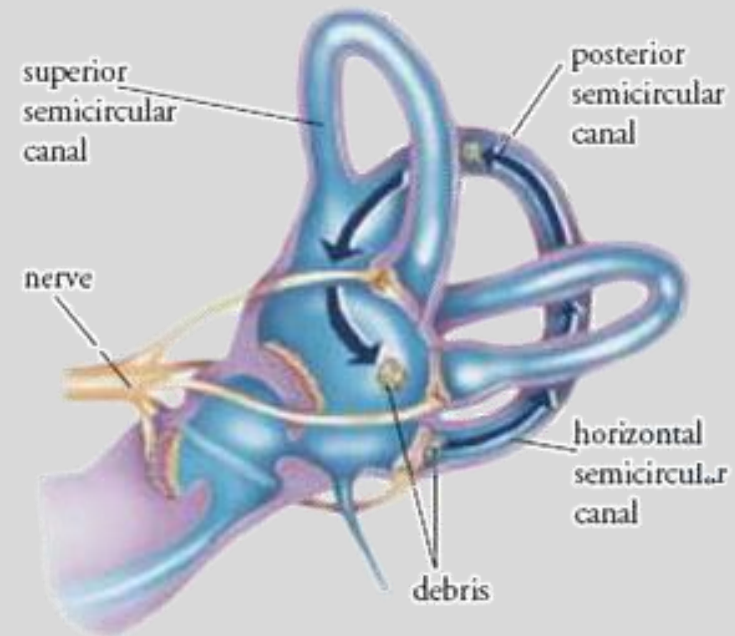
### Benign Paroxysmal Position Vertigo (BPPV)

**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)

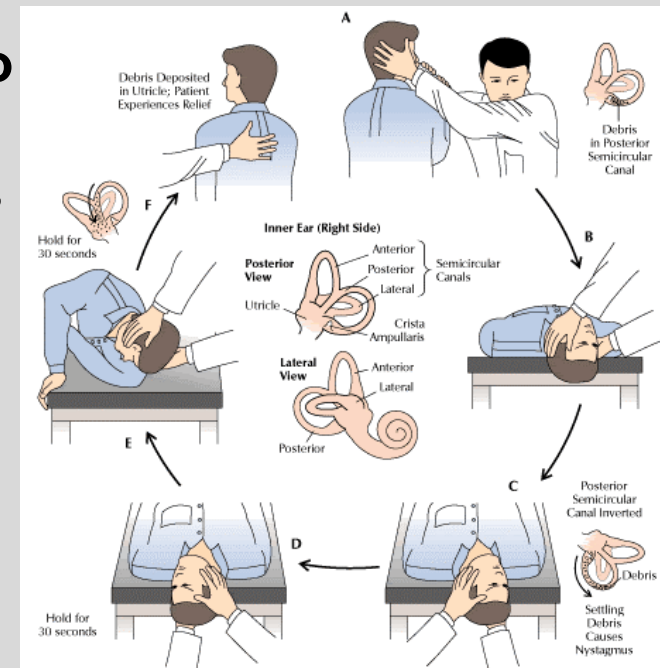
Patients experience intense, debilitating vertigo

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**

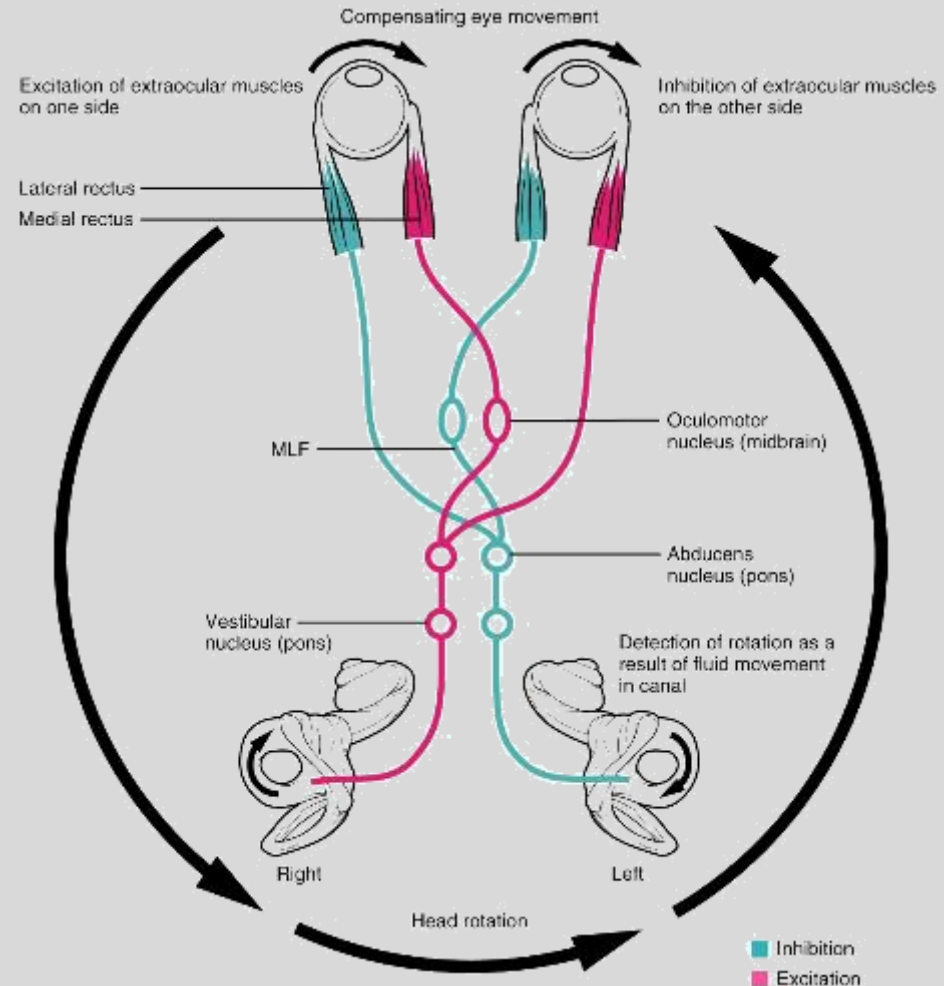
**Couples the vestibular system with the eyes**

**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

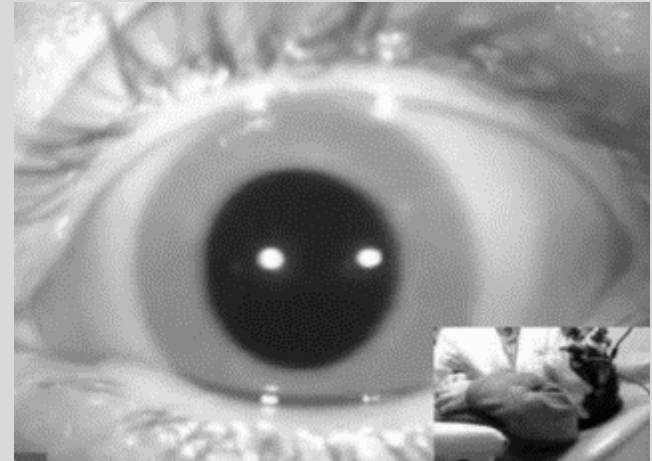
drug use (opiates, barbiturates, marijuana)

#### Congenital nystagmus

heritable trait (recessive)

results in resting nystagmus

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



Michael Teixido MD

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