## Smell and Taste

(CN I) (CNs VII, CIX, CNX)

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**

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

# Olfactory



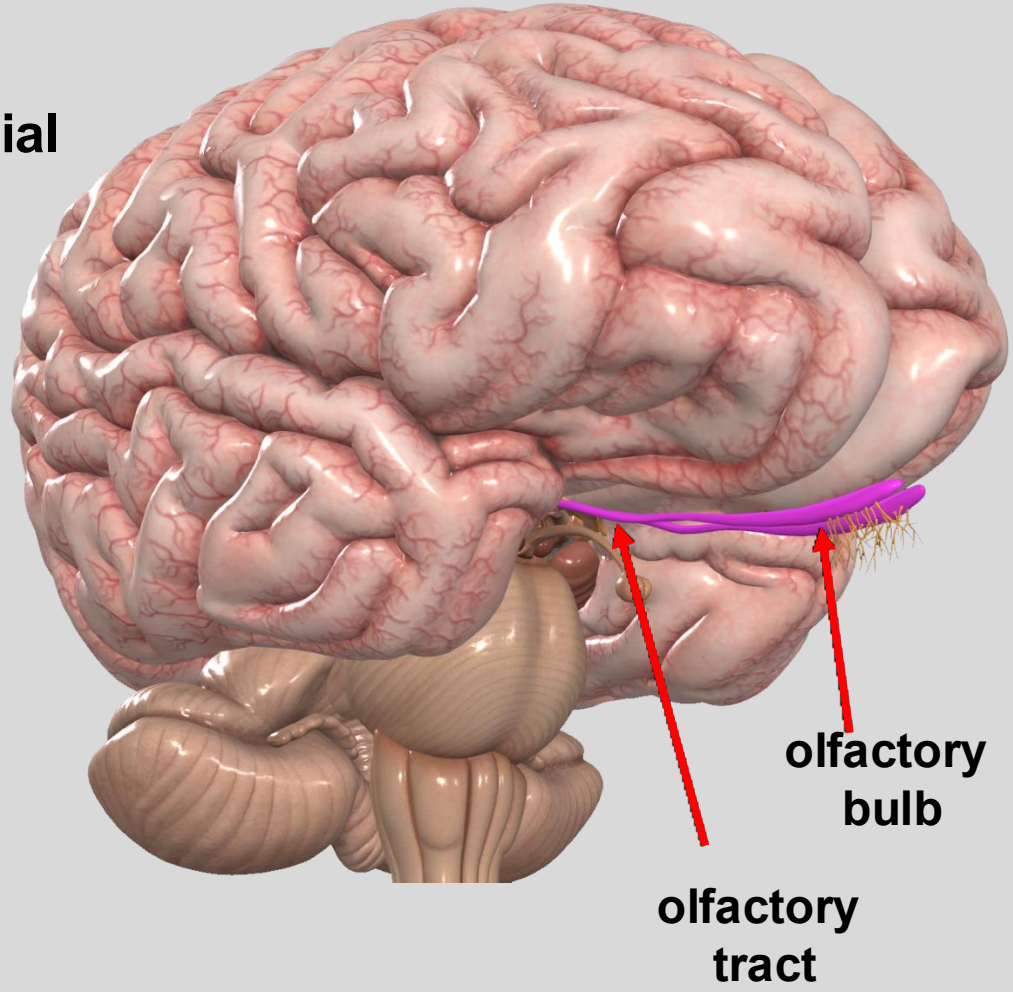
**Olfaction is the least studied cranial nerve**

**Olfactory stalk**

olfactory tract

olfactory bulb

**Olfactory "nerve" is an anterior extension of the forebrain**



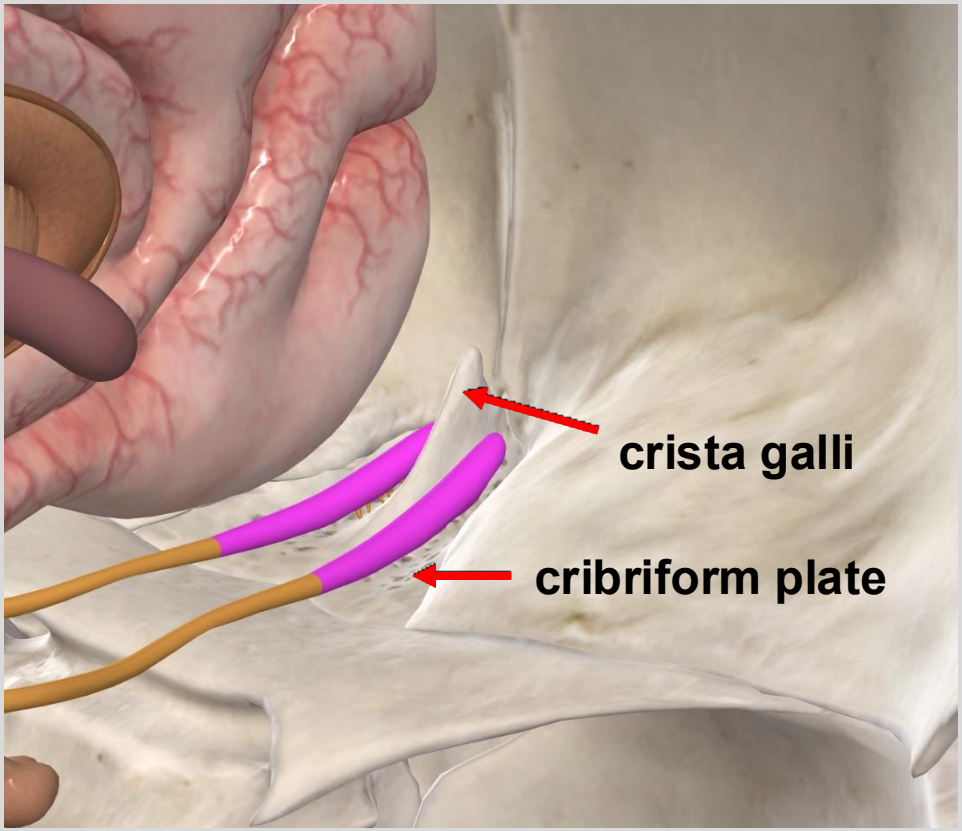

**anterolateral view**

# Olfactory



**~10 nerves / bulb *exit endocranium* through the cribriform plate**

**The nerves end in the mucosa of the superior part of the nasal cavity**

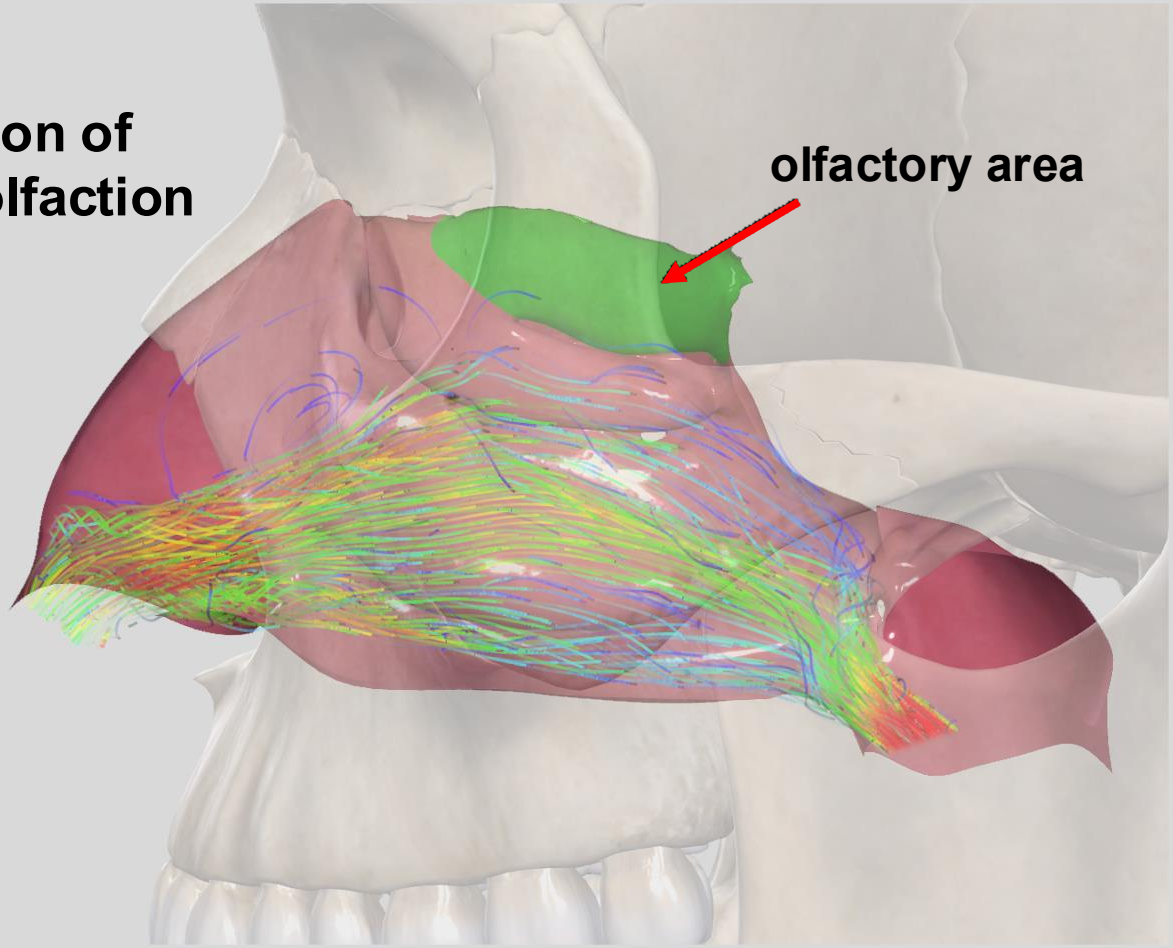



**superolateral view**

# Olfactory



**Only the superior-most portion of the nasal passage handles olfaction**



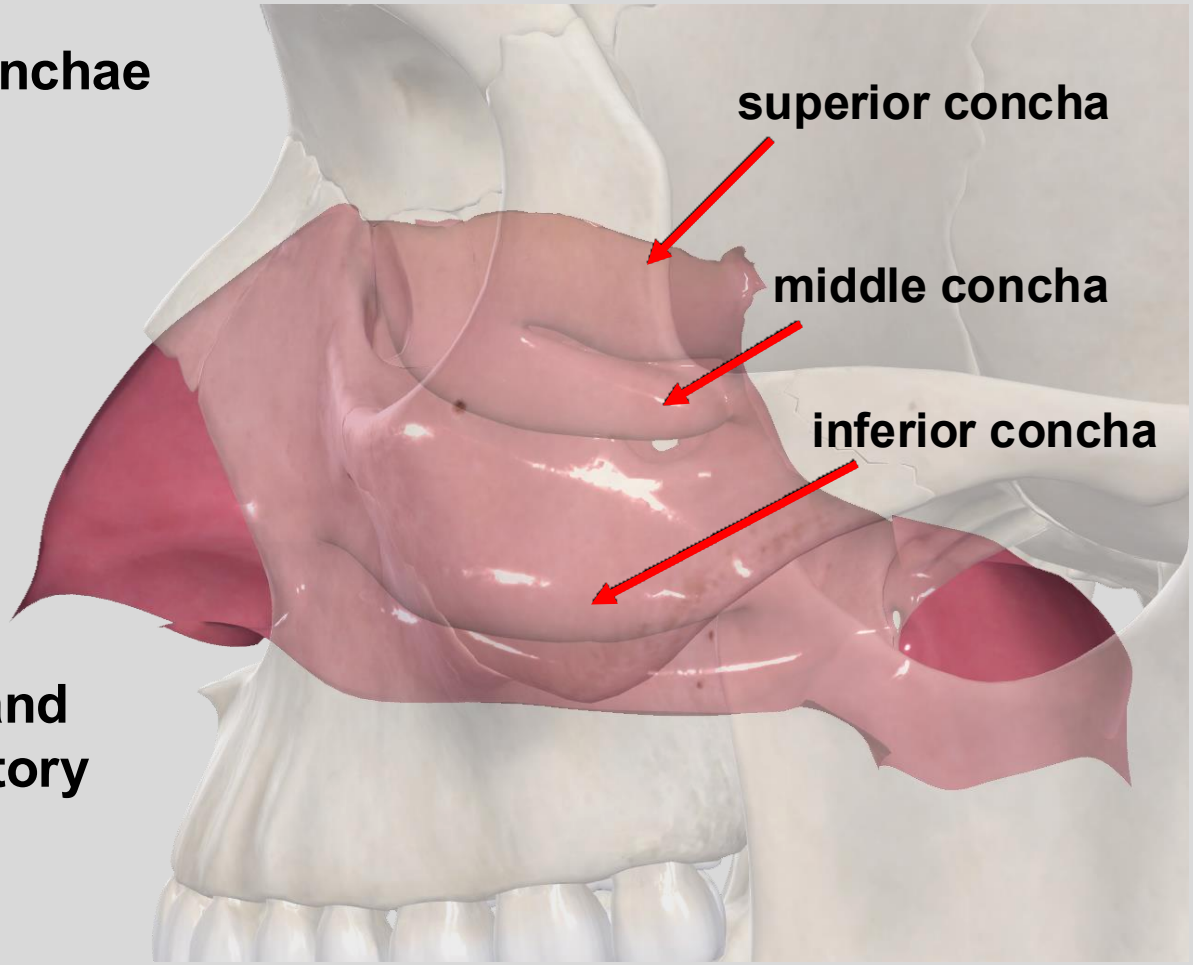

**Most of the nasal passage functions in head thermoregulation and water loss**

# Olfactory



**Nasal passage houses 3 conchae**

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

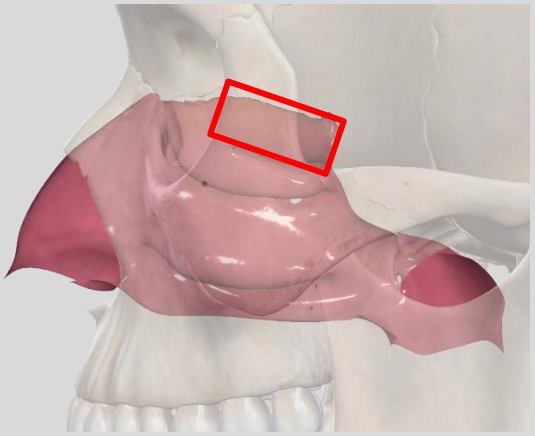



**Only the superior concha and adjacent walls house olfactory epithelia**

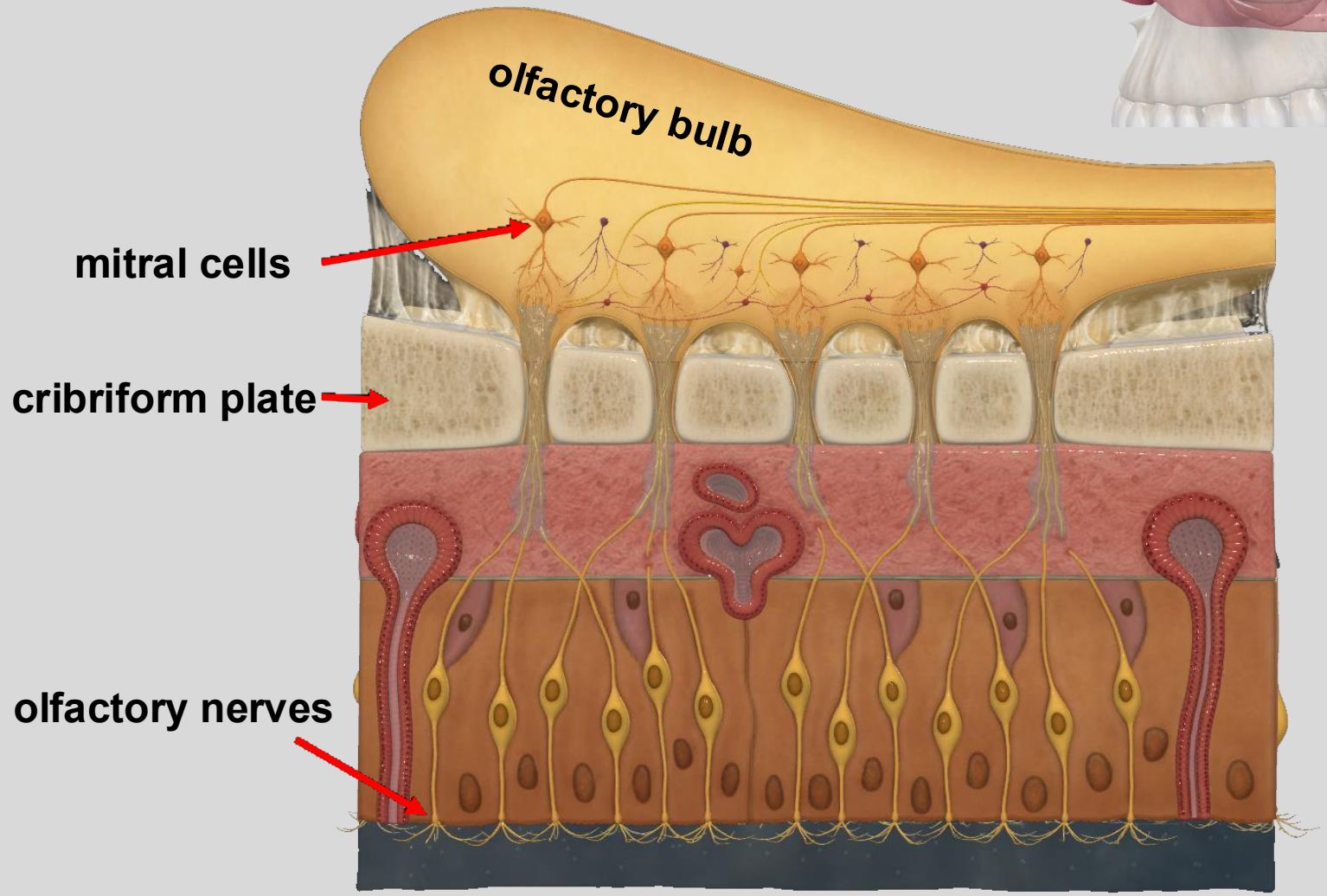
Latin: *concha* = seashell

# Olfactory





**Path of olfactory information back to the brain**



# Olfactory

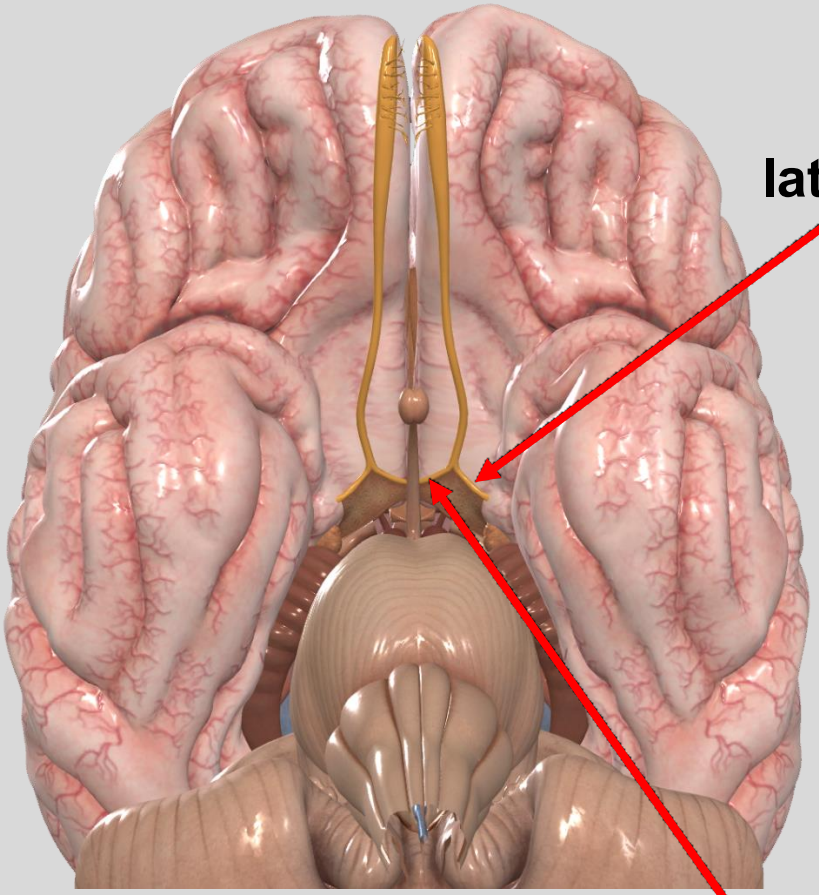


**Olfactory signal travels back to the brain along the olfactory stalk**

**Stalk splits into 2 striae**

1. lateral stria
2. medial stria

**Olfactory is the only cranial nerve to directly enter the cerebrum**



# 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



**Taste is conveyed along multiple cranial nerve (CN VII, IX, X)**

**The tongue is our main organ for taste**

**However, taste receptors are also (sparsely) located on:**

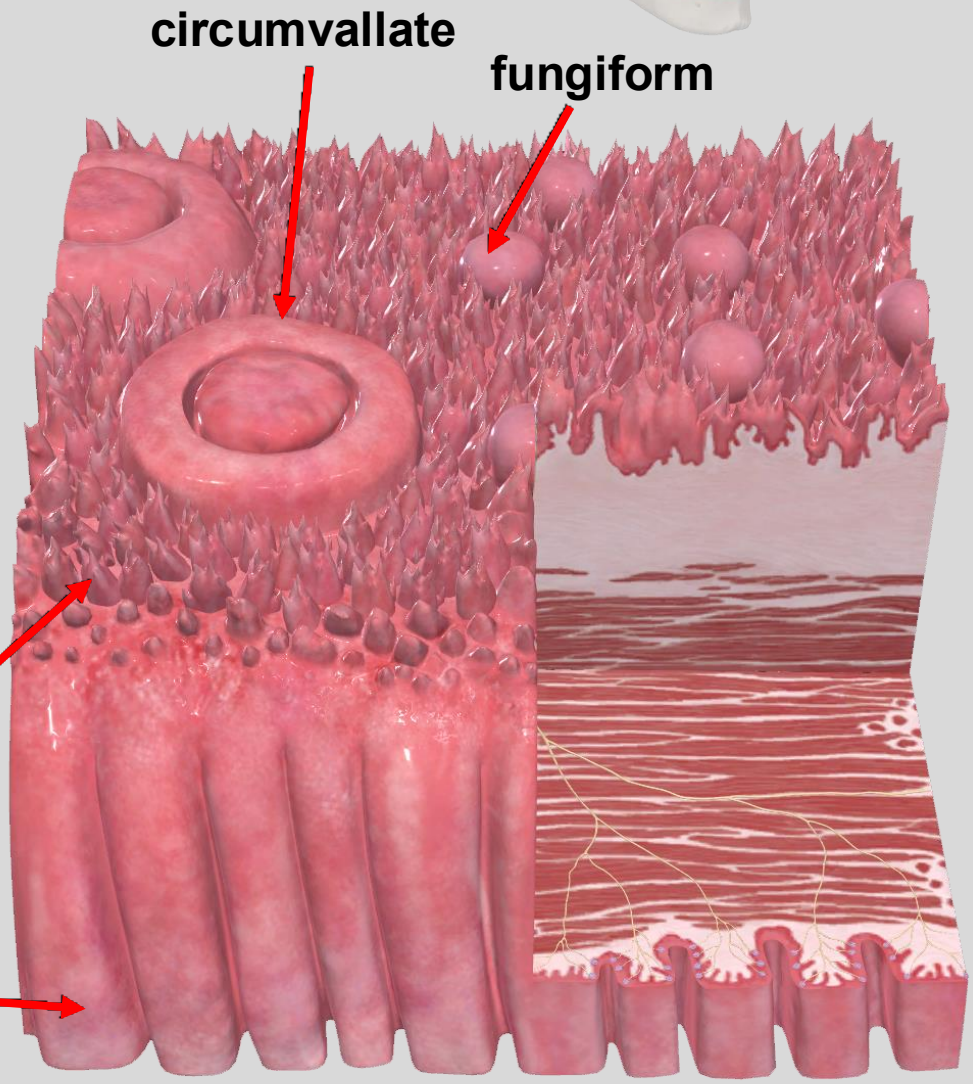
- oral soft palate
- parts of pharynx

# Taste

**Taste receptors reside on lingual papillae**

**4 types of lingual papillae**

1. filiform — hundreds, but no taste receptors
2. foliate
3. fungiform
4. circumvallate — least numerous at 8–12



# Taste

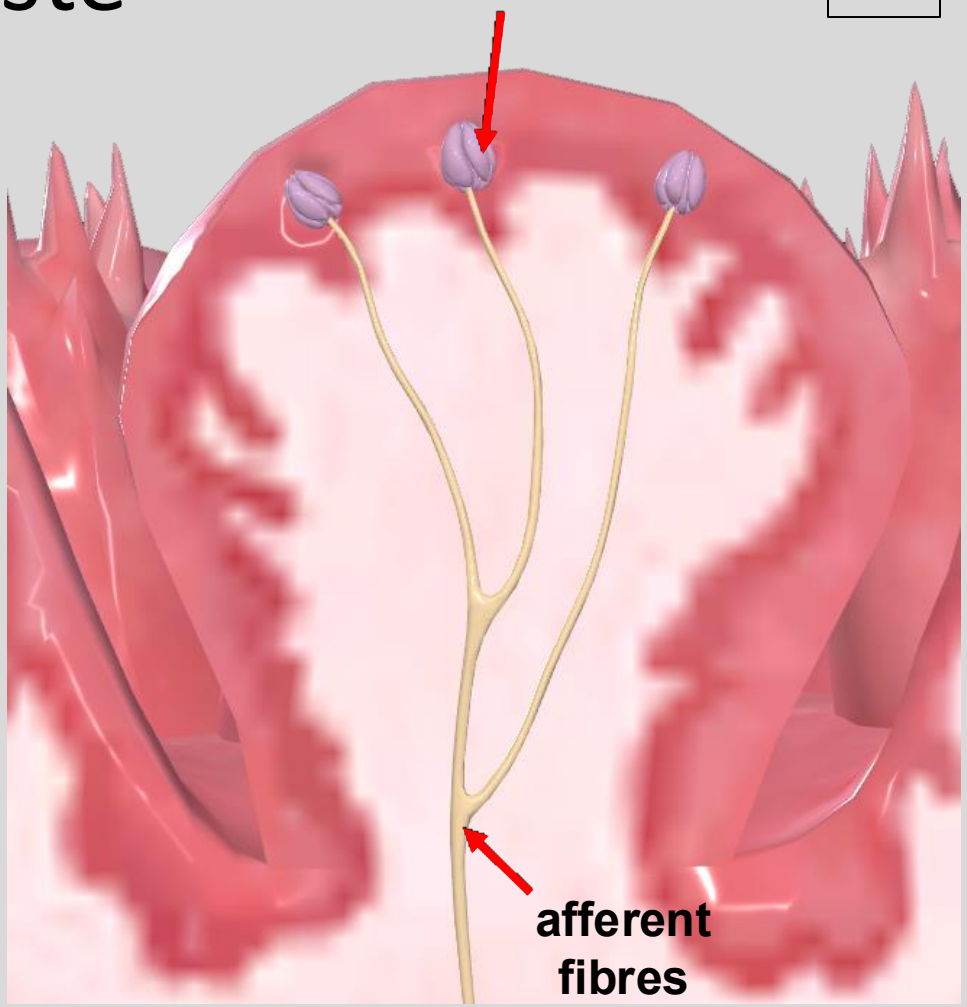
## Taste buds

**50–150 taste receptors / taste bud**

**Hundreds of taste buds / lingual papilla**

**5 recognized taste categories**

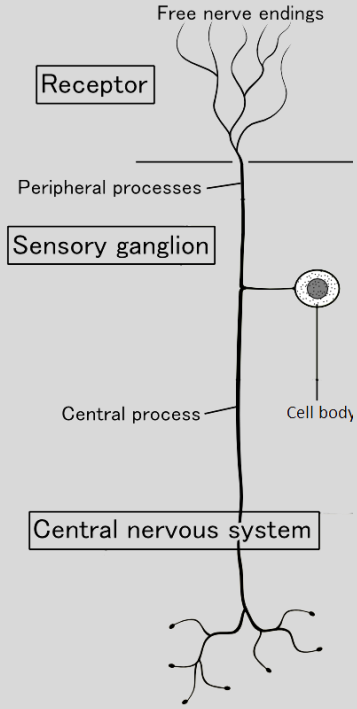
1) Sweet
2) Salty
3) Sour
4) Bitter
5) Umami (savory)




**sagittal view of fungiform papilla**

# 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

## Taste buds

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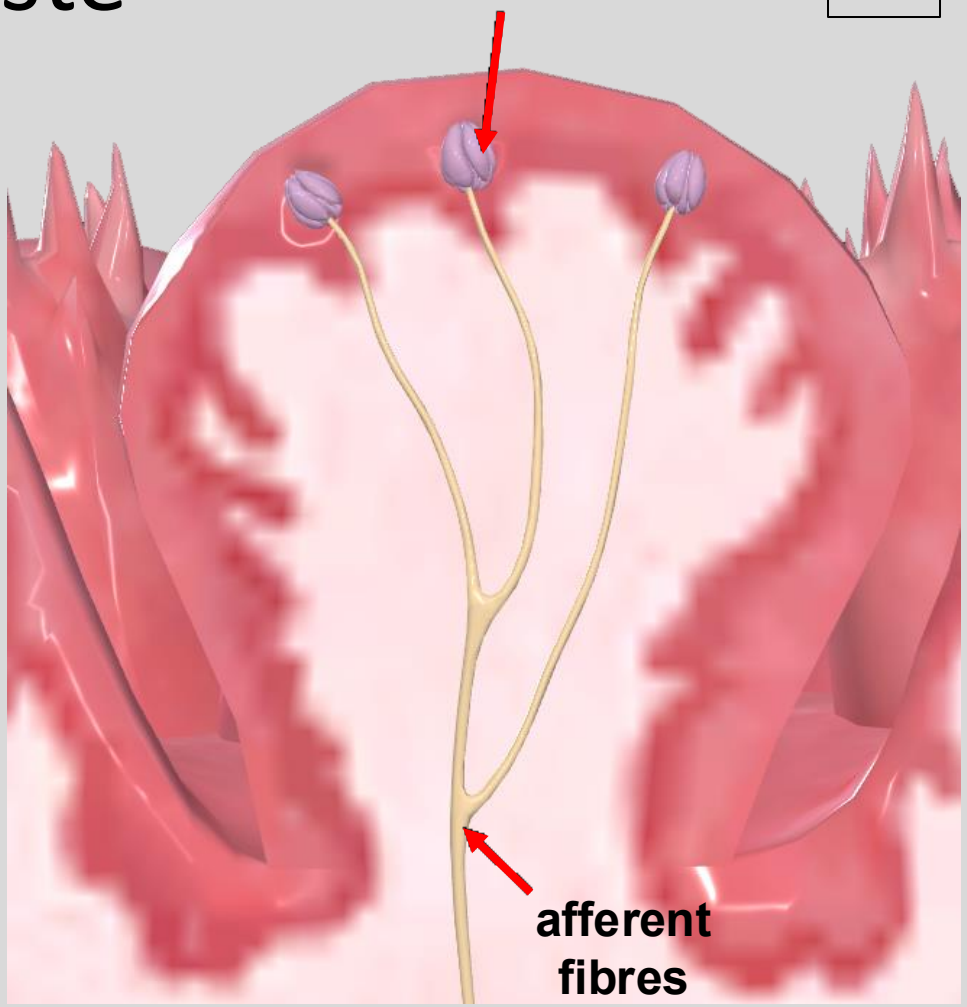



**sagittal view of fungiform papilla**

***All 5 categories can be recognized everywhere on the tongue (no regionalization)***

# Taste

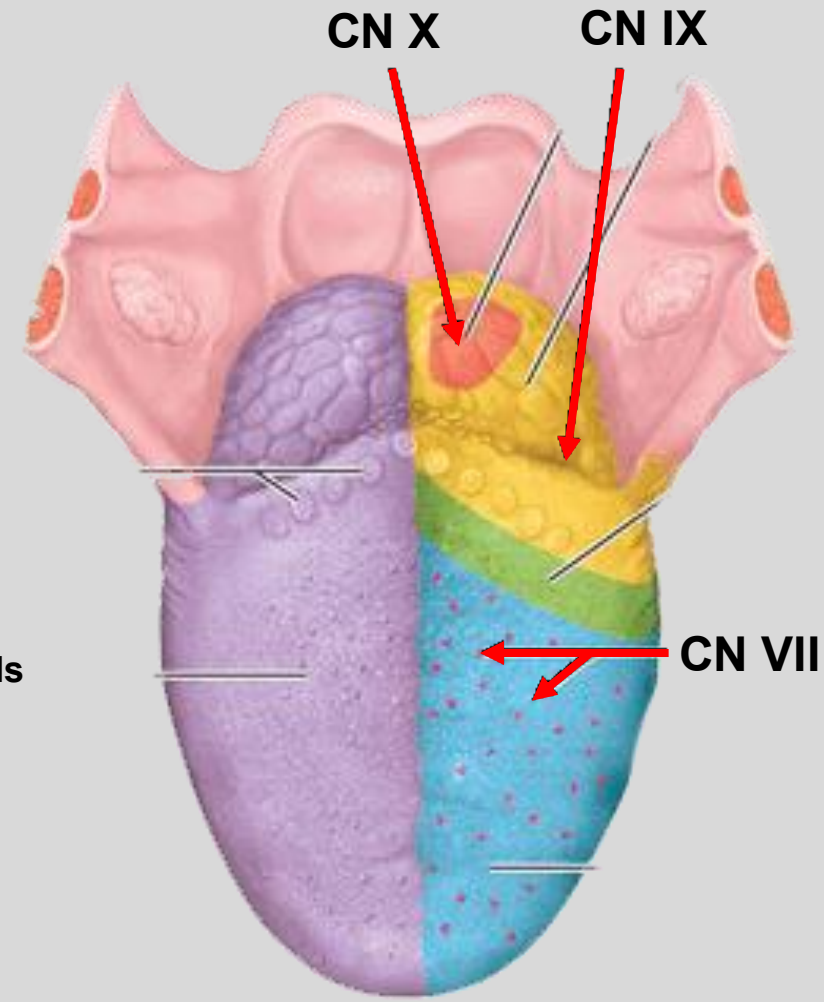


**Multiple cranial nerves convey taste from the tongue**

**Glossopharyngeal (CN IX) innervates the posterior 1/3rd**

**Vagus (CN X) innervates small regions of the tongue, oral soft palate and pharynx**

**Facial (CN VII) innervates the anterior 2/3rds of the tongue via chorda tympani**




**superior view** Figure 8.91

# Taste

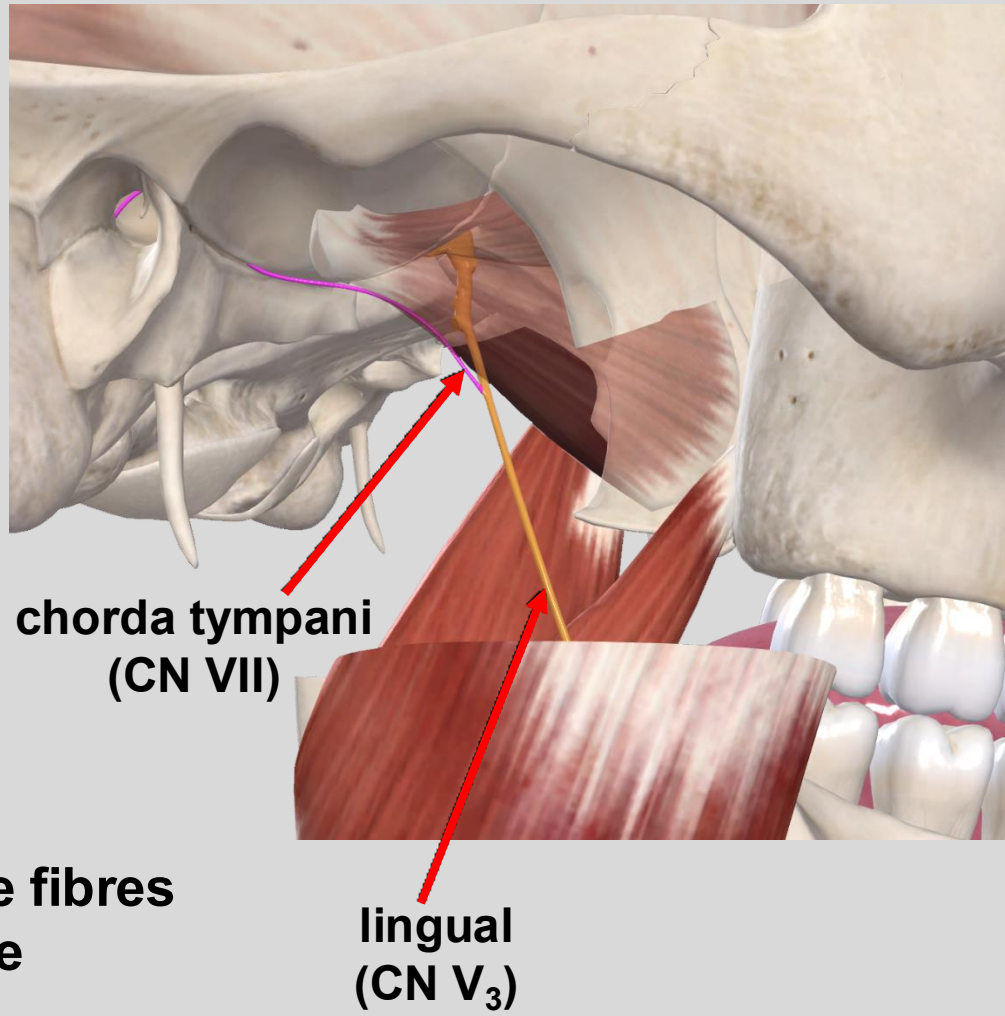


## Chorda tympani

**Branch of facial that *exits the skull* through the petrotympanic fissure**

**"Hitches a ride" with the lingual nerve (CN $V_3$) to enter the tongue**

**Though bundled together, the nerve fibres of CN $V_3$ and CN VII remain separate**



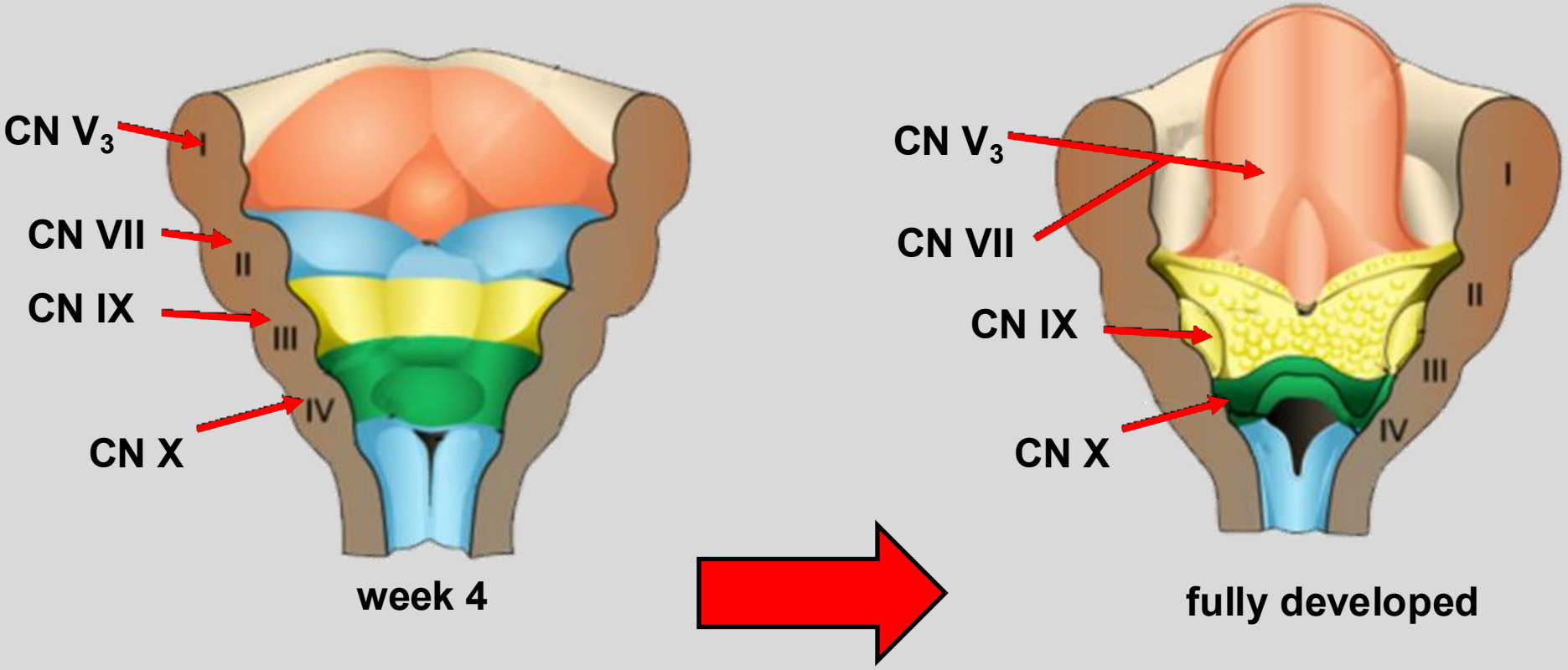
# Taste



**The tongue forms from the first 4 pharyngeal arches**

**Each pharyngeal arch is associated with its own cranial nerve**

**Primordial tongue had proto facial nerve fibres that migrated from arch II to arch I and were dragged into the anterior tongue as it developed**



# 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



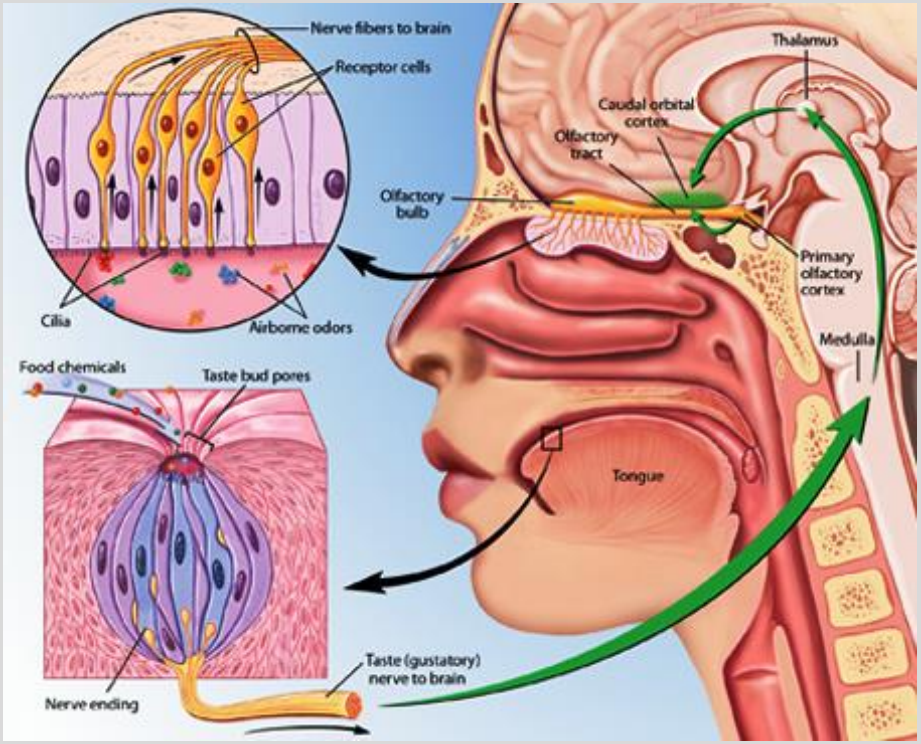
**Coupled senses = 2 or more senses that work together to perform a new function**

**Smell and taste are deeply intwined**

**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***

## Lecture Feeback Survey

https://comresearchdata.nyit.edu/redcap/surveys/?s=HRCY448FWYXREL4R

Vision (CN II)

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# Vision



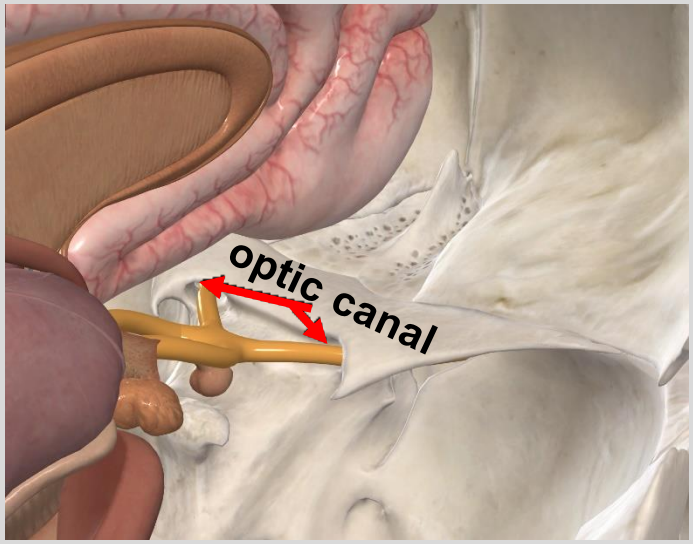
**The most important special afferent in our body**

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

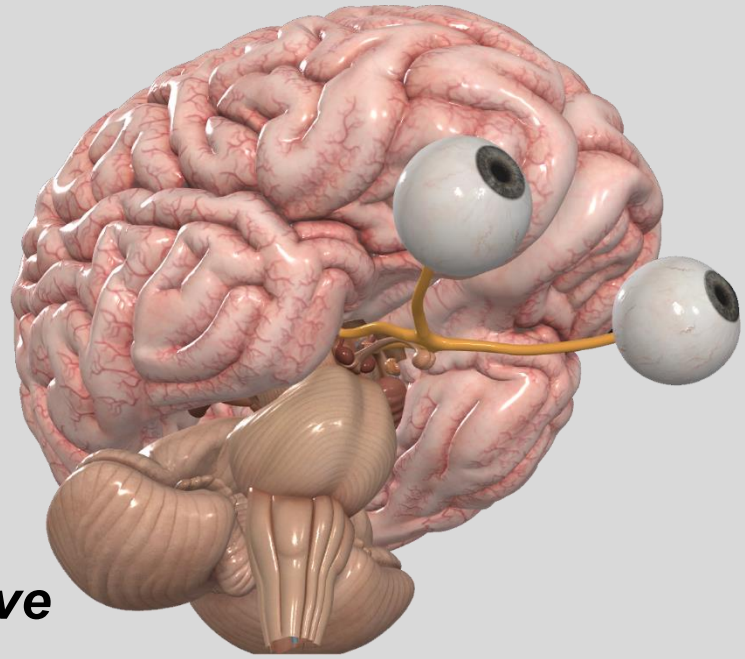
**Optic nerve is an anterior extension of the forebrain**

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

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



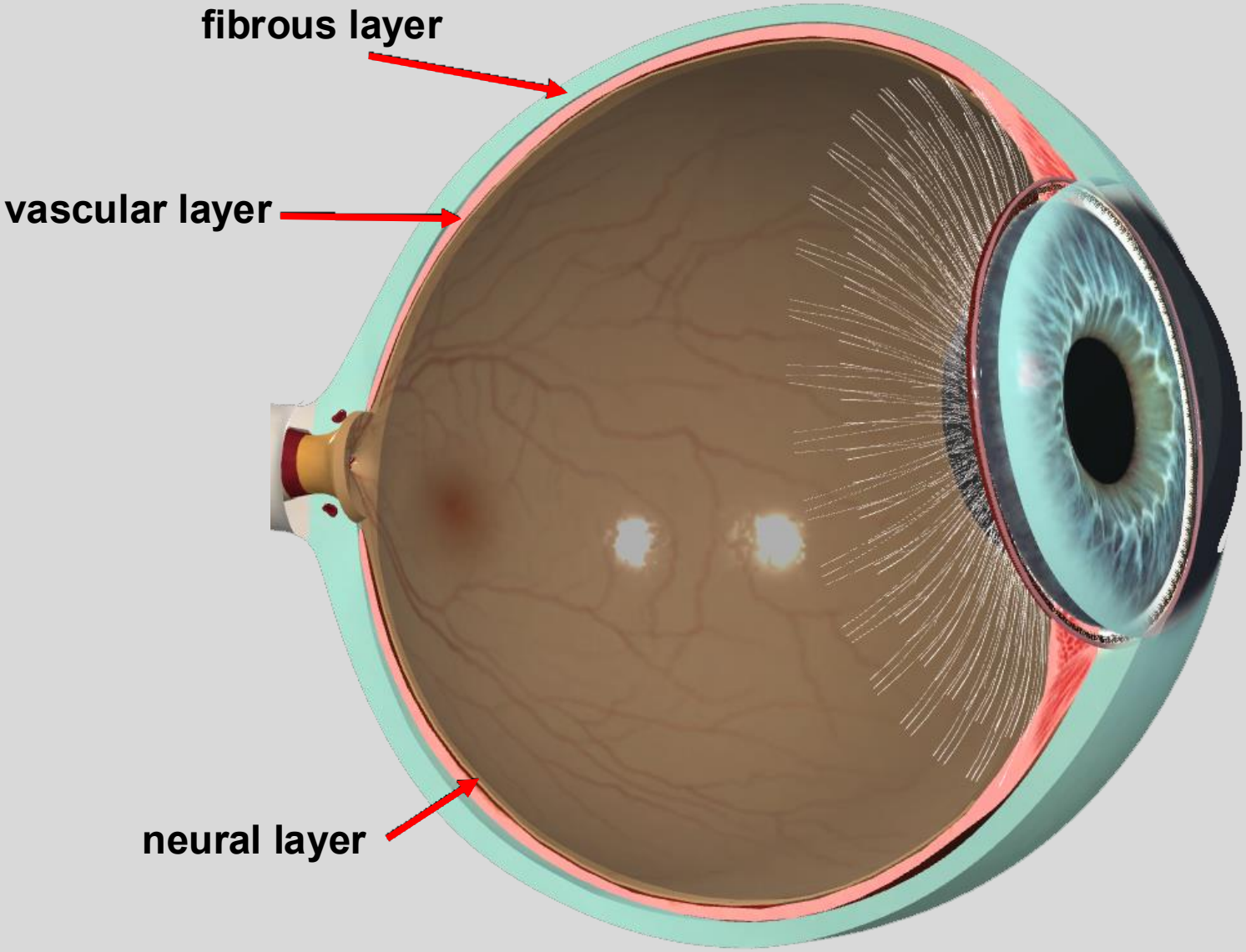

**superolateral view**



# Vision



**The eye can be divided into 3 layers**



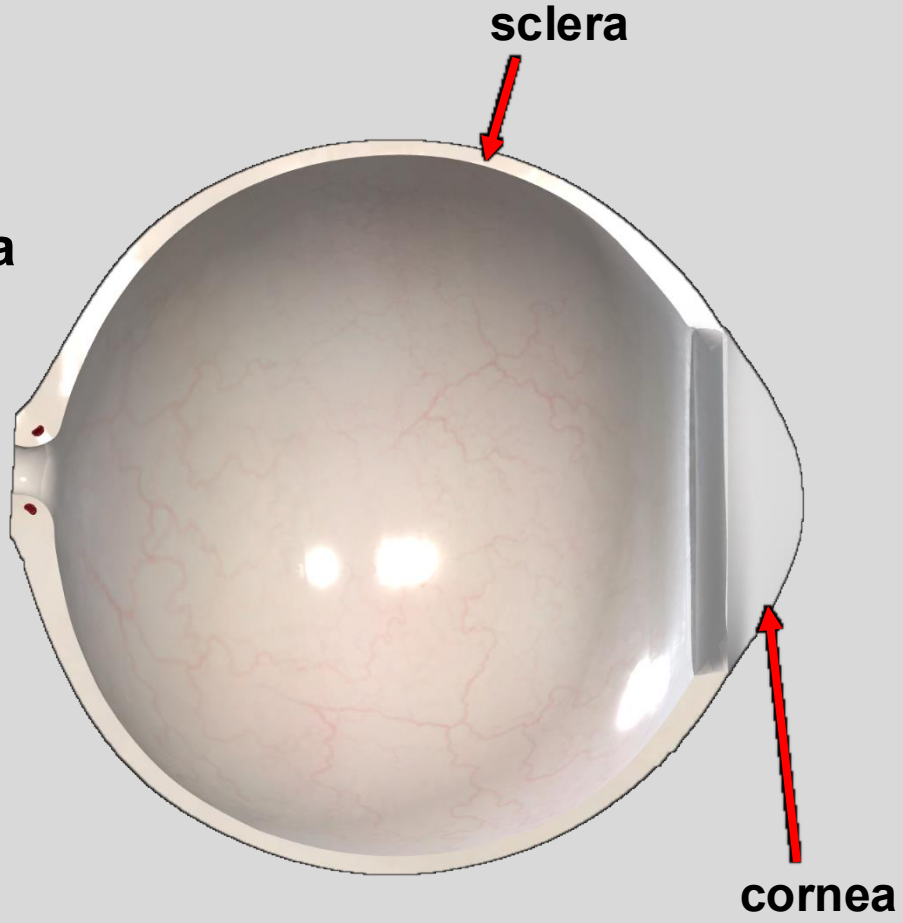
# Vision



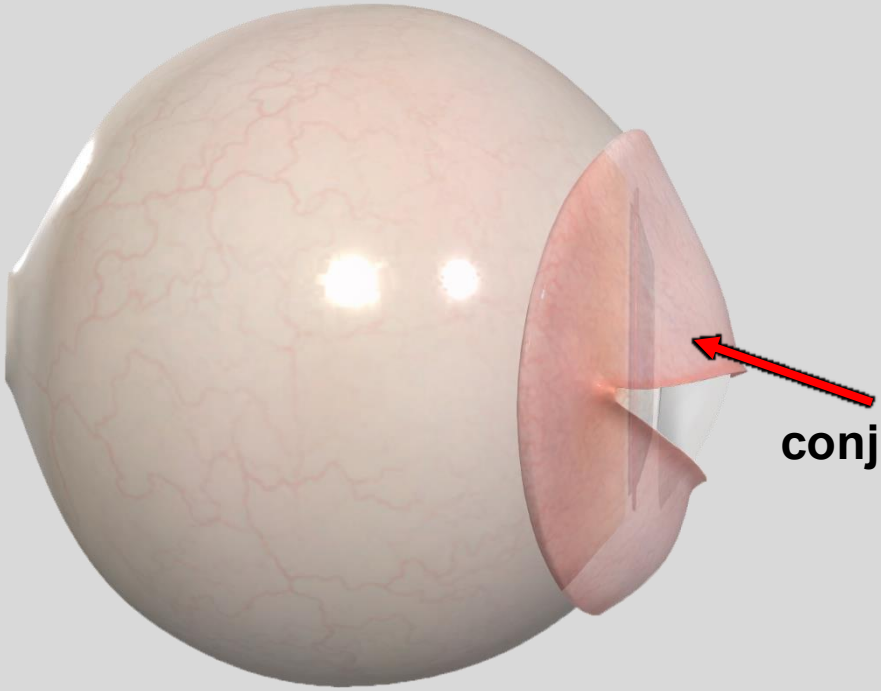
## Fibrous Layer

Outer covering is the sclera

Cornea is the clear part of the sclera




## Conjunctival Layer




The conjunctival layer supports, protects, and moistens the eye

# Vision



## Fibrous Layer

Sclera and cornea have the same composition

Collagen fibre orientation determines if light can pass through or not

Sclera blocks out light and protects against physical damage

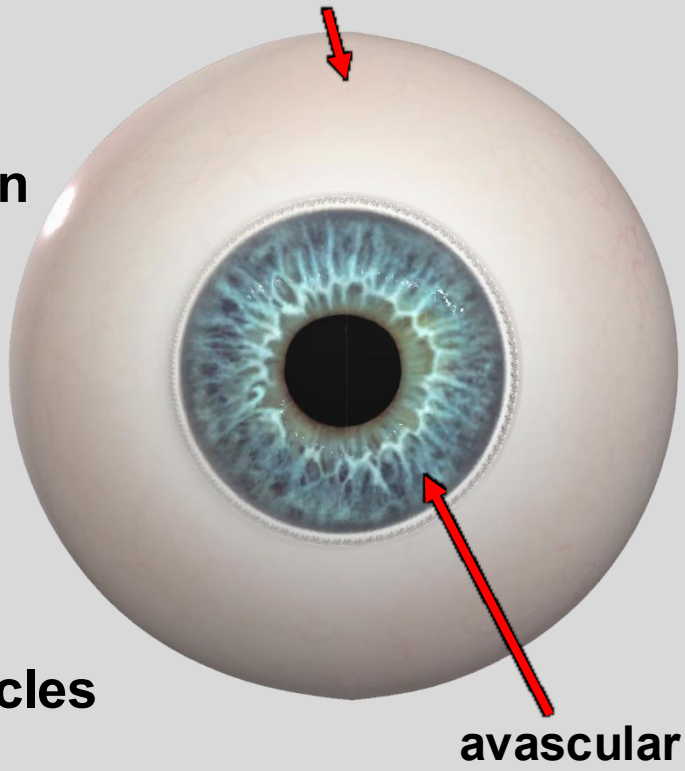
Distal attachment site for all extraocular muscles

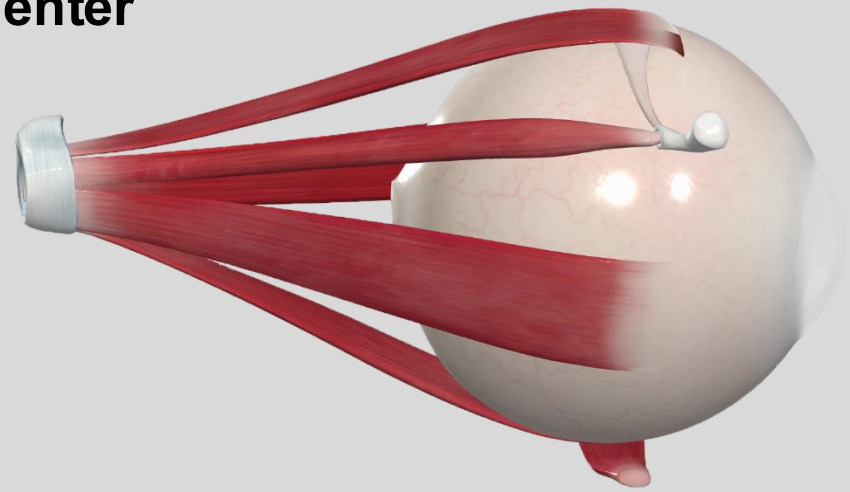
The cornea is the window for light to enter

Cornea blocks most UV light

Cornea is the main light refractor (2/3$^{rds}$ of refraction)

Cornea is highly sensitive to touch



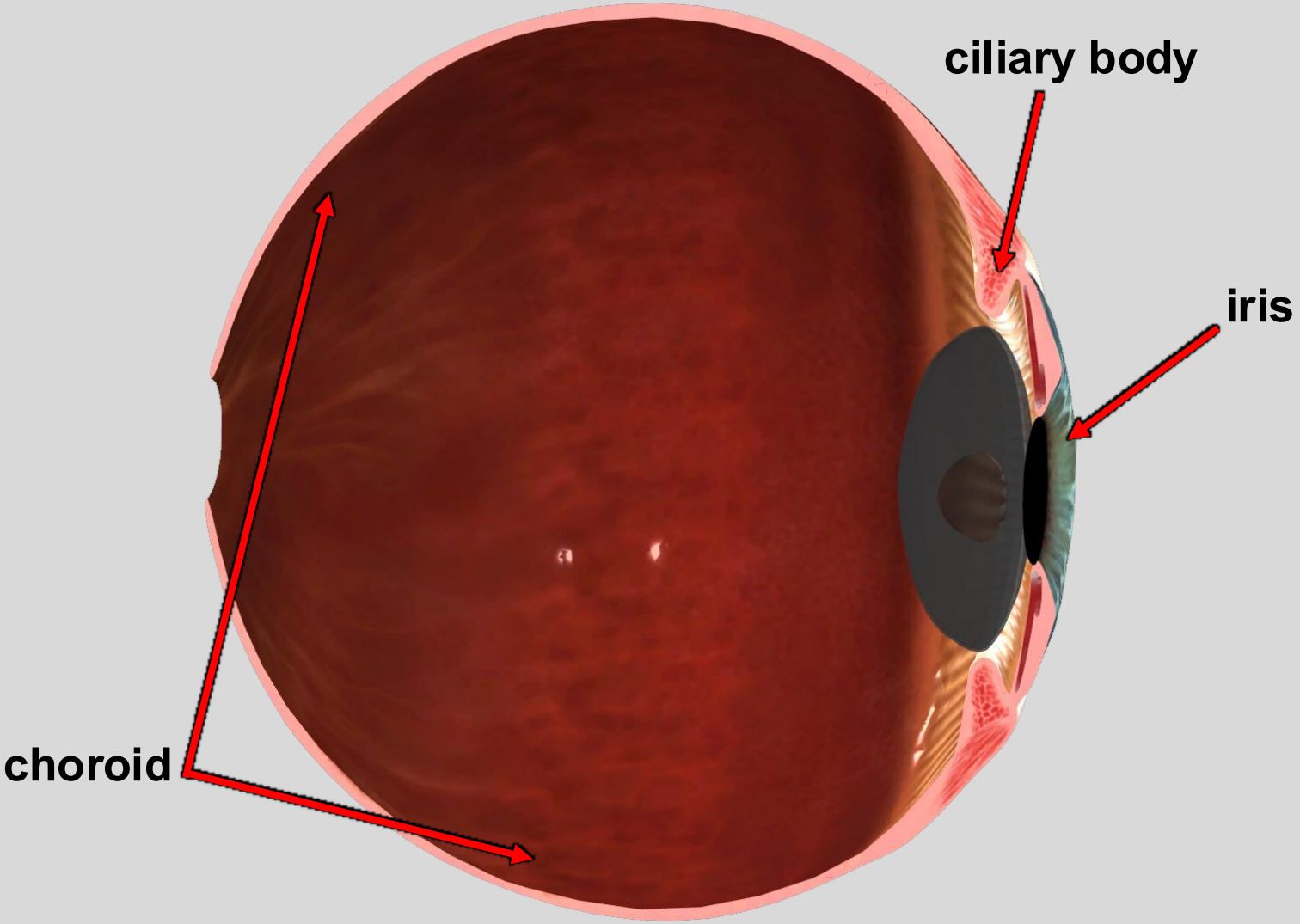



# Vision



## Vascular Layer

**3 layers comprise the vascular layer**



# Vision



## Vascular Layer: Iris

**Lies anterior to the lens**

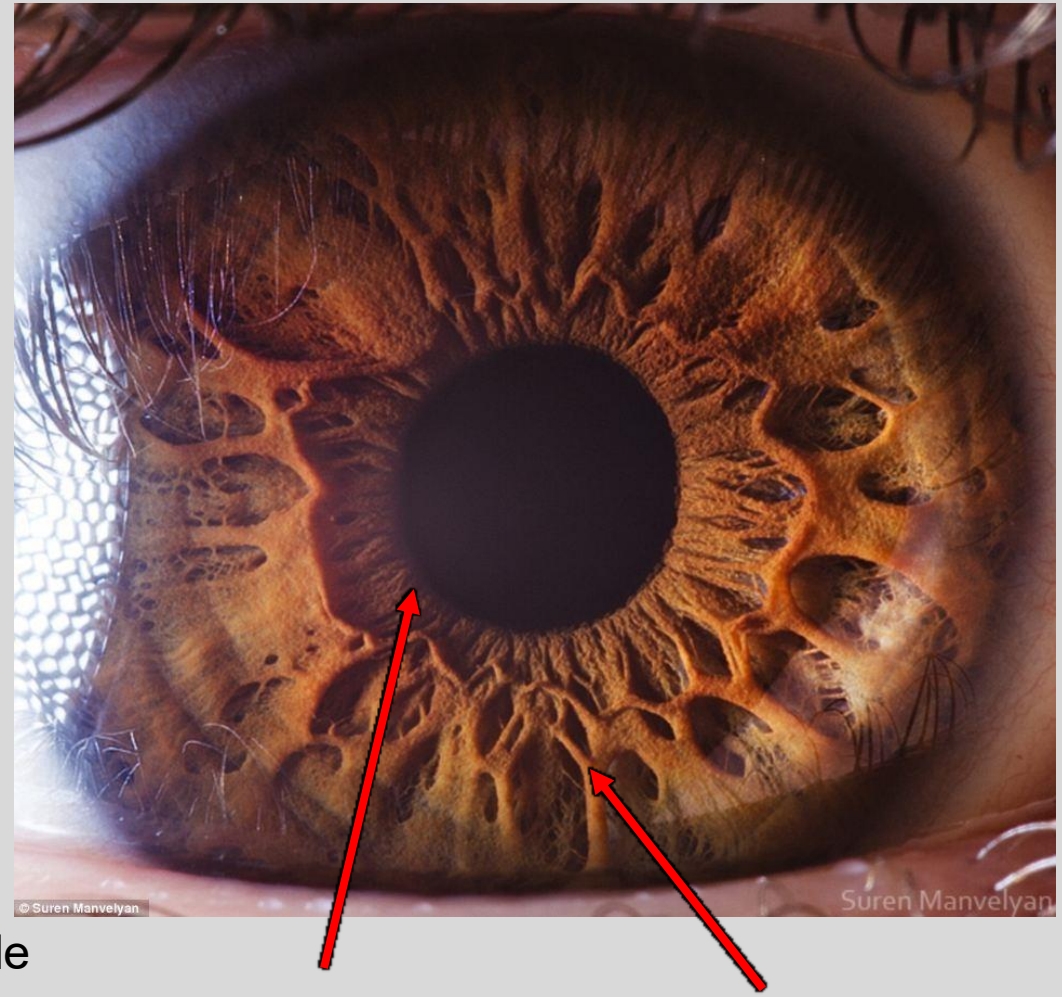
**Gives colour to the eyes**

**Adjusts pupil diameter**

**Iris houses 2 muscles**

sphincter pupillae (constricts)
- ring of smooth muscle
- parasympathetically activated

dilator pupillae (expands)
- radially arranged smooth muscle
- sympathetically activated



# Vision



## Vascular Layer

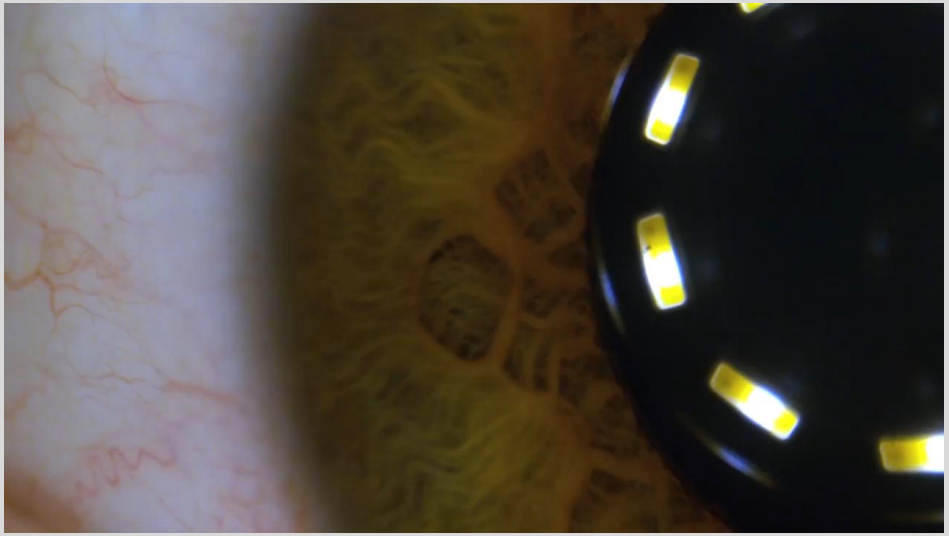
### sphincter pupillae

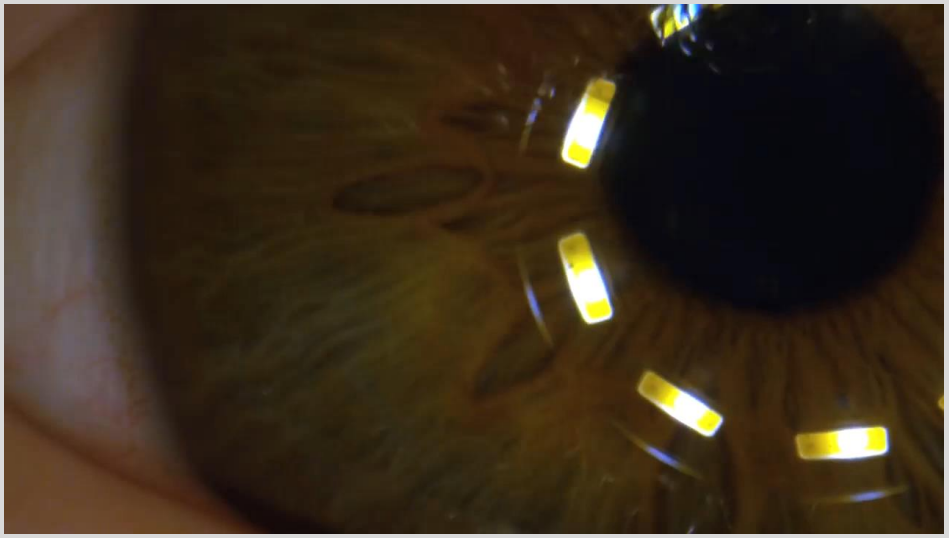
- circular fibres
- parasympathetic
- fast contraction

### dilator pupillae

- radial fibres
- sympathetic
- “slow” contraction

**Movies**





Slow Mo Guys
https://www.youtube.com/watch?v=EjIbmQsWtqc

# Vision



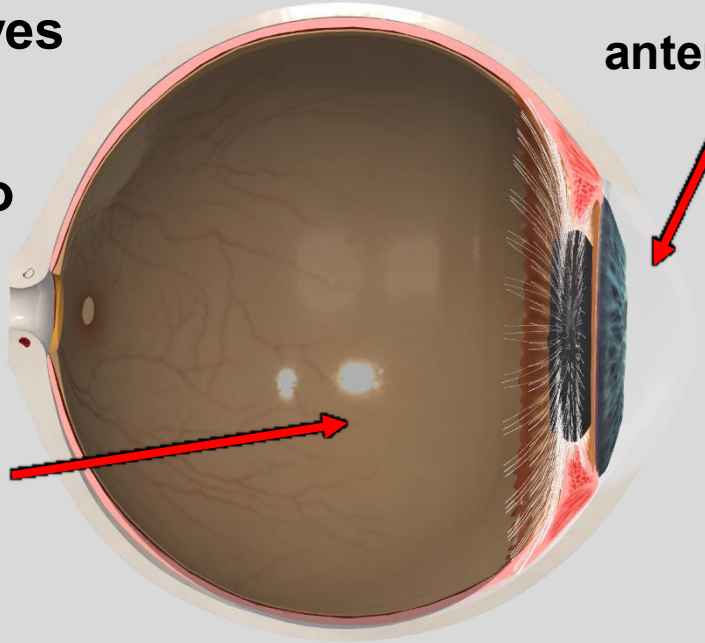
## Vascular Layer: Iris

**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**



**anterior compartment**

**<u>aqueous humour</u>**

**maintains pressure and feeds cornea**

**posterior compartment**

# Vision



## Vascular Layer: Ciliary Body

**A ring of smooth muscle attached to the lens**

**Responsible for deforming the lens**

**Produces aqueous humour**

**Attached to lens via zonular fibres (Zonule of Zinn)**

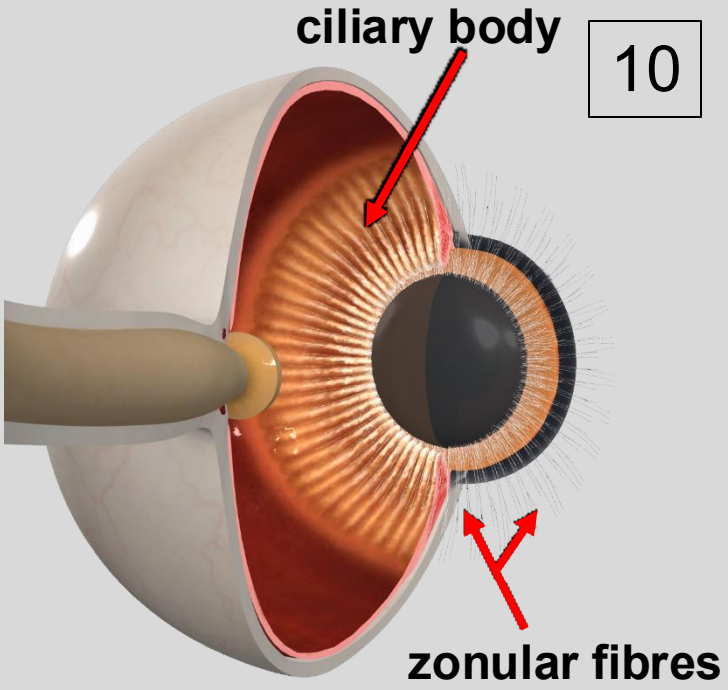
**At rest, zonular fibres are tensed**

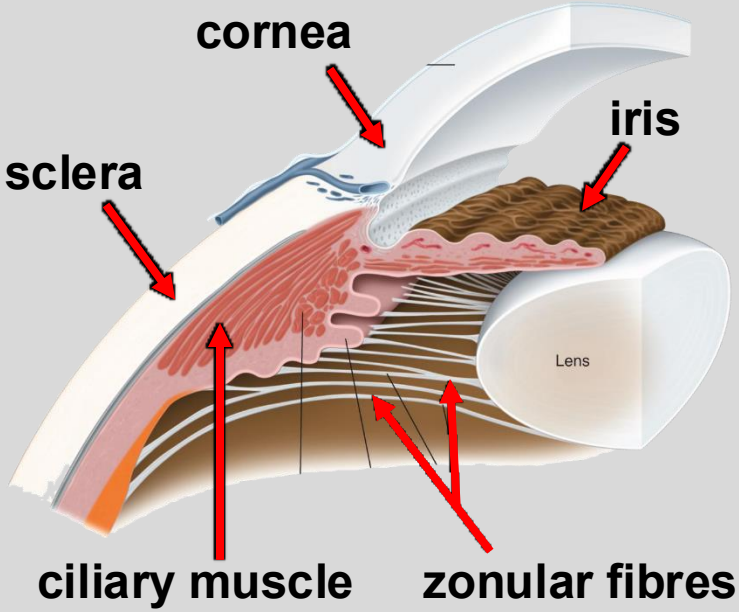
lens is stretched

**Contraction of ciliary body loosens zonular fibres**

lens returns to original (biconvex) shape

**Ciliary body is parasympathetically innervated via the short ciliary nerves)**



# Vision: The Eye



## Vascular Layer: Choroid

**Feeds the internal structures of the eye**

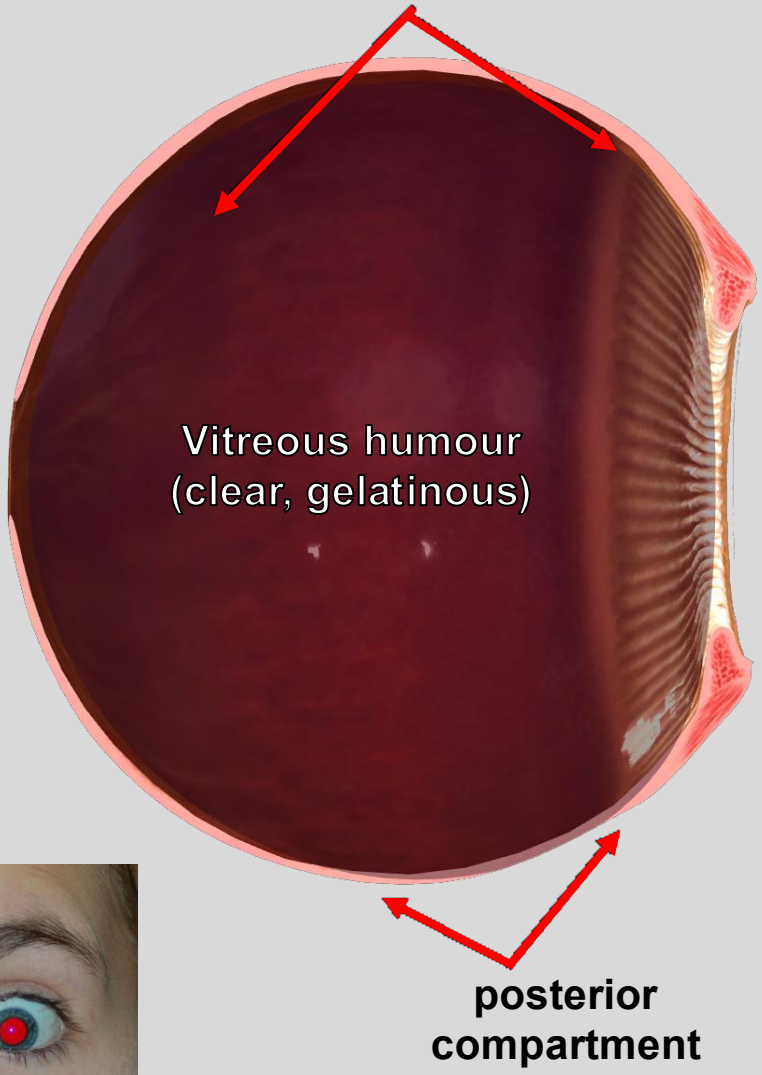
**Dark red in colour**

**Blood supply to the retina**

tightly adhered to posterior retina

loosely attached to anterior retina

**Anterior retina requires constant pressure from the vitreous humour to maintain attachment to choroid**




**red eye is reflection of the choroid**

# Vision: The Eye

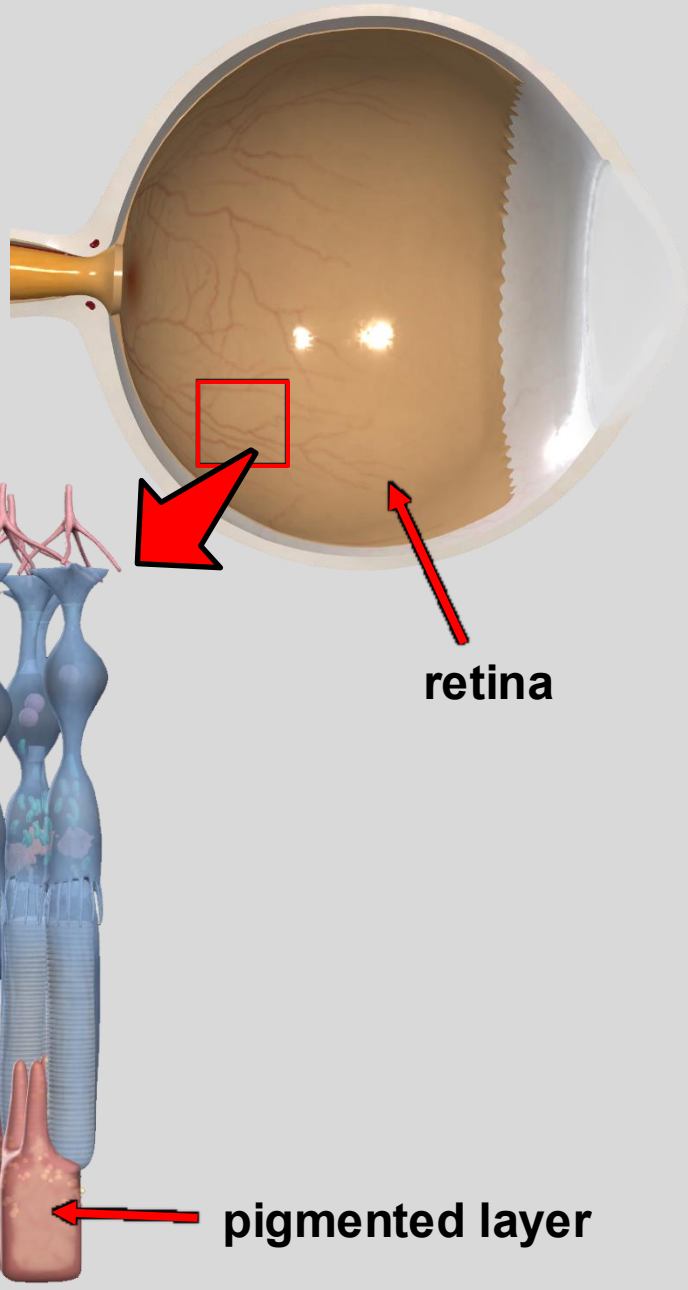


## Neural Layer

**The retina is the innermost layer of the eye**

**~150 million different neurons**

**Consists of two layers**



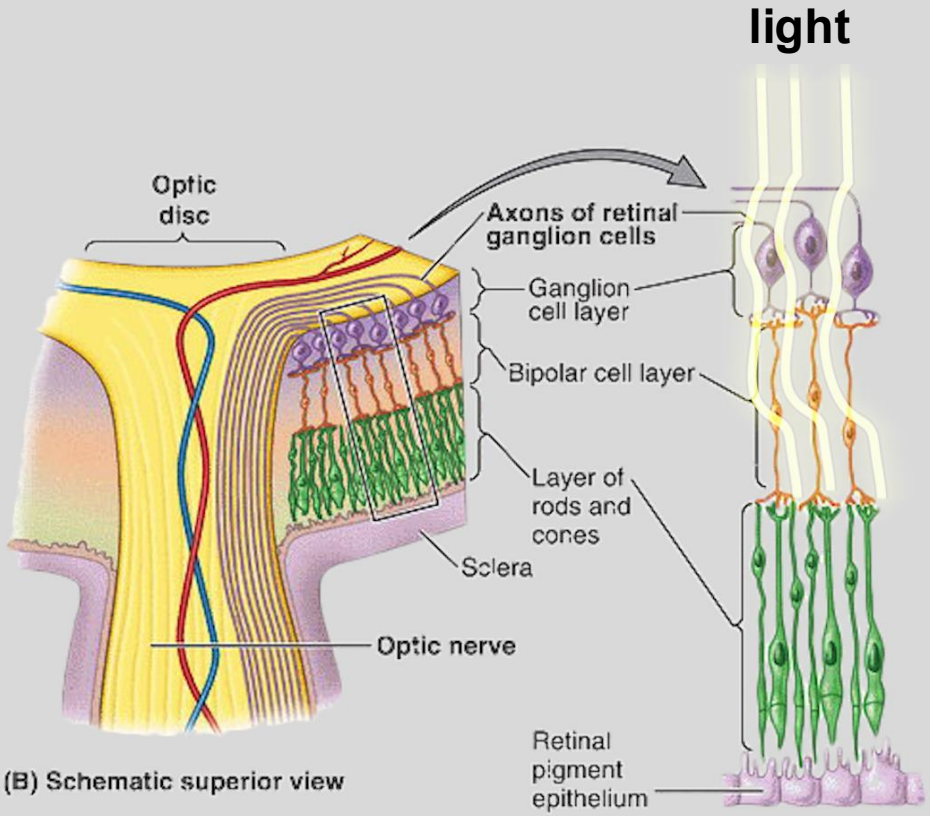
# Vision: The Eye

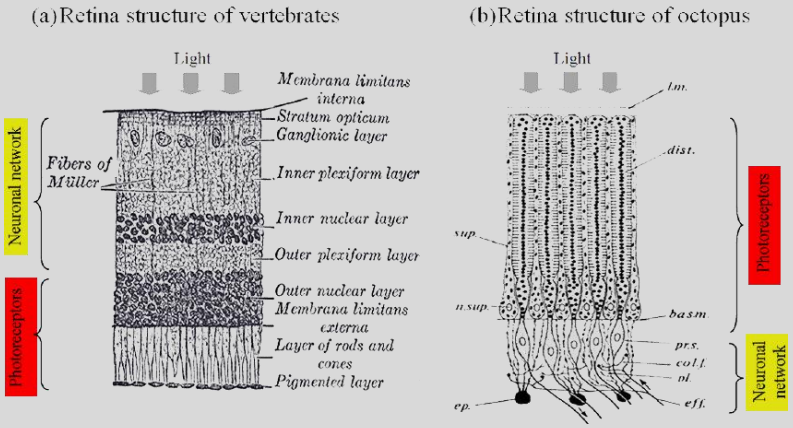


## Neural Layer: Retina

**Our eyes are built backwards**

**Light must pass through a mesh of non-photoreceptive neurons before reaching the photoreceptors**




**octopus arranged it “right”**

# Vision: The Eye



## Neural Layer: Retina

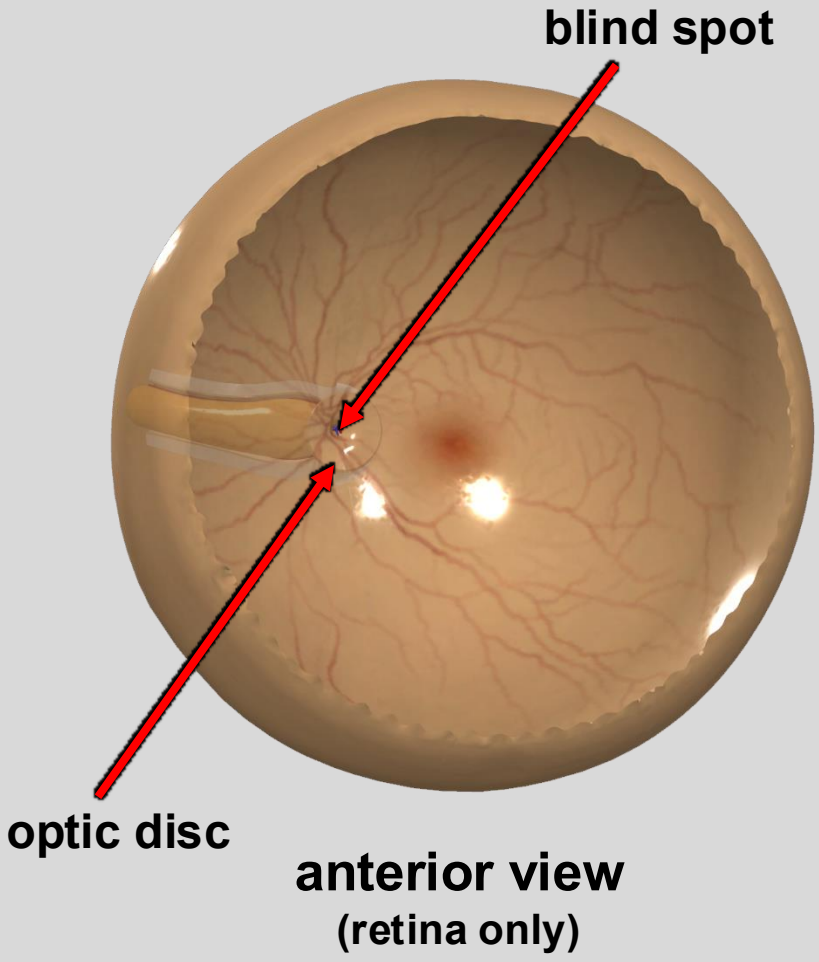
**Backwards construction of eye results in two unique anatomical structures**

**1. Optic disc**

**Convergence point for all blood vessels and neurons of the retina**

**No light passes through resulting in a *blind spot***

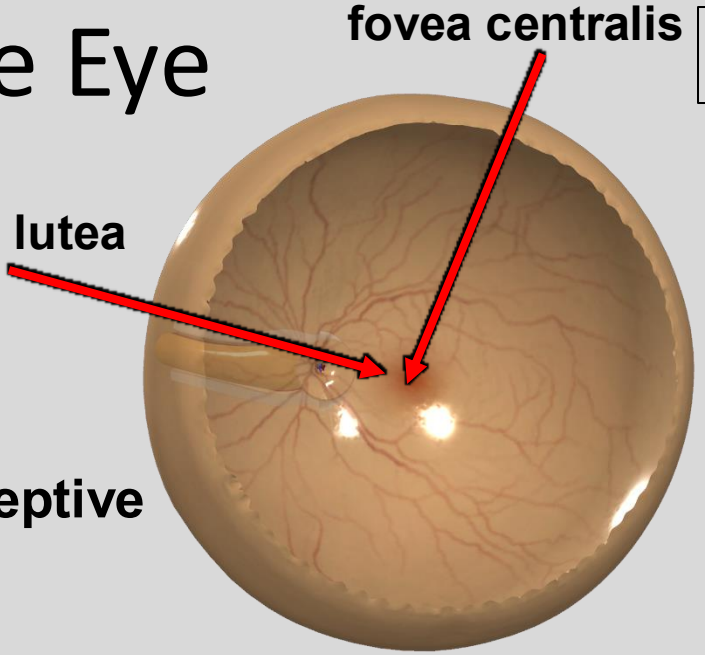
**The brain pieces multiple images together to fill in the blind spot**



# Vision: The Eye



## Neural Layer: Retina




anterior view
(retina only)

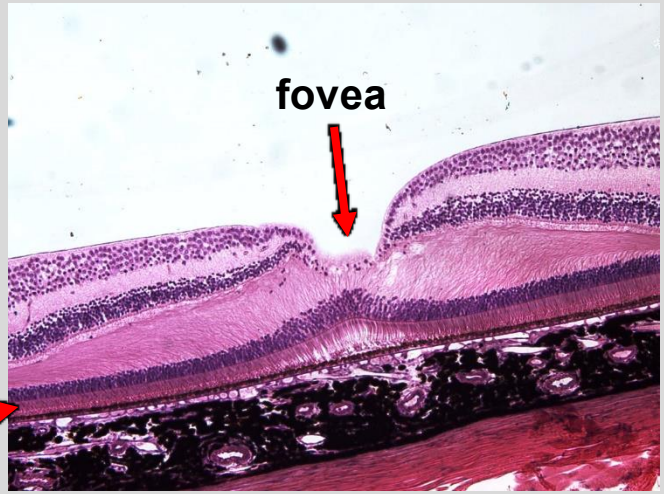
**2. Macula lutea**

**"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**



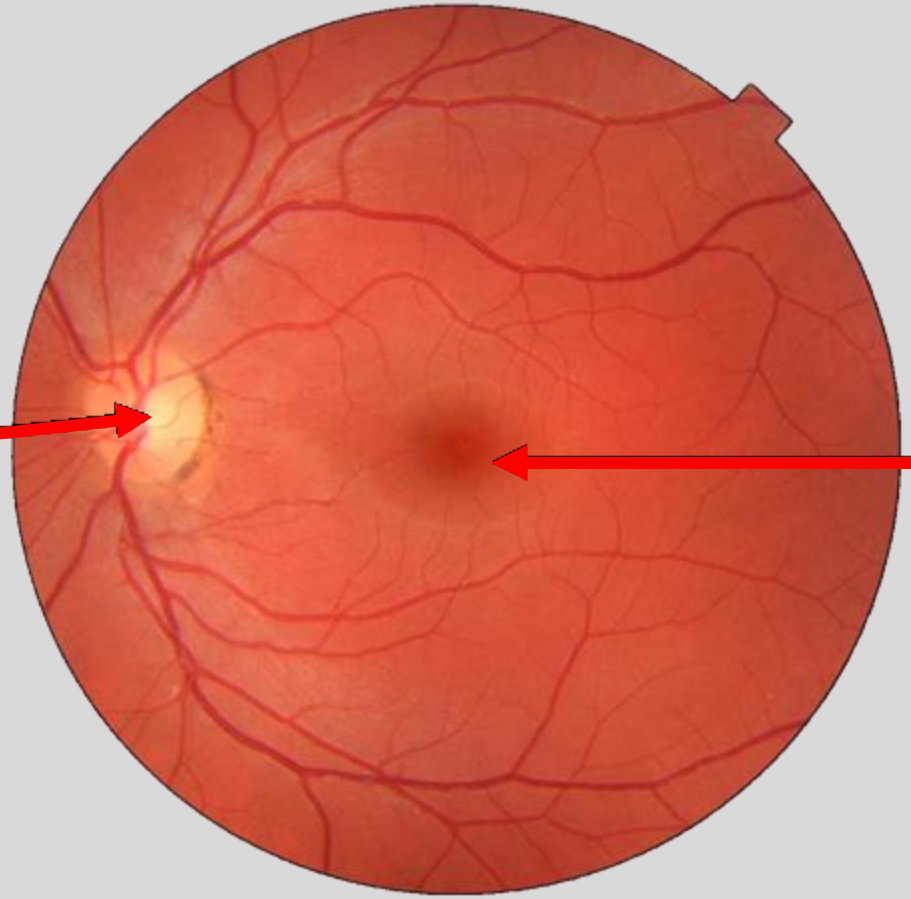

Latin: *macula* = spot / stain + *lutea* = yellow

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

# Vision: The Eye



## Neural Layer: Retina



optic disc
(blind spot)

looks like a
bright spot

macula lutea
(fovea)

looks like
a shadow

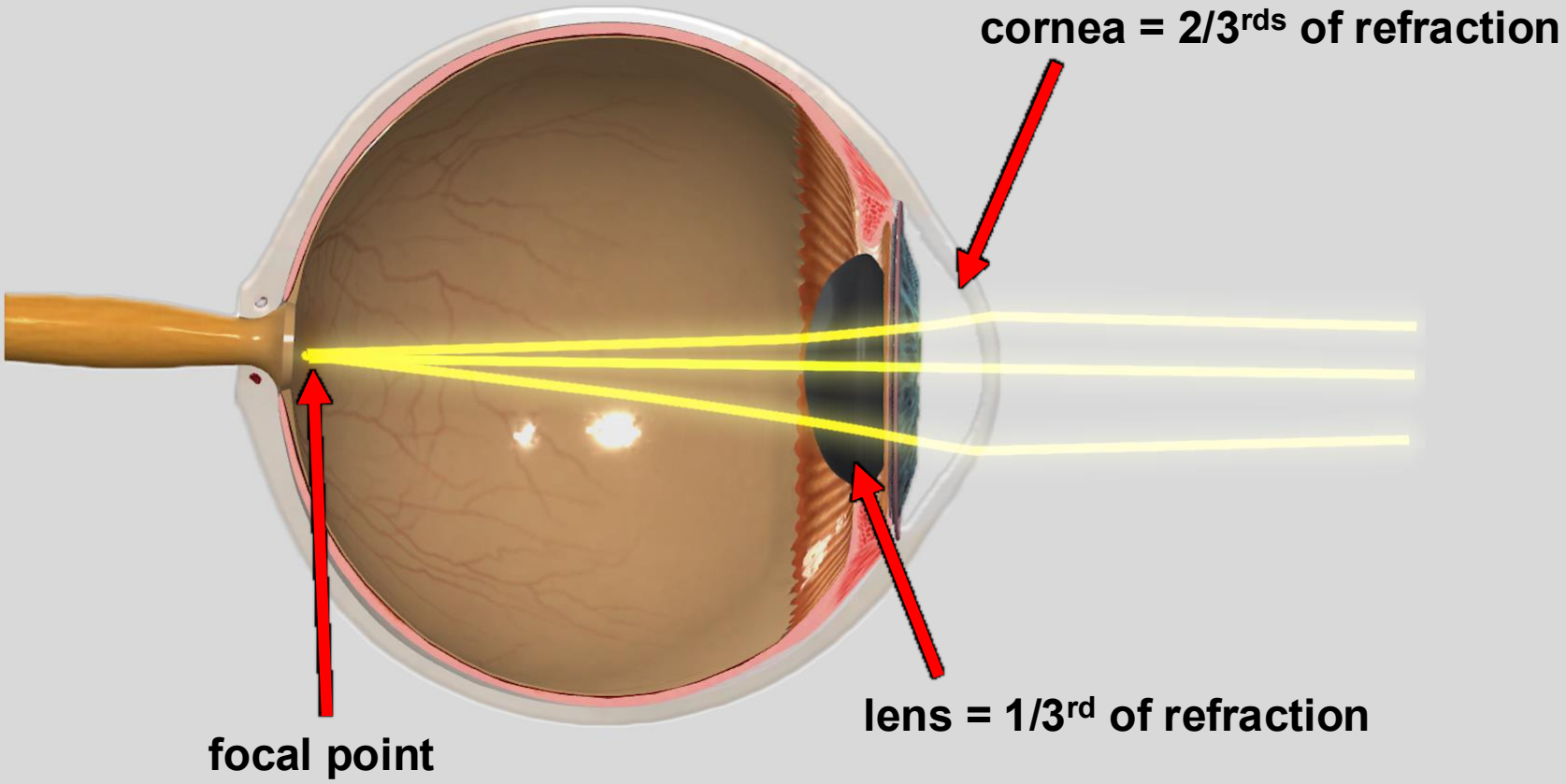
ophthalmoscopic view

# Vision: The Eye



## Accommodation

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



# Vision: The Eye

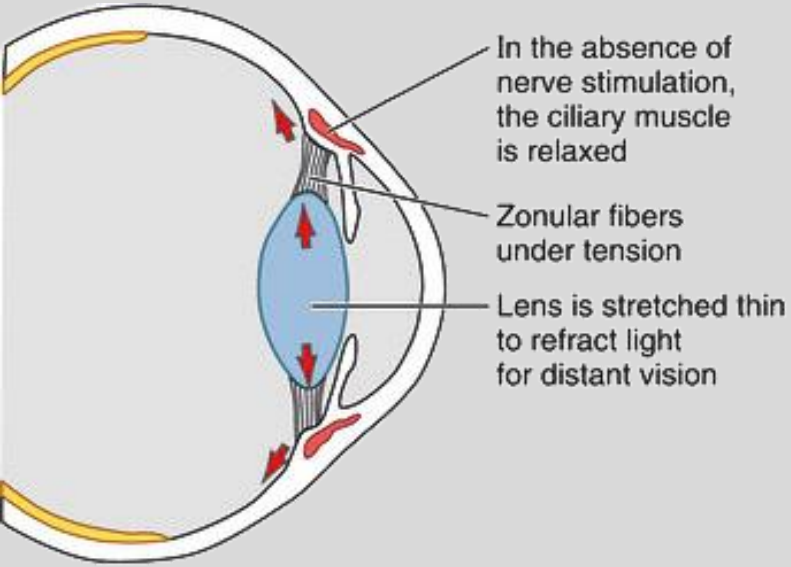
**dissected lens**
**(cow)**

## Accommodation

**The lens is spherical and elastic**

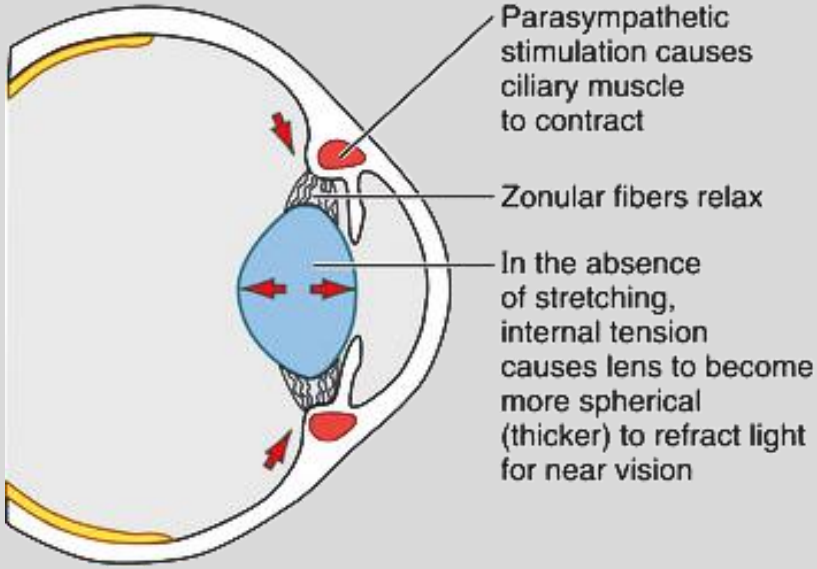
**Deforming the lens changes the focal point**

**Distance focus stretches the lens**




**Stretching is a *passive* act**

**Near point focus = rounder lens**




***Active contraction* of ciliary body**

# Vision: The Eye



## Accommodation

**Accommodation is counterintuitive**

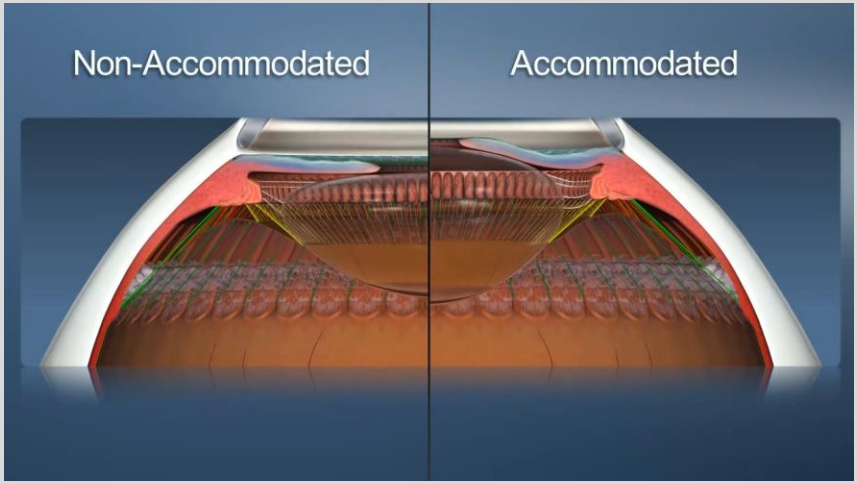
**Changing lens shape (stretching) is a passive process**

**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



## Visual Field

**Eyes are divided into 2 hemiretinae**

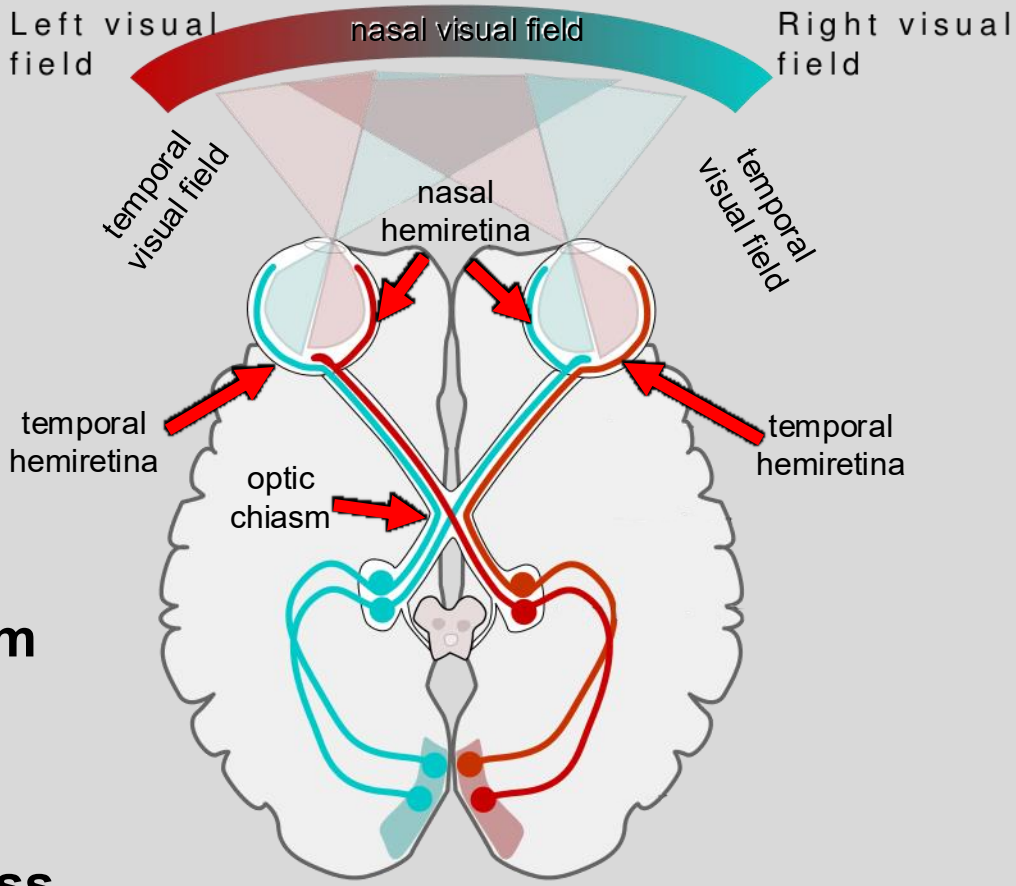
1. Temporal hemiretina
2. Nasal hemiretina

**This splits the visual field in two**

1. Temporal visual field
2. Nasal visual field

**Each hemiretina receives input from *the opposite* visual field**

**Only nasal hemiretina neurons cross over (decussate) at the optic chiasm**



# 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**

**Cataract in 55-year old male**

**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

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

# Vision: The Eye

## Clinical Correlates

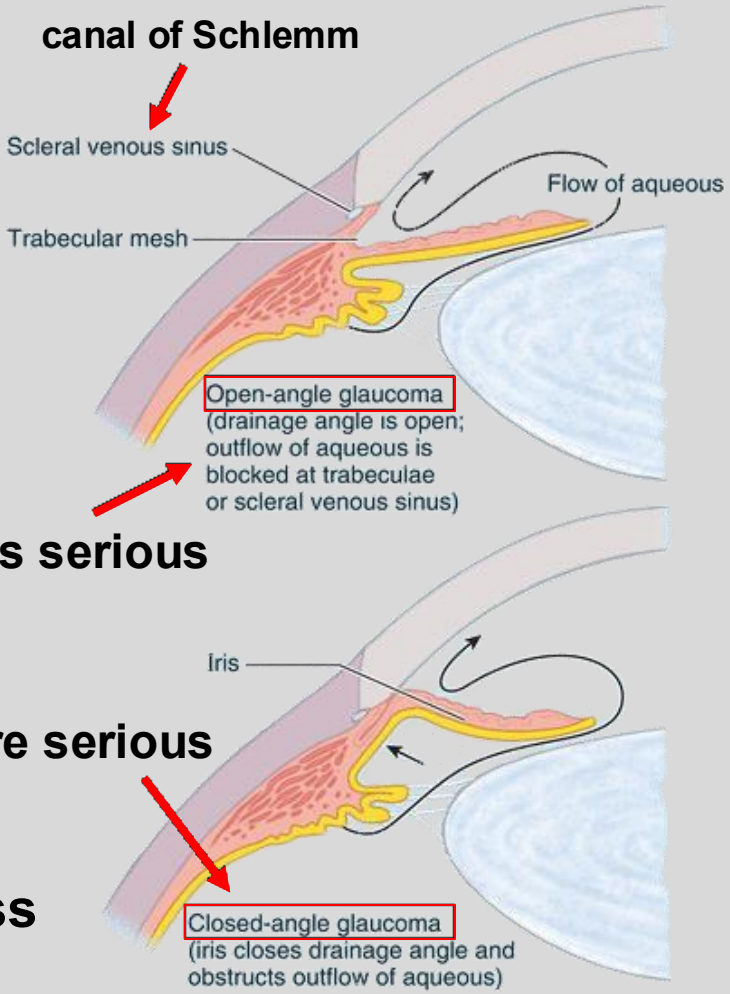
### Glaucoma

**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

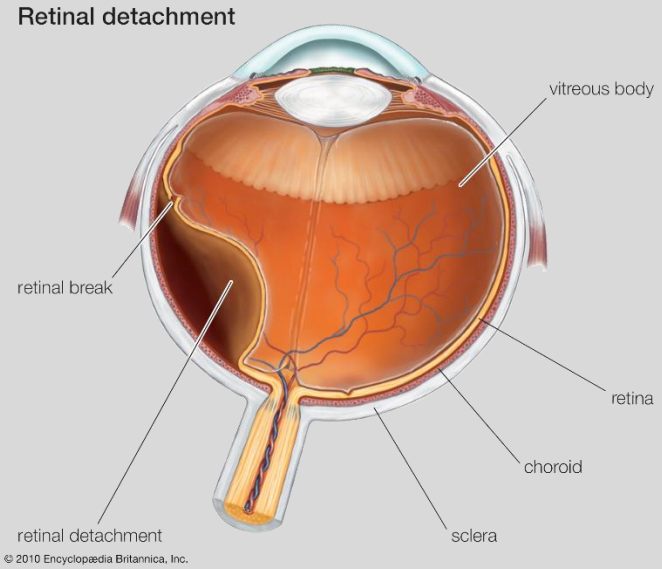
### Retinal detachment

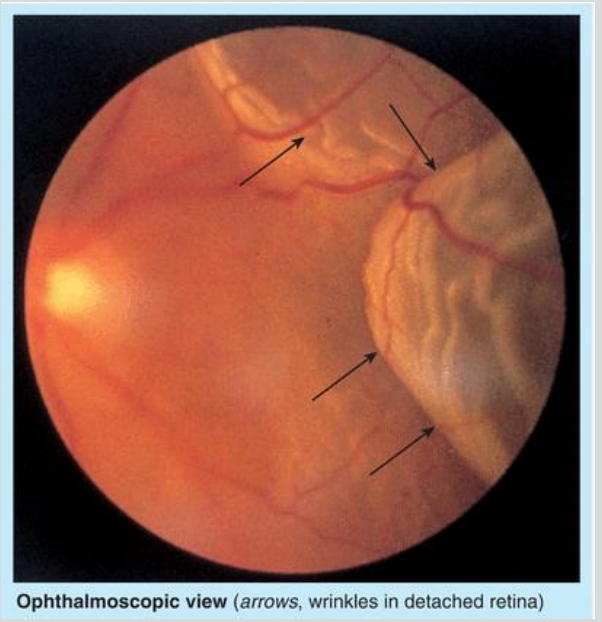
**Neural layer of retina requires ocular pressure to maintain attachment to choroid**

**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)

# Lecture Feeback Survey

https://comresearchdata.nyit.edu/redcap/surveys/?s=HRCY448FWYXREL4R

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

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

# CN VIII — Vestibulocochlear

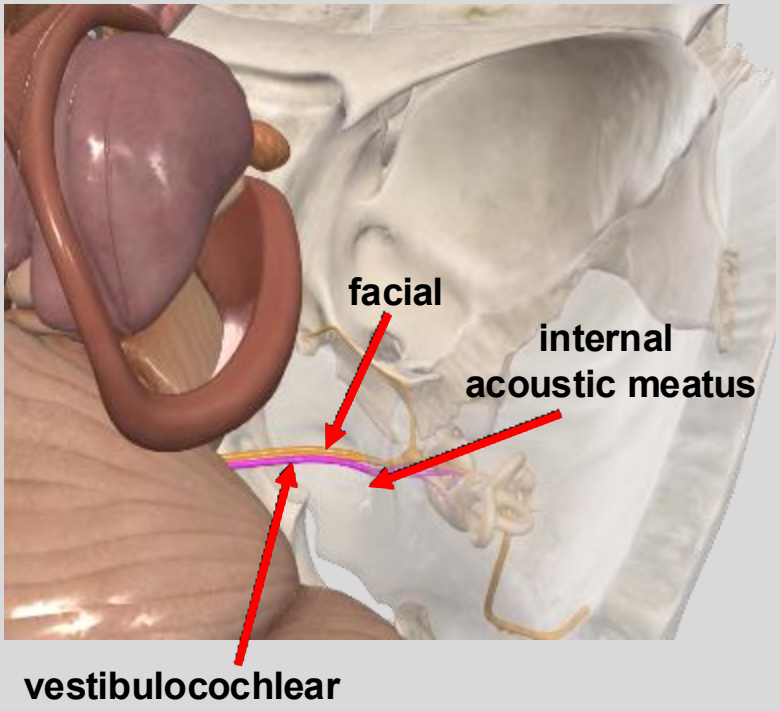


**Exits endocranium through internal acoustic meatus**

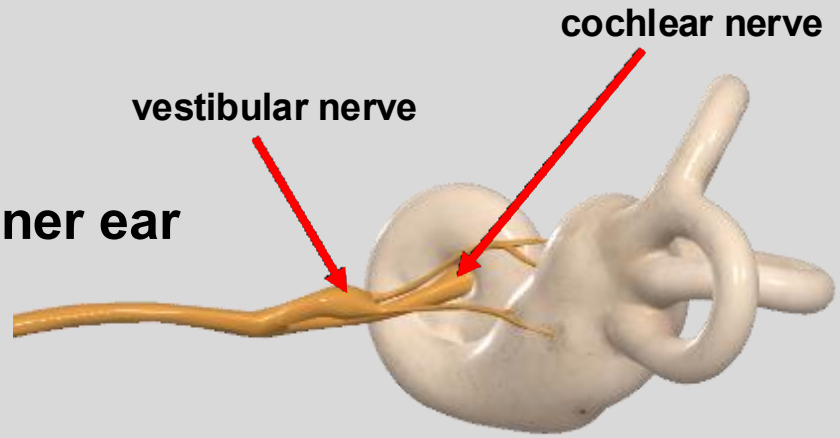
**Shares this exit with facial (CN VII)**

**Vestibulocochlear quickly splits into 2 nerves**

1. Vestibular nerve
   vestibular system (balance)
2. Cochlear nerve
   cochlea (hearing)




**Vestibulocochlear *does not leave* the inner ear**



# Otic Capsule

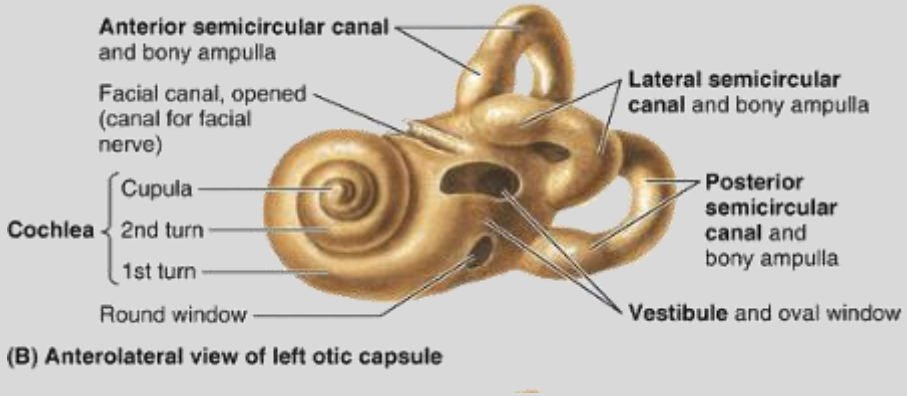


**Comprised of an endosseous (bony) labyrinth**

**endosseous (bony) labyrinth**

**Filled with perilymph**

Same constituency as extracellular fluid




(B) Anterolateral view of left otic capsule

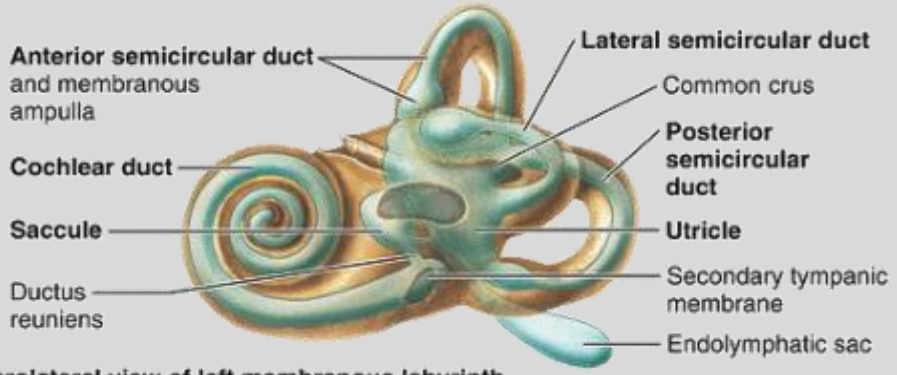
**Deep to the bony labyrinth is the membranous labyrinth**

**membranous labyrinth**

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

**Filled with endolymph**

Same constituency as intracellular fluid




(C) Anterolateral view of left membranous labyrinth (through transparent otic capsule)

Greek: *ōtikós* = of the ear

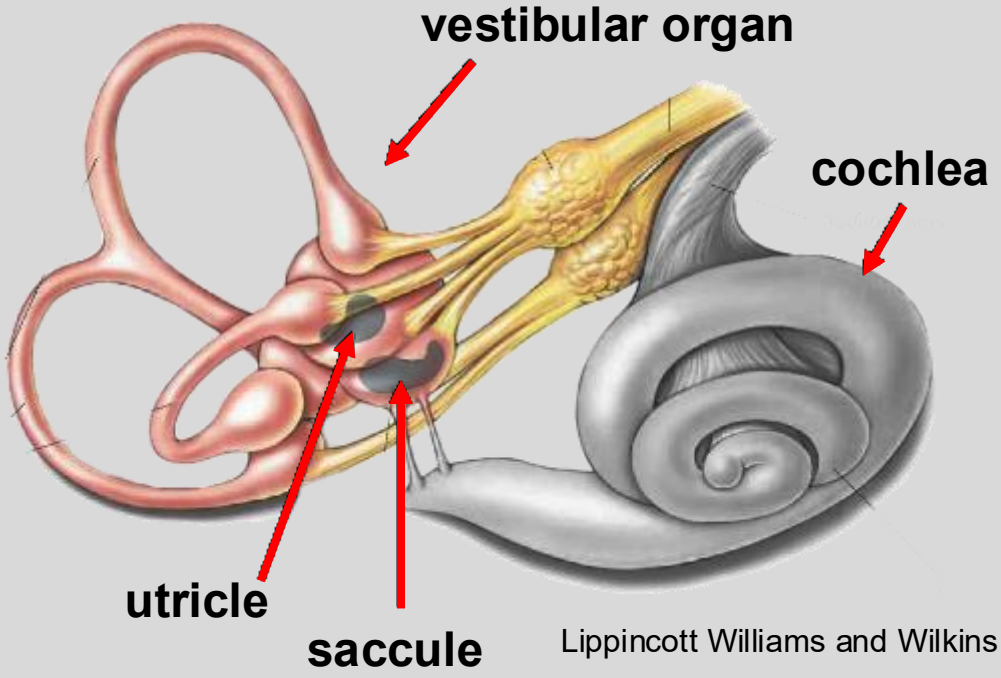
# Vestibular Organ



**Provides our sense of balance and direction**

**Comprised of 2 structures**

1) Otolith organs
2) Semicircular canals




**There are 2 otolith organs**

1) Utricle
2) Saccule

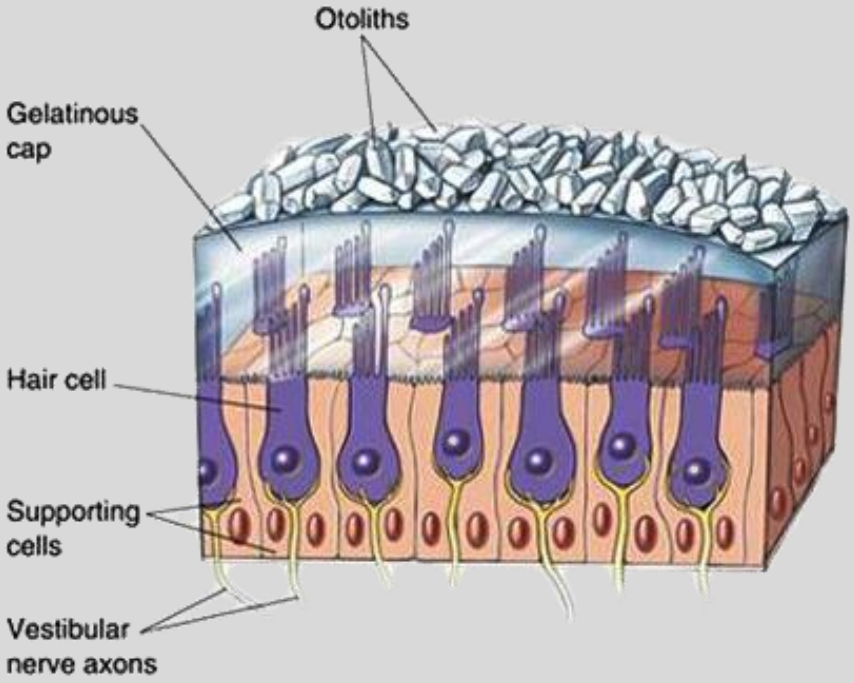
# Vestibular Organ



## Otolith organs

**Greek: *oûs* = ear + *líthos* = stone**

**Otoliths are small calcifications**




**They give weight to the utricle and saccule**

# Vestibular Organ



## Otolith organs

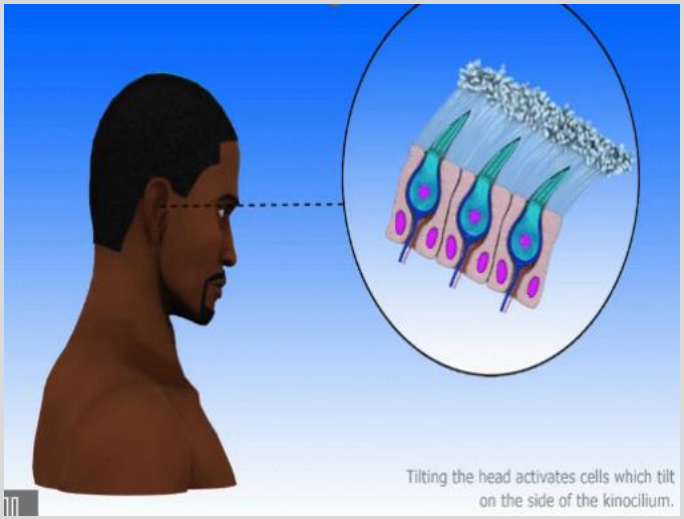
### Utricle

**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

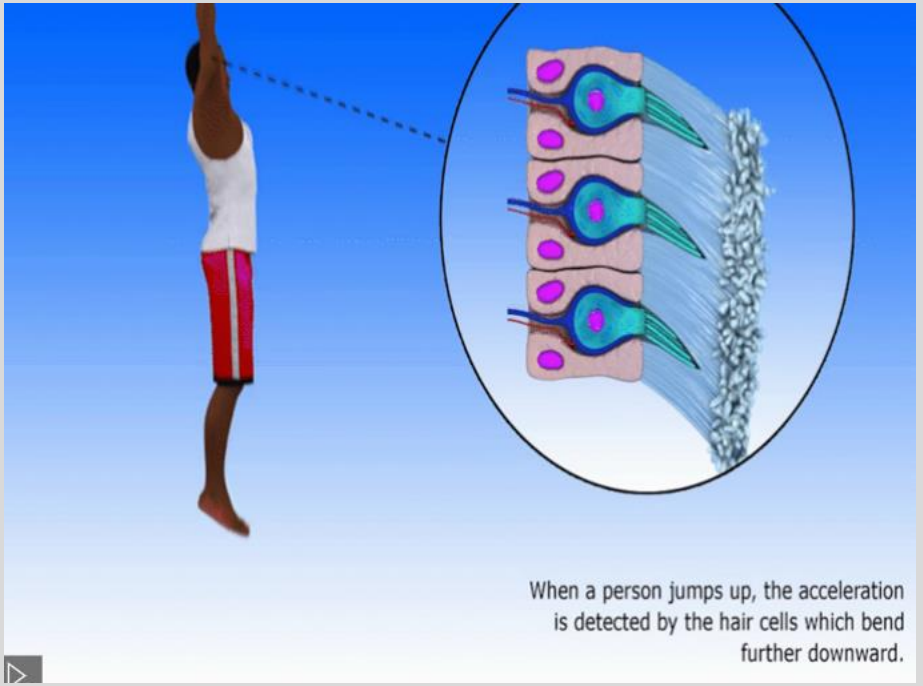
### Otolith organs

**Saccule**

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

**Senses vertical acceleration**

**Functions as our gravity sensor**




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

# Vestibular Organ



**Semicircular canals (SCC)**

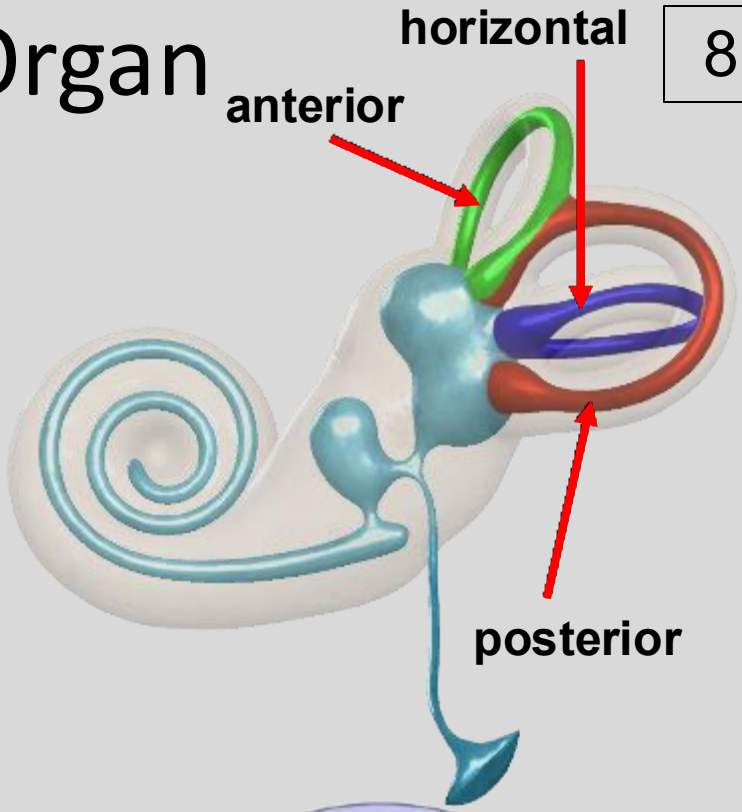
**Provide head orientation information**

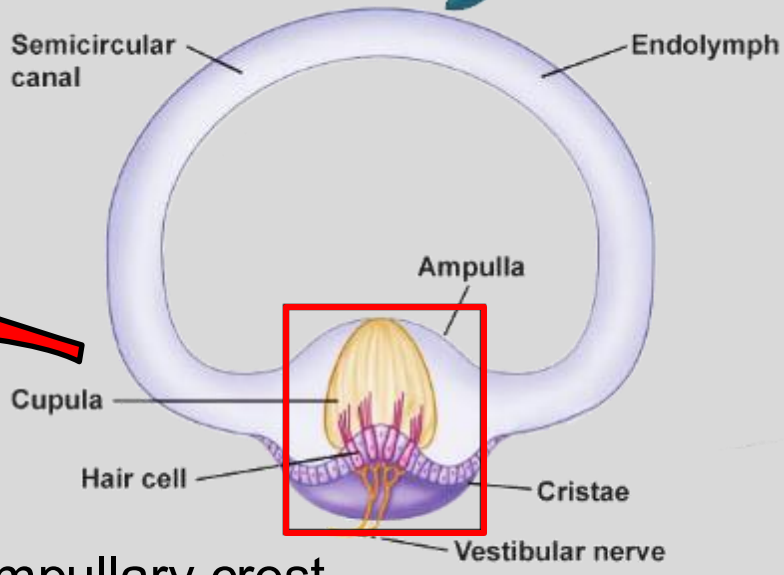
**3 semicircular canals**

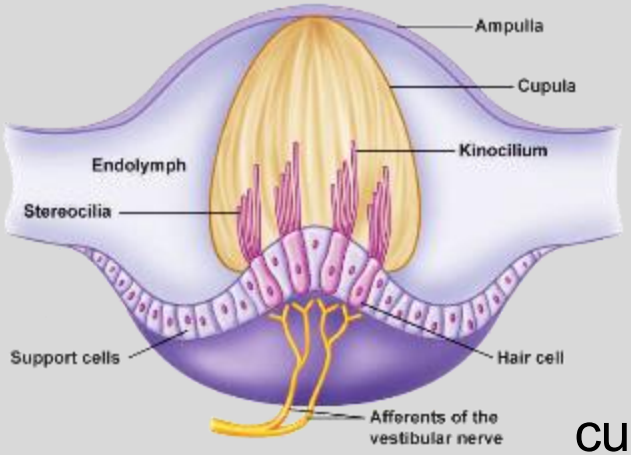
1) Anterior
2) Posterior
3) Horizontal

**Canals are filled with endolymph**

**Each canal expands into an ampulla**




cupula + cristae = ampullary crest

# Vestibular Organ



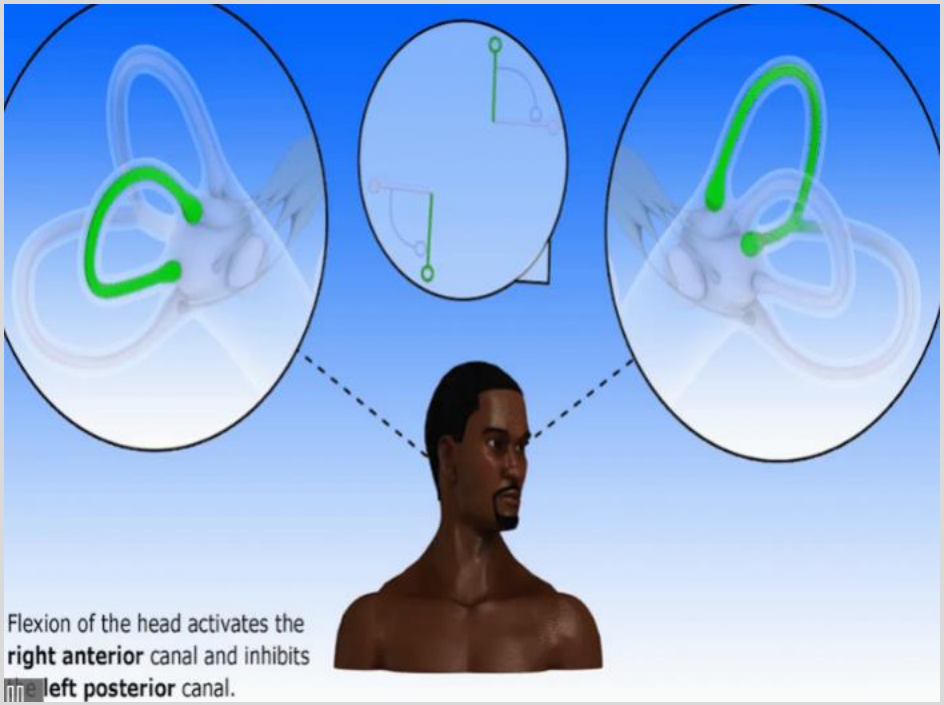
## Semicircular canals (SCC)

**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=ZiFyIfBWyOo

# Vestibular Organ

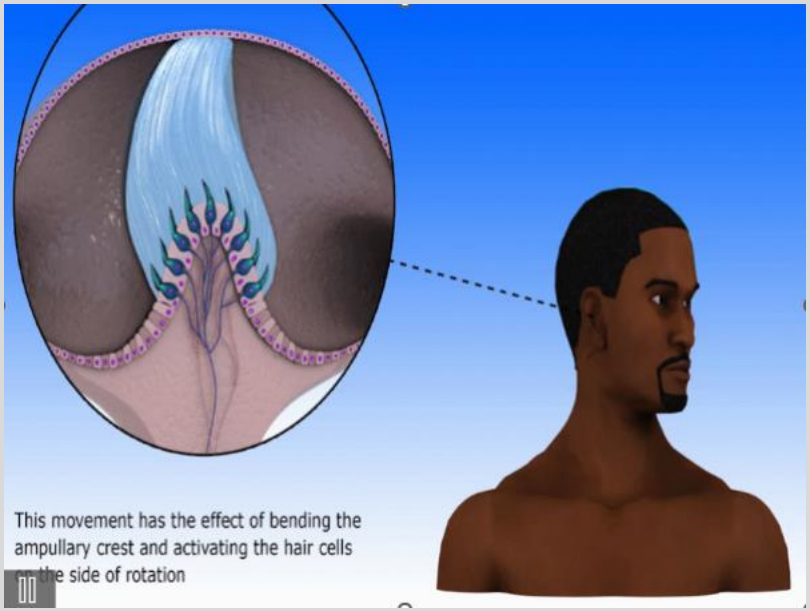


## Semicircular canals (SCC)

**Head rotation moves endolymph in SCCs**

**Places uneven pressure on cupula, bending it**

**Bending of cupula results in:**




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

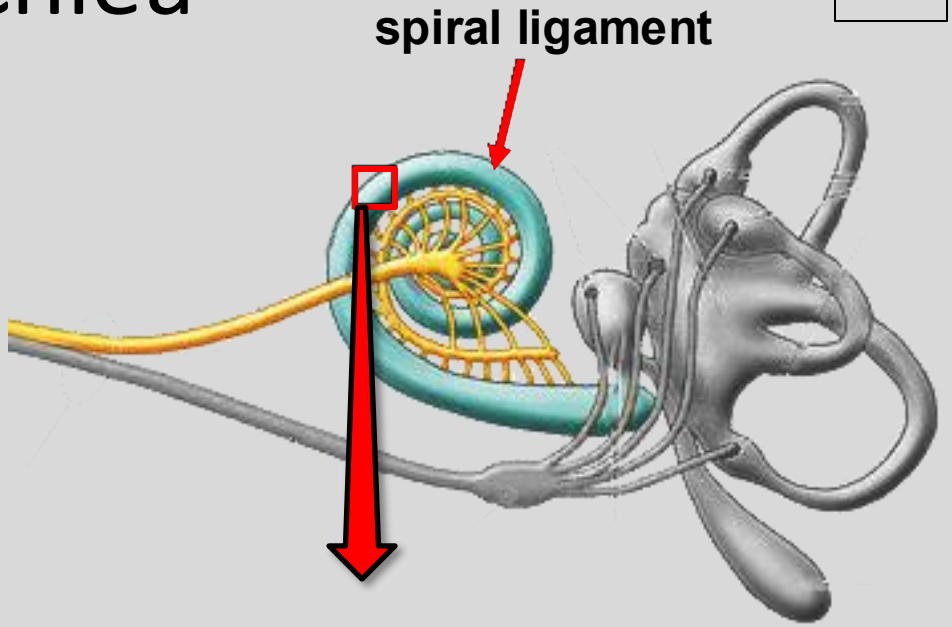
Depolarizing afferent neurons on ***turning*** side

Hyperpolarizing afferent neurons on ***opposite*** side

**Asymmetry of firing pattern determines which way the head is turning**

# Cochlea

**Cochlea is our spiral hearing organ**

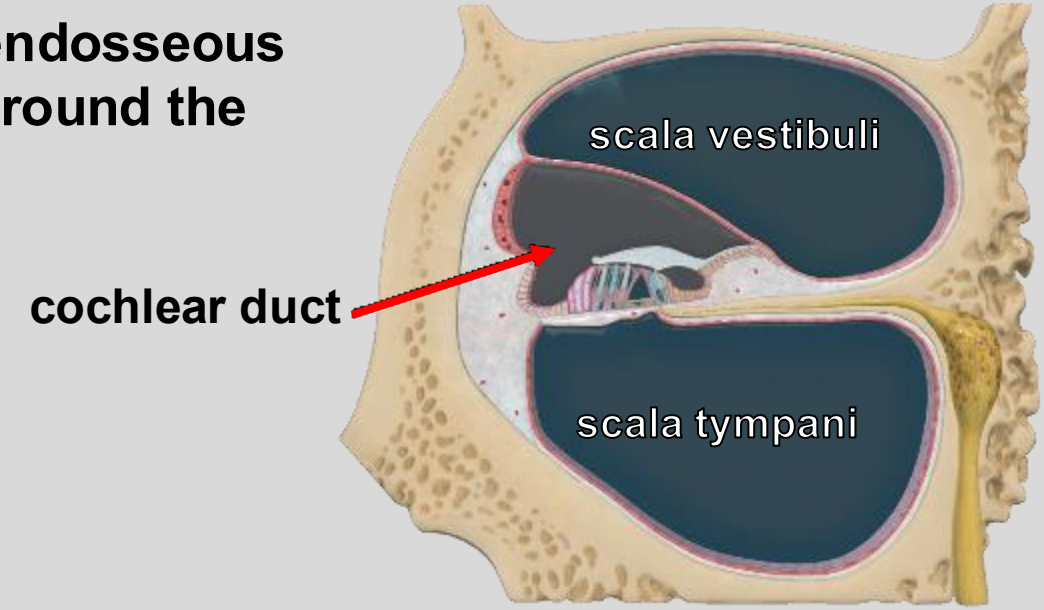



**Hearing information is sent back on the cochlear nerve**

**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




Greek: *kokhlías* = spiral / snail-shell

# Sound Transmission

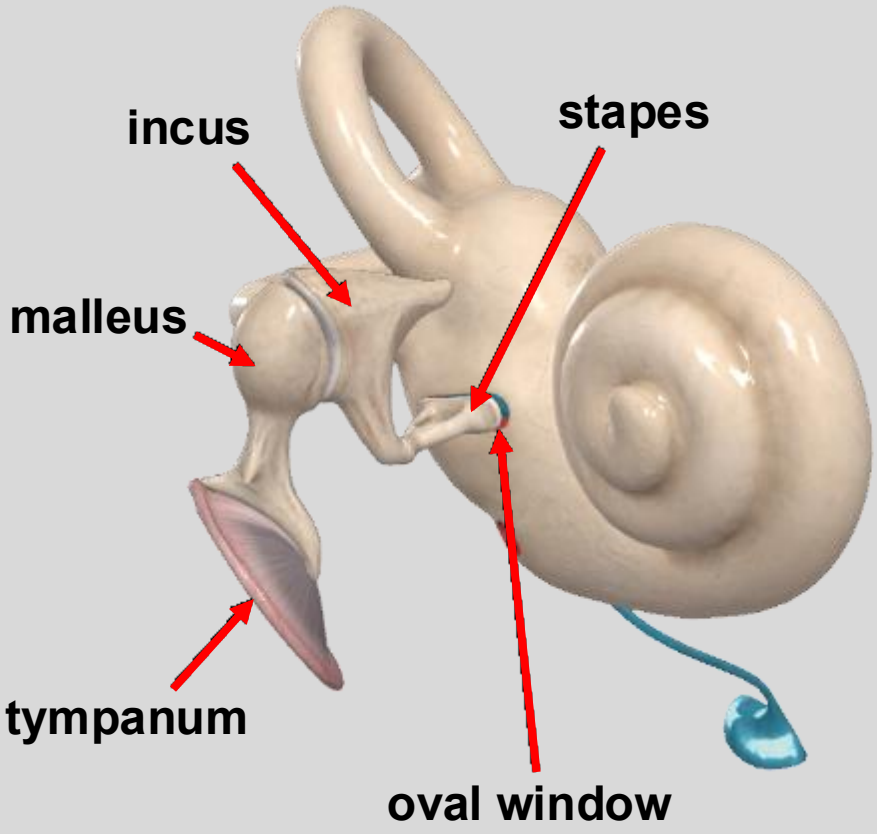


## Middle Ear

**Sound waves hit tympanic membrane**

**Sound is transduced through middle ear via the ear ossicles**

**Footplate of stapes transfers energy to inner ear via the oval window**

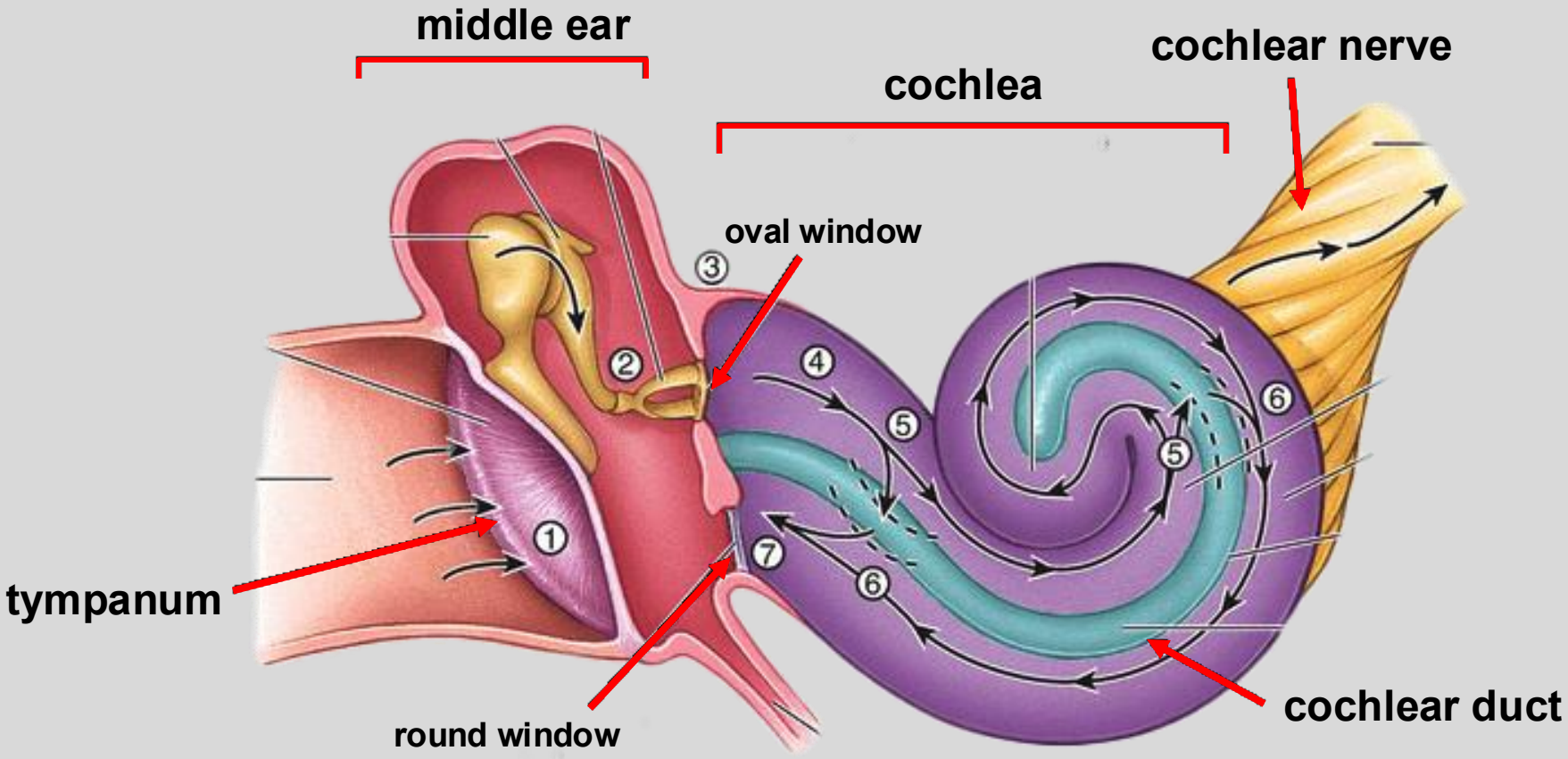


# Sound Transmission



## Inner Ear

**Pressure wave travels through the endosseous labyrinth distorting the cochlear duct at specific frequencies**




Moores Fig. 8.12

# Cochlea



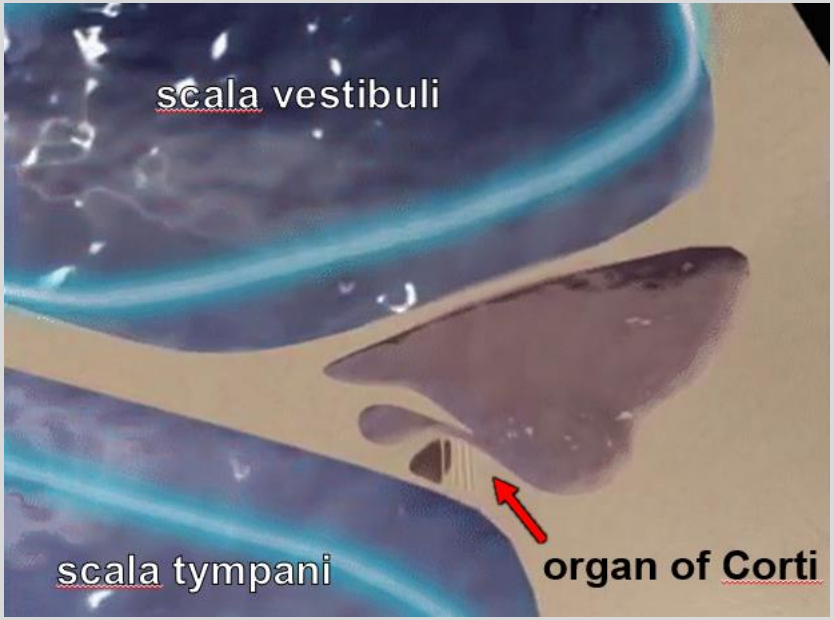
## Organ of Corti

**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**




Brandon Pletsch
https://www.youtube.com/watch?v=PeTriGTENoc

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

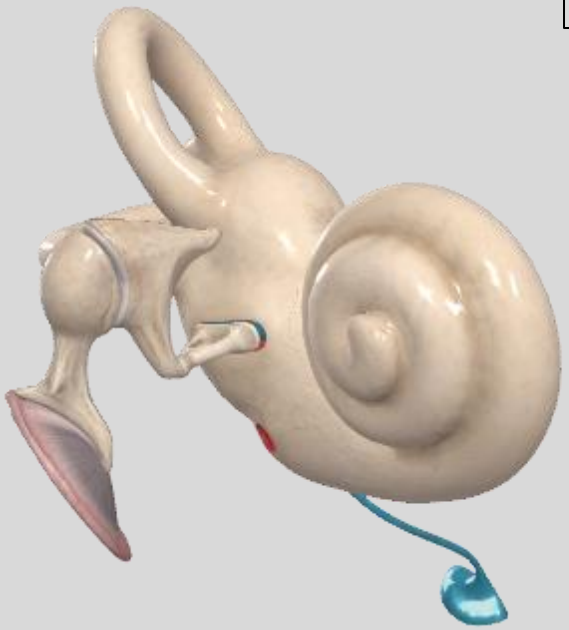
**Neuron activation occurs at different frequencies along the cochlea**

**Lower frequencies travel further up the spiral**

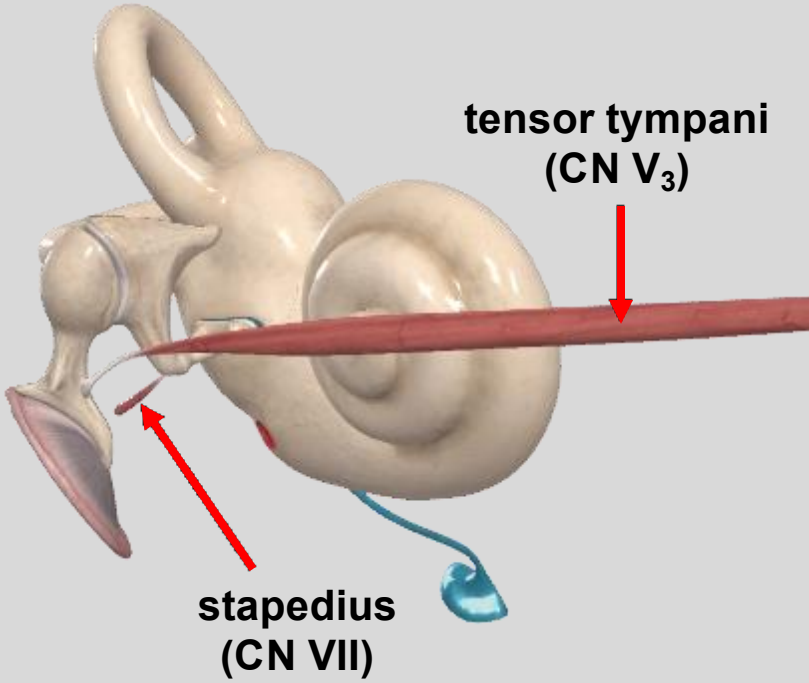
# Cochlea



**Size difference between tympanum and stapes, naturally amplifies sounds**



**Middle ear muscles reduce vibration of ear ossicles, dulling sound and protecting the inner ear**



# Hearing

## Clinical Correlates

### Hearing Loss

**Can be congenital or acquired**

**<u>Conductive hearing loss</u>**

**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**

**<u>Sensorineural hearing loss</u>**

**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**


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

# Hearing

## Clinical Correlates

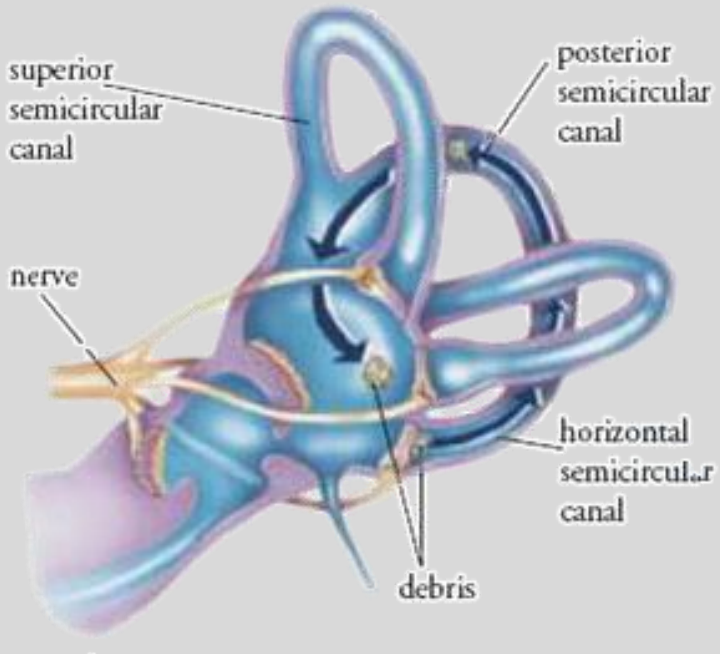
### Benign Paroxysmal Position Vertigo (BPPV)

**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)

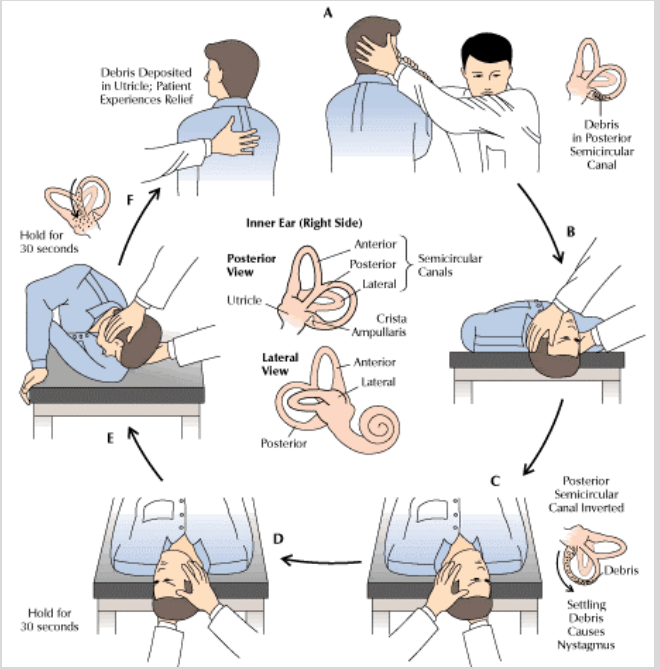
**Patients experience intense, debilitating vertigo**

**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**

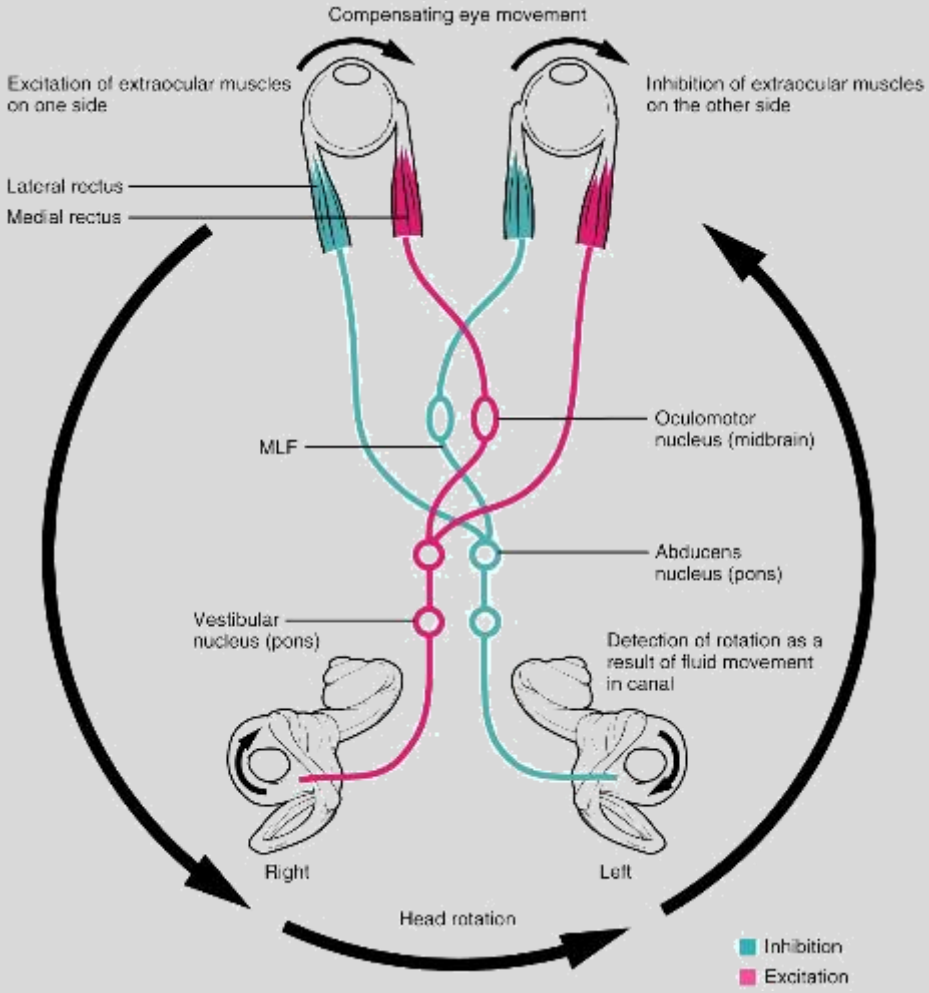
**Couples the vestibular system with the eyes**

**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

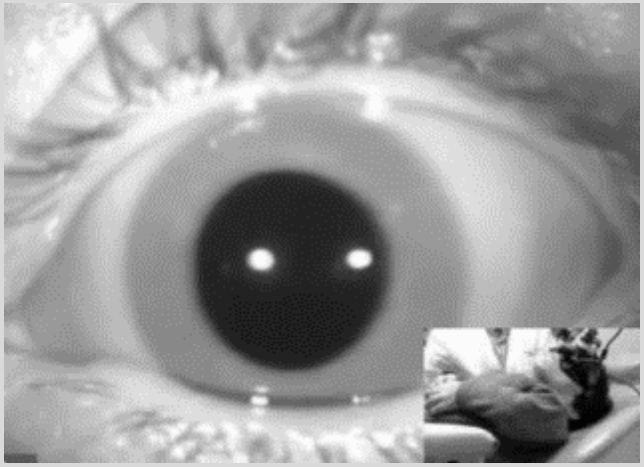
Mercedes-Benz, 2013 https://www.youtube.com/watch?v=nLwML2PagbY

# Coupled Senses

## Clinical Correlate

### Nystagmus

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



Michael Teixido MD

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

**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**

# Lecture Feeback Survey

https://comresearchdata.nyit.edu/redcap/surveys/?s=HRCY448FWYXREL4R